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Stress and Distress in Response to Psychosocial Stimuli

Laboratory and Real Life Studies on Sympathoadrenomedullary and Related Reactions

Edited by Lennart Levi

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Preface

The studies on which this presentation is based have been carried out over a four-year period, 1962—65. The subject matter of chapters 1—3 and 5—8 has not been published before except as short, preliminary communications. Although Chapters 4 and 5 have appeared previously, as indicated in the relevant acknowledgements, the contents have been to some extent re-written, re-edited and expanded for the purpose of this volume.

I wish to express my sincere gratitude to all those who have made these projects and the compilation of this volume possible:

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Mrs. Isabella Levi, B.A., my beloved wife, who all through the years has not only been my best critic and support but has also helped me prepare the tables and read the proofs, and who, together with my dear sons and parents, and Mr. Allan Wahlberg, my best friend, has patiently endured the stress and distress I could not avoid creating in conducting the research and compiling this book, and to whom this book is dedicated.

Last but not least, to all my experimental subjects, who patiently and willingly agreed to expose themselves to a variety of stimuli, and to others not named here or in the acknowledgements at the end of each chapter, whose kindness, courtesy and help have made this work possible, I express my deep indebtedness.

Stockholm, April 1972

Lennart Levi

1 INTRODUCTION: PSYCHOSOCIAL STIMULI, PSYCHOPHYSIOLOGICAL REACTIONS, AND DISEASE

By Lennart Levi

1.1 Objectives of this chapter

The evidence that environmental *physical* stimuli may cause physical disease—in the sense that exposure, avoidance or manipulation of them increases, decreases, or removes the chance of becoming ill or reverses ill health when it occurs—is established for a large number of factors and diseases.

The role of extrinsic, *psychosocial* stimuli is not so clear. We shall endeavour to present a survey of present knowledge (cf. Kagan and Levi, 1972). To do so we shall consider some hypotheses, speculations, and research concerning the relationship between psychosocial stimuli and

— mechanisms thought to be associated with disease;
— precursors of disease;
— disease itself.

In this chapter, and throughout this book, an attempt will be made to focus on the general, *non-specific* aspects of man's reaction to a variety of psychosocial stimuli. The author is clearly aware of the theoretical and clinical importance of stimulus as well as of response *specificity* but felt that the non-specific aspects are not only equally important but have so far attracted less attention.

1.2 Definitions

First we shall define some terms (Kagan and Levi, 1972).

Psychosocial stimuli: In this context we are referring to stimuli which originate in social relationships or arrangements (i.e. in the environment), affect the organism through the mediation of higher nervous processes and may be suspected, under certain circumstances and in certain individuals of causing disease.

Psychobiological program: A propensity to react in accordance with a certain pattern, e.g. when solving a problem or adapting to an environment. Determinants of this program in an organism are genetic factors and earlier environmental influences.

Mechanisms: These are physiological reactions in the organism induced by psychosocial stimuli which, under some conditions of intensity, frequency or duration, and in the presence or absence of certain interacting variables, may lead to precursors of disease, and, eventually, to disease itself.

Stress: This is used here in the sense that Selye described it, namely the *non-specific* response of the body to any demand made upon it; a stereotyped, phylogenetically old adaptation pattern, primarily preparing the organism for physical activity, e.g. fight or flight. These "stone age" responses, which may be provoked by a variety of psychosocial and other conditions of modern life, when no physical action is possible or socially acceptable, have been suspected of eliciting physical and mental distress or malfunction, or even structural damage. Briefly, then, stress is one of the *mechanisms* suspected of leading under certain circumstances to disease (cf. Selye, 1971).

Precursors of disease: These are malfunctions in mental or physical systems which have not resulted in disability but which, if continued, will do so.

Disease: Disease is disability caused by mental or somatic malfunction. Disability is failure in performance of a task. This must always include

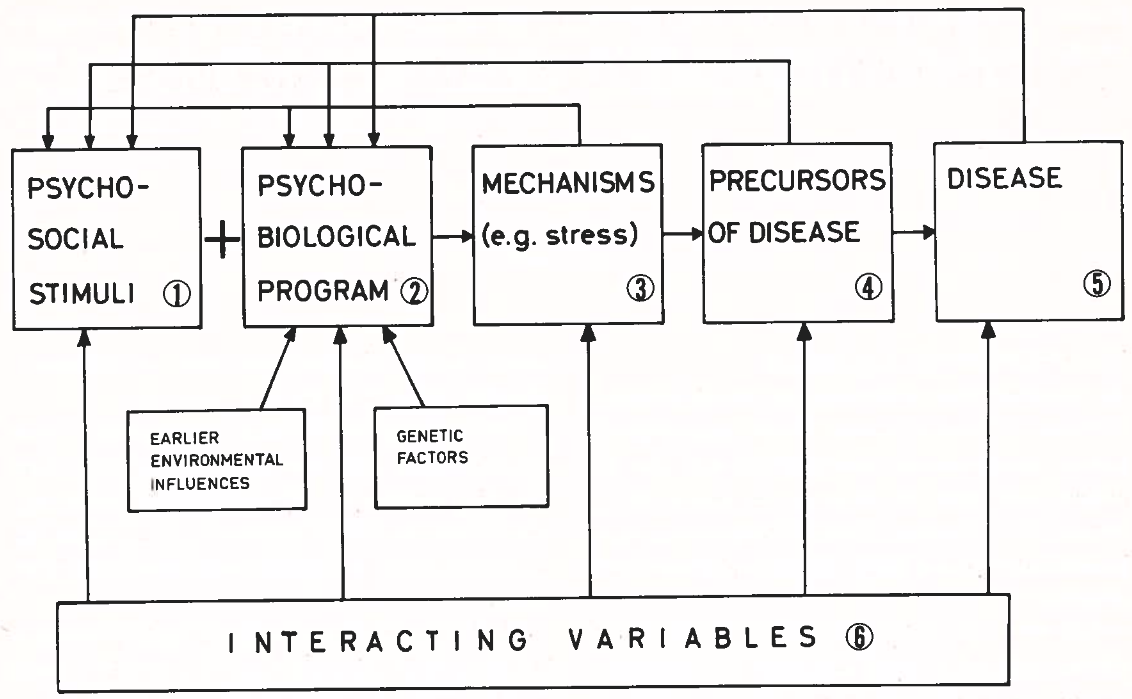

Figure 1:1. A theoretical model for psychosocially mediated disease. The combined effect of psychosocial stimuli (1) and the psychobiological program (2) determines the psychological and physiological reactions [mechanisms (3), e.g. stress] of each individual. These may, under certain circumstances, lead to precursors of disease (4) and to disease itself (5). This sequence of events can be promoted or counteracted by interacting variables (6). The sequence is not a one-way process but constitutes part of a cybernetic system with continuous feed-back (Kagan and Levi, 1972).

tasks considered essential, might include tasks considered normal, and, when more is known, will include tasks that are considered optimal. (In applying this definition it is necessary to state the level of the biological hierarchy to which it refers. Disease as defined is different at the cell, organ, and organism level.)

Interacting variables: These are intrinsic or extrinsic factors, mental or physical, which alter the action of "causative" factors at the mechanism, precursor, or disease stage. By "alter" we mean they promote or prevent the process that might lead to disease.

Examples to clarify the use of these terms will be given below. It must be said now that although it is often possible to categorize factors according to the above definitions, there are many occasions when the category is not clear or when categories are interchangeable. Nevertheless we think they will facilitate discussion, and probably lead to a better understanding of the problems (cf. Carlestam and Levi, 1971; Kagan and Levi, 1972).

1.3 A theoretical model for psychosocially mediated disease, and some hypotheses

Our theoretical model (cf. Lachman, 1964; Simon and Newell, 1964; Chapanis, 1964) of this abovementioned relationship in the pathway of psychosocially mediated disease has been visualized in figure 1:1.

Our experimental work, part of which is to be reported in the present context, has been based on this model and on the following series of hypotheses.

Every psychosocial change can act as a stressor in Selye's sense of the word. In response to such an exposure, and in accordance with the phylogenetically old adaptation pattern ("psychobiological program", cf. figure 1:1) which man has in common with his prehistoric ancestors and with all primates, the neuroendocrine system becomes activated, preparing the organism for physical activity, e.g. fight or flight, even in situations where such reactions are clearly inadequate. The resulting increase in "stress (Selye)" may lead to an "increased rate of wear and tear" in the organism, in predisposed individuals eventually leading to disease of one type or another.

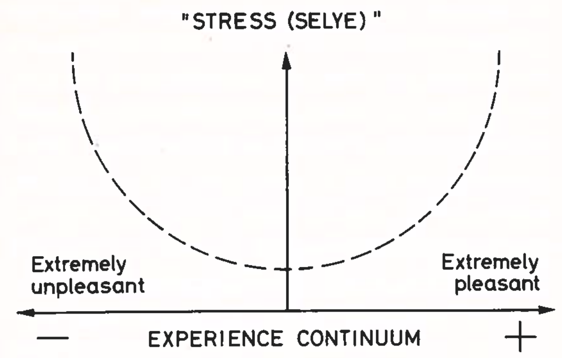

Figure 1:2. Theoretical model regarding the relation between physiological stress as defined by Selye and pleasant, indifferent, and unpleasant experiences of various environmental stimuli, e.g. "life change". Note that the physiological stress level is lowest during indifference but never goes down to zero. Pleasant as well as unpleasant emotional arousal is accompanied by an increase in physiological stress (but not necessarily in distress).

Should this be so, one might expect (a) that a great variety of stimuli, physical as well as psychosocial, would, directly or indirectly (cf. Mason, 1971), evoke physiological responses, some features of which (e.g. changes in sympathoadrenomedullary activity and possibly in plasma lipid level) are stereotyped and nonspecific, (b) that a positive and statistically significant relationship should exist between the degree of e.g. life change (Rahe, 1969) and sympathoadrenomedullary activity (e.g. as reflected in adrenaline excretion), and between life change and various types of morbidity, and (c) that e.g. hyperlipoproteinemia should predict not only death in degenerative myocardial disease but also death in general, being a mechanism and/or a precursor in a nonspecifically evoked pathogenetic process. Evidence supporting these hypotheses would point to the existence of a common, general, nonspecific factor in the pathogenic process, in addition to a number of more or less specific ones.

One of the crucial points in this chain of reasoning is that "stress (Selye)" can be evoked by *every* or almost every change, including psychosocial change. This would mean that increases in "stress (Selye)" should occur as concomitants not only of psychological reactions usually described as unpleasant but also of those described as clearly pleasurable, cf. figure 1:2. If this is so, not only the unpleasant reactions but the pleasant ones too should be accompanied by "an increased rate of wear and tear in the organism". This aspect of psychophysiological relationships has been almost totally neglected in the past.

Over the past few decades the concept of "stress" has become increasingly popular and is now often used by many behavioral scientists and by laymen to indicate a sequence of events that almost by definition are regarded as annoying, distressful, and/or noxious and harmful. This is not the way the term is used here. True, Selye and others usually assume that "stress (Selye)" is positively related to "the rate of wear and tear in the organism", thus being potentially harmful at least from the viewpoint of an internist. However, one should not forget that "stress (Selye)" or certain aspects of it may very well be beneficial from, say, the *performance* viewpoint, particularly when the performance involves physical activity. As to psychological performance, an inverted-U relationship has often been demonstrated between efficiency and arousal level, cf. O'Hanlon (1970) and Frankenhaeuser (1971). In a long series of studies, Frankenhaeuser and her group have shown that high adrenaline excretors usually perform significantly better in tasks involving perceptual conflict, choice-reaction, and under-stimulation, but not in those involving over-stimulation, where the opposite is the case (for review of these studies, see Frankenhaeuser, 1971).

1.4 Type of evidence to be reviewed

The relationships shown diagramatically in figure 1:1 have been studied in several kinds of investigation, in animals and in man.

In neurophysiological studies, different parts of the brain have been stimulated chemically or electrically and concurrent psychic and physiologic reactions have been measured (Bajusz and Jasmin, 1964; Nalbandov, 1963) to clarify pathogenic mechanisms. In studies making use of psychological, sociological and epidemiological methods, groups of patients and matched control groups of healthy subjects have been compared for recent or premorbid exposure to various psychosocial stimuli, or with respect to "program" or interacting variables. Studies have been prospective or retrospective. They show associations between psychosocial stimuli or interacting variables and mechanisms; and between mechanisms and precursors of disease; and between psychosocial stimuli and disease. Attempts have also been made to assess the relative importance of genetic and environmental factors in the pathogenic process by comparing uniovular and biovular twins who were subjected to different environmental influences after birth. Studies have also been made of the entire pathogenic process as represented in figure 1:1, subjects or groups with certain characteristics being exposed to psychosocial stimuli assumed to be noxious, and the reactions in terms of mechanisms, precursors and disease being studied over time. Studies with precursors and *diseases* as endpoints have been made on *animals*, and analogies have been made with respect to corresponding processes in man. Generally, two classes of psychosocial stimuli have been applied: the specific, and the non-specific (cf. Wolff, 1960).

The *specific* stimuli have little or no effect in themselves and assume significance only because of their capacity to act as signals and symbols. The nature and degree of the psychological and physiological reactions they evoke are dependent mainly on individual past experience. Symbols that are gravely threatening to a certain individual may be meaningless to a neutral observer, and vice versa.

The other approach involves *non-specific* stimuli, which influence the mechanisms in almost every subject whatever his past experiences, although the degree of the reaction may vary considerably from individual to individual.

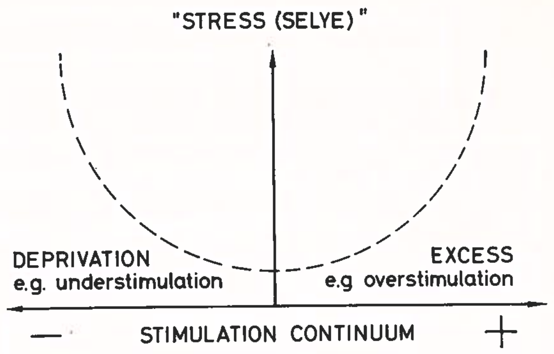

Figure 1:3. Theoretical model regarding the relation between physiological stress as defined by Selye and various levels of stimulation. According to this hypothesis, deprivation of stimuli as well as excess is accompanied by an increase in "stress (Selye)".

In both cases, the responses are markedly modified by a great number of interacting variables. Some of these variables have been experimentally manipulated.

Some of these studies will be referred to below as evidence of a relationship between psychosocial stimuli, interacting variables, mechanisms, precursors of disease, and disease. Where possible we will indicate whether this relationship is certain, probable, or speculative.

1.5 Psychosocial stimuli and physiological mechanisms

1.5.1 Some general considerations

First we will discuss some of the psychosocial *stimuli* that have been suspected to be pathogenic, under certain circumstances and in certain individuals.

As mentioned above, every psychosocial (or physical) environmental change can evoke "stress (Selye)". A perusal of the literature leaves the reader with the impression that the relationship between psychosocial stimulation and "stress (Selye)" can be best described as a U-shaped curve, cf. figure 1:3. The highest stress levels are usually found at the extremes of the stimulation continuum, i.e. during exposure to over- or understimulation. In general, deprivation or excess of almost any influence is found to be stress provoking in Selye's sense of the word. For instance, high stress levels may be induced during sensory

deprivation and sensory overload, in response to extreme affluence as well as to extreme poverty, parental overprotection as well as parental deprivation, extreme permissiveness as well as extreme restriction of action, etc.; for discussion, see Kagan and Levi (1971, 1972), and Carlestam and Levi (1971). William Cowper (1731—1800) obviously refers to a similar relationship, emphasizing that "Absence of occupation is not rest/ A mind quite vacant is a mind distressed" (*Retirement* 1. 623).

In an impressive series of studies, Rahe (1969) has demonstrated the pathogenic significance of the degree of life change, although his studies did not cover the mechanisms involved. Rahe's model of the relationship between life change (the sum of pleasant and unpleasant changes) and morbidity seems to be unipolar, i.e. the higher the life change, the greater the risk for subsequent morbidity. One is tempted to consider whether the model shown in figure 1:3 is applicable to Rahe's general hypothesis too. If so, life change could be just another example of stimulation, which would mean that very low as well as very high degrees of life change would be accompanied by high levels of "stress (Selye)".

Examples of experimental psychosocial stimuli will be given later in the present chapter and in the next one. Suffice it to emphasize that many of the stimuli are not "purely" psychosocial, and that very often the experimental or "real life" condition exposed the subject to a rather complex mixture of stimuli, which makes it extremely difficult indeed to demonstrate that a certain reaction, precursor or disease is causally related to this or that specific psychosocial stimulus.

In his penetrating discussion of the "non-specificity" concept in stress theory, Mason (1971) further emphasizes the difficulties implied in all attempts to partial out the primary effects of purely physical stimuli (e.g. cold, heat, physical trauma, physical exertion) from the secondary effects elicited by *psychological reactions* to them. At least with reference to adrenocortical function, he puts forward the alternative hypothesis that the non-specificity and stress concepts should be regarded not as physiological but rather as behavioural, i.e. involving a higher level of central nervous system function than was previously realized.—Although it would have been tempting to carry this discussion further, it does not fall directly within the scope of the present discourse (which is centered on the responses to *psychosocial* stimuli only) and will therefore not be dealt with in more detail.

The *mechanisms* demonstrated to be influenced by such psychosocial stimuli can be classified into the following rather broad categories:

- — mental (higher nervous) processes
- — endocrine processes, especially hypophyseal, adrenal and thyroid function
- — lymphatic and immunoreactive processes
- — other physiological processes.

In the present context we will focus on the *endocrine* mechanisms, particularly on the secretion of adrenaline, noradrenaline, corticosteroids and thyroxine. Although there probably are many other endocrine mechanisms, these have been considered particularly relevant and studied most.

1.5.2 Sympathoadrenomedullary activity

It is well established that the *sympathoadrenomedullary system* is influenced by a great variety of psychosocial stimuli in animals as well as in man (cf. e.g. Selye, 1960). It has been claimed that if a sympathoadrenomedullary stimulation lasts too long or is repeated too often, the result will first be functional disturbances in various organs and organ systems (cf. Dunbar, 1954). It has further been hypothesized that such a dysfunction, if long-standing and/or intense, may result in permanent structural changes of pathogenic significance at least in predisposed individuals (Nodine and Moyer, 1962; Raab, 1966; Wolf and Goodell, 1968). The theory that the sympathoadrenomedullary system reacts by an increased secretion of adrenaline in various emergency states, including those elicited by psychosocial stimuli, was put forward by Cannon and summarized by him as early as 1929. Twenty-five years passed, however, before this increased secretion was actually demonstrated.

In 1954, using Euler's new, sensitive fluorimetric methods, Euler and Lundberg first demonstrated an increased urinary catecholamine excretion in airforce pilots and passengers during ordinary flight, and they attributed this to the psychosocial stimuli arising from the situation to which the subjects were exposed. In 1957 and 1958, Elmadjian, Hoagland and their collaborators at the Worchester Foundation published data demonstrating an enhanced urinary catecholamine excretion in professional hockey players as well as in amateur boxers and psychiatric patients in situations comprising a variety and combination of psychosocial and physical stimuli (Elmadjian, 1963). Using a composite program of emotionally charged films, a stimulus that can be considered to be rather "purely" psychosocial, Euler et al. (1959) demonstrated that this type of stimulus was equally effective in evoking such catecholamine reactions.

Since then, enhanced sympathoadrenomedullary activity has been demonstrated in response to a wide variety of situations comprising psychosocial stimuli, such as matriculation and other exams (Bogdonoff et al., 1959, 1960; Pekkarinen et al., 1961; Pàtkai et al., 1967), centrifuge rides (Silverman and Cohen, 1960; Frankenhaeuser et al., 1962; Goodall, 1962; Berman and Pettitt, 1961), extensive medical examinations (Ulvedal et al., 1963), dental treatment (Weiss et al., 1965), acrobatic, supersonic and space flight (N.A.S.A., 1961; Klepping et al., 1963; Colehour and Graybiel, 1964; Hale, 1965), motor-car driving (Smith and Bennet, 1958; Schmid and Meythaler, 1964), water immersion (Goodall et al., 1964), sensory deprivation (Mendelson et al., 1960; Cohen et al., 1961 a), hospital admission (Tolson et al., 1965; Nelson et al., 1966), and a variety of laboratory situations characterised by over-stimulation, under-stimulation, anticipation, and conflict (Frankenhaeuser, 1971).

These studies clearly imply exposure to psychosocial (several of them also to physical) stimuli. However, some of these exposures have been of relatively short duration, while others clearly do not belong to the everyday experience of an ordinary population.

However, a number of the stimuli used in studies at our laboratory (Fröberg et al., 1971) do relate closely to habitual activity and some have been of prolonged duration. In *laboratory* studies, groups of subjects have been exposed to a variety of psychosocial stimuli including: (a) simulated industrial work (sorting of steel balls), (b) simulated office work (proof reading), (c) appearance before an audience, (d) film programs chosen to induce anxiety, aggressiveness, and other emotional reactions, (e) simulated psychomotor tasks, and (f) prolonged function under simulated ground combat conditions. In a series of *field* studies, the reactions of various occupational groups to real life stimuli have been studied, namely the stimuli arising from the subjects' own work situation. These situations included those facing (a) telephone operators, (b) invoicing clerks and IBM operators paid a salary, (c) the same subjects paid on a piece-wage basis, (d) office clerks subjected to changes in work environment (conventional offices and office landscapes, and different noise levels), (e) supermarket cash desk girls (during rush hours and ordinary conditions), (f) paper mill workers working in three shifts, night and day, and (g) engine-drivers working irregular shifts at various seasons.

Further data indicating an increased liberation of catecholamines in response to a variety of psychosocial stimuli or in different states of emotional arousal have been presented by Eiduson et al. (1957), Sulkowitch et al. (1957), Regan and Reilly (1958), Bergsman (1959), Nilsson (1960), Shatalova and Myager (1960), Friedman et al. (1960), Cohen et al. (1961 b), Sloane et al. (1964), Hames et al. (1965), and Goudonnet (1971) and reviewed by Hoagland (1961), Sourkes (1962), Euler (1965), Schildkraut (1965), Kety (1966), Frankenhaeuser (1967), Graham et al. (1967), Mason (1968 b), and O'Hanlon (1970).

Briefly, then, this "annotated bibliography" clearly indicates that psychosocial stimuli do, indeed, influence sympathoadrenomedullary activity.

1.5.3 Adrenocortical activity

Increased *adrenal cortical activity* has been noted in response to hospitalization (Mason et al., 1965), anticipation of laboratory procedures (Mason, 1959; Persky et al., 1959), thoracic surgery (Price et al., 1957), medical exams (Bliss et al., 1956), psychiatric interviews (Hetzel et al., 1955; Oken et al., 1960; Persky et al., 1958), pursuit-meter operation and psychological tests (Freeman et al., 1944; Korchin and Herz, 1960), motor-car driving (Frost et al., 1951; Hill et al., 1956), participation in flying activities (Craven and Smith, 1955; Hale et al., 1958; Colehour, 1964), or in intense combat action (Elmadjian, 1955; Pace et al., 1956), whereas viewing Disney nature-study films actually lowered the 17-hydroxycorticosteroids in plasma (Handlon et al., 1962).

For review in the field of psychosocial stimuli and adrenal cortical response see Hamburg (1963), Berkun et al. (1962), Rubin and Mandell (1966), and Mason (1968 a). Briefly, it is generally agreed that adrenal cortical stimulation occurs in response to a variety of psychosocial stimuli, but that the hypophyseo-adrenocortical system reacts more slowly and requires somewhat higher stimulus intensities before reacting than does the hypothalamo-adrenomedullary system. A very comprehensive discussion of the reactions of the hypophyseo-adrenocortical system is to be found in Yates and Maran (1972).

1.5.4 Thyroid activity

The evidence concerning the relationship between psychosocial stimuli and *thyroid function* is less conclusive and will therefore be presented and discussed in more detail. Stimulation of the anterior hypothalamus or median eminence as well as of the hippocampal formation produces a definite increase in thyroid hormone secretion, as does stimulation of the cervical sympathetic nerve and of the vagal nerve (McKenzie and Solomon, 1964). According to Rees and Moll (1968), the hypothalamus is involved in the maintenance of the secretion rate of thyroid stimulating hormone (TSH) under normal conditions, possibly through the mediation of a thyrotropin-releasing factor (McKenzie and Solomon, 1967). A long-acting thyroid stimulator (LATS), probably of pathogenic significance in Graves' disease, has also been reported (McKenzie, 1966; McKenzie and Solomon, 1967; Hetzel, 1968). Recently, Persky et al. (1968) reported a statistically significant relationship between LATS and Thematic Aperception Test (TAT) and Holtzman test hostility content, as well as between emotional arousal and TSH.

A variety of hormones, the catecholamines probably being the most potent and physiologically important, have been reported to influence thyroid function. Thus, adrenaline injection in man has been reported to raise TSH and protein-bound iodine (PBI) levels, without, however, altering iodine uptake (Johnston, 1965); on the other hand, Reiss et al. (1949) report an increased uptake, with a maximum 3—4 hours after the injection. As with the related problem of stressor effects on thyroid function, part of the controversy is probably explained by the tendency to apply results obtained in animal experiments to considerations of thyroid physiology in man; furthermore, there is a time and a dose dependency of catecholamine-provoked thyroid reaction. Small doses probably increase and larger doses inhibit thyroid secretion, cf. Söderberg (1958) and Ramey (1966). Ackerman and Arons (1958) report that the stimulating effect of adrenaline is exerted directly on the thyroid gland, because the effect is not abolished by hypophysectomy in dogs. The picture is further complicated by the simultaneous increase in thyroid hormone elimination reported to occur in response to catecholamine infusion, cf. Pitt-Rivers (1960), Ackerman and Arons (1958) and LaRoche and Johnson (1967).

As mentioned in the above review, it has been found that emotional reactions due to psychosocial stimuli are accompanied by a marked increase in adrenal cortical and medullary activity in humans, cf. Levi (1968). Most conspicuously, there is a rise in catecholamine excretion, sometimes to levels indicative of phaeochromocytoma. It is conceivable that these endogenous catecholamines affect thyroid function in much the same way as do exogenous catecholamines, and, if so, one or more links in the hypothalamic-hypophyseal-thyroidal chain are used as a target area.

Against this background, many studies have been made in which animals have been exposed to various environmental stimuli. The results are diverse and conflicting. This may be due, at least in part, to (a) differences in the time chosen for measurement of thyroid activity in relation to the preceding stimulus exposure, (b) specific effects of the various stimulus procedures applied, and (c) reactions specific to the species of mammals used in the experiments, in addition to the more obvious factors of (d) assay methods, (e) variations in attempts to control extraneous influences like dietary and nondietary iodine intake, and (f) criteria of thyroid function. Some of the Soviet studies, making use of conditioned reflex techniques, have been summarized by Amiragova (1959). She concludes that the cerebral cortex exerts its influence on the thyroid gland through neuro-humoral pathways, a variety of "higher nervous stimuli" increasing the liberation of thyroid hormone. Similarly, exposure of mice to cats, which might be considered as a "psychosocial" stimulus, significantly increased the thyroid uptake of I^{131} (Rantanen et al. 1965, cf. also Eickhoff 1967). Giving I^{131} to tame rabbits exposed to barking dogs, Kracht (1954) demonstrated that "elimination of thyroid-stored iodine began 10—30 minutes after stress, though not with equal intensity" as in wild animals subjected to the same stimuli.

Exposure of sheep to insertion of a cannula into the jugular vein has been reported to produce rapid but transient rises in plasma protein-bound iodine (PBI) and PBI^{131} (Falconer and Hetzel, 1964). Subsequently, after these changes had subsided, similar rises were demonstrable after a series of firework explosions, and, most consistently, after exposure to a barking dog. These rises lasted up to 2 hours. The same authors report that restraint was followed by an increase in PBI^{131}, but after training no such effect was observed.

Using the conditioned avoidance technique in monkeys, Mason et al. (1961, 1968 d) report slow but prolonged elevations in plasma butanol extractable iodine. With a similar experimental design, Harrison et al. (1966) and Harrison (1968, personal communication) induced thyroid hypersecretion, which, however, was not seen in every monkey and did not bear a direct relationship to the degree of emotional upset observed.

As to previous studies in man, a number have attempted to relate different psychiatric clinical states (for review see Hamburg and Lunde, 1967; McKenzie and Solomon, 1967; Dewhurst et al., 1968 a; Mason, 1968 c) and fluctuations in these states to the thyroid function of the patients in question. Thus, Board et al. (1956) report PBI levels distinctly higher than in controls in 30 patients within 24 hours of their admission to the psychiatric section of a general hospital. Similarly, Hetzel et al. (1956) report increases in serum PBI in euthyroid patients subjected to stressful real-life experiences. Related results have been reported by Kleinsorge et al. (1962).

Sensory deprivation experiments inducing anxiety and depression have also been reported to evoke increased plasma levels of TSH (Zuckerman et al., 1966). Using the opposite type of emotional stimulus—an arousing film ("Wages of Fear")—Alexander et al. (1961) and Flagg et al. (1965) demonstrated that the viewing procedure was accompanied by significant PBI and PBI^{131} increases, particularly in hyperthyroid subjects. Wolff (1953) describes fluctuations in plasma protein-bound iodine in association with exposure to stressful life experiences. Increases of as much as 100 per cent were recorded in some subjects. Some changes took place within an hour of the beginning of the stimulus exposure, a psychiatric interview. In a similar investigation, Tingley et al. (1958) examined the protein-bound iodine on control days as well as on stress days (exams for the medical student subjects) and found significant increases during the latter conditions. Similarly, three out of four medical students, exposed to an important examination, reacted with a significant elevation of thyroidal I^{132} uptake (Crooks, 1968). More recently, Persky et al. (1968) and Dewhurst et al. (1968 b) have reported a statistically significant relationship between emotional reactions of various kinds and TSH levels. Exposing a total of 63 army officers and corporals to a 75 hour vigil including 72 hours of intellectual performance and/or performance in an electronic shooting range under controlled environmental conditions, Johansson et al. (1970) demonstrated a highly significant increase in protein-bound iodine,

in individual cases to levels clearly above what are usually considered normal limits. Part of this study is to be reported in detail in Chapter 7. Briefly, then, it may be concluded that a variety of psychosocial stimuli may elicit significant increases in protein-bound iodine as well as in other indices of thyroxine release, in animals as well as in man.

1.5.5 Psychosocial stimuli: influence on human physiology

Thus, there is good evidence for a variety of effects of psychosocial stimuli on neuroendocrine function. The neuroendocrine reactions thus elicited can, theoretically, in turn influence all or nearly all existing physiological variables.

The thyroid hormones have been shown to increase the turnover of carbohydrates, lipids, calcium, and magnesium, the heart rate and contractility, and total peripheral resistance, the secretion of hydrocortisone and growth hormone, and the sensitivity of some tissues to the catecholamines. The catecholamines are powerful vasoactive agents with pronounced effects on carbohydrate and lipid metabolism. The adrenal cortical hormones regulate, among other things, the carbohydrate metabolism and the metabolism of minerals and water. Consequently, a very large number of physiological processes are influenced, directly or indirectly.

In summary, we know that psychosocial stimuli cause physiological changes, which in turn *could* lead to precursors and disease.

1.6 Interacting variables, precursors, and disease

Interacting variables may be predisposing or protective. Either may be extrinsic (environmental) or intrinsic.

Many predisposing interacting variables that appear to be physical in nature may have a psychical element, e.g. heat, noise, overcrowding, malnutrition, cf. Mason (1971).

Many of the protective interacting variables are of a psychosocial origin, e.g. habituation, adaptation, coping, and substitution.

Partly depending upon the presence, or absence, of such interacting variables, psychosocial stimuli may or may not influence physiological mechanisms, precursors, or even disease itself.

Some of the psychosocially evoked changes in physiological function do in turn evoke proprioceptive signals to the cerebral cortex. In some individuals, and under certain circumstances, even perfectly "normal" signals of this type may be interpreted by the individual as symptoms of disease (as in the case of hypochondriasis). If the psychosocial stimulation exemplified above is pronounced, prolonged, or often repeated, and/or if the organism is predisposed to react because of the presence of predisposing or absence of protective interacting variables, the results may be hyper-, hypo- or dysfunction in one or more organs and organ systems. Examples of such reactions are tachycardia and palpitations, vasovagal syncope, pain of vasomotor or muscular origin, hyperventilation, increased or decreased gastro-intestinal peristalsis etc. These reactions may, but need not, be accompanied by unpleasant emotional reactions like anxiety, depression, apprehension, etc.

It is often postulated that the development of psychosocially induced diseases is preceded by a "precursor" state characterized by malfunction of mental and physiological systems without apparent disability.

However, as mentioned in connection with the definitions, it is sometimes impossible to demarcate the mechanisms from the precursors or from disease itself. This is particularly so when, in clinical practice, the mechanism and, more often, the precursor, is given the disease label, e.g. as in the case of "gastro-intestinal distress". Thus, there is no sharp borderline between "normal" reactions on the one hand and hypochondriacal reactions and psychological and/or physiological dysfunction characterized as precursors or diseases on the other. Besides, the definition of the level where normality ends and disease begins is closely interrelated with the social psychology of labelling (Mechanic, 1970). For reviews of evidence concerning the reactions described above the reader is referred to e.g. Dunbar (1954), Tanner (1960), Simon et al. (1961), Bykov (1959), Roessler and Greenfield (1962), Teitelbaum (1964), Gellhorn and Loofbourrow (1963), Delius and Fahrenberg (1966), Wolf and Goodell (1968), Lader (1969) and Levi (1971).

Further, psychosocial stimuli may also influence health by impeding recovery and aggravating disability, whatever the etiology of the primary disease. Such a psychosocially induced response may be rooted e.g. in an intense anxiety over the disease or the situation, and possibly complicated by secondary gains such as utilization of the disease as a means of avoiding responsibility, justifying one's incapacity and providing a release from social pressure.

The precursors and diseases mentioned above are all clearly influenced by psychosocial stimuli. They are all characterized by disturbed function of one type or another, but presumably not by more or less chronic functional or even structural changes. The role of psychosocial stimuli in the etiology and pathogenesis of "psychosomatic diseases" where such changes have taken place (as in the case of peptic ulcer, bronchial asthma, essential hypertension, thyrotoxicosis, and degenerative heart disease) is less clear, partly because so little is known about the etiology and pathogenesis of these disorders.

According to some of the hypotheses mentioned above, the human organism's pattern of response to a variety of environmental stimuli, including the psychosocial ones, constitutes a phylogenetically old adaptational process ("stress" in Selye's sense), preparing the organism for physical activity, usually for fight or flight. However purposeful these activities may have been in the dawn of the history of mankind, they have ceased to be very adequate in the adaptation of modern man to the endless number of socioeconomic changes, social and psychological conflicts, and threats involved in living in a highly industrialized modern, urban society. Furthermore for social reasons, man has to repress many of his emotional outlets and motor activities. This creates a situation in which there might very well be a disintegration between the expression of emotion, the neuroendocrine concomitants of emotion and the psychomotor activities likely to accompany such emotion. For example, in a marital or occupational setting, modern man may feel anxiety or aggression and exhibit the neuroendocrine concomitants of the emotional reaction without showing it in his facial expression or verbal or gross motor behaviour. On the other hand, situations do occur when man is compelled to exhibit emotional expressions and to perform physically or verbally in a way grossly incongruous with his actual neuroendocrine and emotional state. If this "stress" pattern of response to psychosocial stimuli and/or this psychophysiological discrepancy lasts long enough, it has been suspected to be of pathogenic significance. Indeed, processes of this kind have been claimed to constitute a major factor in the etiology of several diseases in the field of internal medicine. An early notice on this psychosomatic relationship is to be found in *Ecclesiasticus* 30: 24 (about 200 B.C.), indicating that "envy and wrath shorten the life".

The evidence for and against this and related hypotheses comes primarily from animal experiments, epidemiological studies, and physiological measurements and observations in clinical practice. A detailed presentation and discussion of such data fall outside the scope of this chapter. In this context, it may suffice to recall the proposed relation between psychosocial stimuli and catecholamines, plasma lipids, corticosteroids, thyroid function, and electrolytes, and to mention the relationship between catecholamines, hyperlipidemia and atherosclerosis, and the combined action of catecholamines, corticosteroids, thyroid hormones and potassium deficiency in degenerative heart disease.

1.7 Psychosomatic research

1.7.1 Some general considerations

"Scientific study of emotion and of the bodily changes that accompany diverse emotional experience marks a new era in medicine. We know now that many physiological processes which are of profound significance for health ... can be controlled by way of emotions. In this knowledge we have the key to many problems of prevention

and treatment of illness." This was written some 35 years ago, by Flanders Dunbar, in the introduction to her first large survey of experimental and clinical studies in the field of "emotions and bodily changes". However, in spite of the innumerable studies published since, part of which have been reviewed above, this "key to many problems of prevention and treatment" has been elusive, and we are still confronted with a confusing variety of controversial *data* on psychosomatic relationships, not to mention the *interpretations* of and the hypotheses built on these data (cf. Mason, 1970).

A perusal of the literature in this field, however, leaves the reader with a feeling that part of this controversy might have been avoided (a) by more attention being paid to methodological problems, and (b) by subjecting the various links in the hypothetical chain of events mentioned above (figure 1:1) to a more systematic and comprehensive study. Here, we review previous knowledge and suggest some new ways of examining Mason's (1970) key question, "What normal body mechanisms are involved in psychosomatic illnesses and how and why do they go wrong?"

Psychosomatic research is primarily concerned with physiological and psychological reactions induced by environmental stimuli that are usually referred to as "psychosocial". In most of the psychosomatically oriented medical literature, various disorders have been related to a number of such stimuli to which the patients usually are said to have been exposed prior to and/or in conjunction with the onset of the particular disease (Levi, 1967).

The constellations of these stimuli inherent in everyday life—at work, in the family, even in the clinical situation—are, however, usually very complex and the interaction with physical stimuli of many types complicates the picture still more. It is, therefore, very difficult clinically or even epidemiologically to distinguish between the various links in the hypothetical chain of events and to map out the relative importance, if any, of one or another of the many psychosocial influences.

As a complement to clinical and epidemiological studies, researchers in various disciplines and parts of the world have increasingly made use of psychophysiological and psychoendocrine experiments by exposing an individual or a group to various *stimuli*, single or combined, intense or moderate, of long or short duration, etc. Or a stimulus has been applied to various *individuals* or *groups*—patients and "healthy controls", females and males, young and old, extroverts and introverts, people who do or do not make use of various coping mechanisms, etc. In either case, we may want to study psychological and/or physiological functions at various levels of complexity, using different methods of measurement and different "languages" in describing the reactions and their underlying mechanisms. Theoretically, we would like to study the entire sequence of events in all relevant groups when exposed to all relevant stimuli, the measurements comprising all relevant variables. This, of course, is not possible. Therefore, in medical research, we are likely to concentrate on stimuli and mechanisms suspected by some as potentially of pathogenic significance, or on individuals or groups likely to be more (or less) at risk than the general population.

1.7.2 The stimuli

The use of different kinds of functional and provocation tests has long been practised in physiology and clinical medicine, the patient being exposed to such stimuli as physical work, ACTH, insulin, cold, and allergens, in order to test the quality and quantity of his response. The psychophysiological experiment makes use of psychosocial stimuli in a corresponding way, by exposing subjects to (a) threats to self-esteem or physical integrity, (b) various types of high or low sensory input, (c) open-ended situations, or (d) environmental change in general, of varying magnitude, frequency, and/or velocity.

As already mentioned, these stimuli may be *specific,* i.e. have a special meaning for the subject, or *non-specific,* that is to say active to some extent on all individuals irrespective of the subject's genetically and environmentally determined psychobiological "programming" (cf. Wolff, 1960).

In a review of psychophysiological "stress" studies, Harris et al. (1956) classify experiments of this type according to the kind and duration of stimulus employed. According to these authors, *short-term stimuli* may be exemplified and categorized into

- Failure stressors (e.g. subjects told about previous failures but given one more chance to solve insoluble problems).
- Workload, pacing and distraction stressors (e.g. subjects have to perform a task, sometimes at above-normal speed, sometimes being distracted by meaningful or meaningless noises, flashing lights, electric shocks, etc.).
- Fear-inducing stressors (real or simulated threats of criticism, of being fired, of physical danger; or unpredictability implied in the stimulus situation, etc.).

Long-term stimuli are similarly subdivided into four categories:

- Combat stressors (subjects are exposed to attack situations or a defensive stand over long periods of time).
- Stressors of hazardous duty (i.e. of submarine and aircraft personnel, or soldiers near the front line area but not in actual battle).
- Stressors of confinement and isolation (i.e. submarine or astronaut duty, prison confinement, low sensory input).
- Prolonged performance stressors (vigilance tests, monotonous work etc. resulting in fatigue).

Most of the short-term studies have been performed in psychological or physiological laboratories, whereas the long-term stressors are often given in a "real life" setting. Many of the laboratory studies have been well designed scientifically but may lack realism and meaning to the subjects tested. The real-life situations, on the other hand, usually have been realistic enough but in many cases badly controlled, and so their results are indecisive.

1.7.3. Interacting variables

It is common knowledge that different individuals do not react identically to any given stimulus or set of stimuli. Neither does an individual react identically on various occasions even if we try to keep the stimulus conditions reasonably constant. The reasons for this inter- and intraindividual variability are manifold: processes like habituation, adaptation, learning, and coping; constitutional factors, genetic as well as acquired; group interaction, interaction effects with other stimuli—just to mention a few. Factors like these must be taken into account when choosing our subjects, and the circumstances for their study.

1.7.4 Reactions

On the reaction side, a study of "emotions and bodily changes" usually implies simultaneous determination of these two sets of variables and an analysis of the relation between them, if any. Trying this, we face a series of problems. Needless to say, the actual, subjective experiences of our subjects are not accessible to direct measurement, neither are the basic neuroendocrine processes which are closely linked to these experiences. We have to be content with mere indirect studies of these phenomena, e.g. the subject's verbal report of his experiences, or measurements of hormone levels in body fluids.

A very large number of such psychological and physiological variables have been described and measured in man's response to various psychosocial stimuli. Psychological responses have been measured by direct observation, by interviews, questionnaires and projective techniques. A great number of physiological measurements have dealt with various aspects of cardiovascular, respiratory, gastro-intestinal and renal function, each study usually focusing on a few variables, and without paying much attention to the underlying physiological mechanisms, treating them as a "physiological black box" (Mason, 1970).

1.7.5 What to measure, and why

Another set of studies—including those by the present author—have dealt not so much with specific organ functions but with the more basic, integrative aspects of physiological response, i.e. the neuroendocrine reactions. During the last two decades, chromatographic, isotope, immunoassay, microspectrophotometric and fluorimetric methods

of measurement have become available that allow a relatively detailed study of functions related to what is commonly called the hypophyseo-adrenocortical and the hypothalamico-adrenomedullary axes. In man, these functions have usually been studied by determining various hormones (and compounds influenced by these hormones) in blood, urine, liquor and in various tissues.

In some of these studies, the psychological responses were assessed simultaneously, with respect to self-ratings by the subjects, and to performance when work of one type or another was involved.

The primary target for the studies conducted at our laboratory has been the human organism's sympathoadrenomedullary activity [measured as the urinary excretion of adrenaline and noradrenaline, analyzed fluorimetrically, Euler and Lishajko (1961)]. This set of variables was chosen for several reasons. First, the responses of the sympathoadrenomedullary system have been studied less than those of the adrenocortical system, partly because satisfactory methods for assay of hormones belonging to the last-named system have been available for a longer period of time. Second, it is known that the catecholamines may play important roles in the physiology of the human organism, in health as well as in disease. Third, earlier studies conducted by the present author and by others gave reason to suspect a rather close relationship between sympathoadrenomedullary and psychological function.

Some of the studies comprised measurements of other physiological variables as well (e.g. plasma lipids, erythrocyte sedimentation rate, serum iron, protein-bound iodine, urine flow and specific gravity, urinary creatinine, ECG pattern), to provide data relevant to specific objectives of the study.

1.8 General objectives of the studies to be presented

It is the purpose of the rest of this monograph to discuss methodological issues and to present five typical investigations from our laboratory. They were carried out over a four-year period (1962—65) and all had the following general objectives in mind.

Firstly, to ascertain whether, and, if so, to what extent exposure to some psychosocial stimuli encountered by modern man (e.g. piece-work) actually elicits significant changes in sympathoadrenomedullary and other physiological functions as reflected in changes in a number of blood and urine constituents. Should this be so, it may turn out to be necessary to take the psychosocial situation of the patient into account when clinically interpreting laboratory data on these constituents.

Secondly, to find out whether any physiological reactions provoked in this way have a reasonably high and steady correlation with the subjective state experienced and, one may hope, reported by the subject. The objective would be to see if the physiological reactions could be used as a predictor or index of subjective reactions in cases where these are not readily accessible to direct measurement with psychological methods (Euler, 1964 and 1965), as an index which cannot be masked by verbal or overt behaviour (cf. Mason, 1970).

Thirdly, to study possible interindividual differences in the "programming" of the organism as reflected in differences in different groups' (males and females) reactions to identical stimuli.

Fourthly, to see if physiological reactions to psychosocial stimuli experienced under relatively long-term conditions were similar to those produced in acute laboratory experiments.

Fifthly, to identify mechanisms by which psychosocial stimuli are likely to lead to disease.

Much of the discussion to be presented in the following chapters is based on the "stress (Selye)" concept. As repeatedly emphasized by Selye, this concept should be regarded as a working hypothesis, to be evaluated and re-evaluated with refined methods. The use of this concept does not necessarily imply an unconditional acceptance of an *absolute* "non-specificity". Clearly, there is a progressively greater burden of proof involved as we move through the sequence of hypotheses that a particular bodily response is evoked (a) in a relatively great diversity of *situations*, to (b) by a relatively great diversity of *stimuli*, to (c) by "*every* stimulus". At the present stage, all of these hypotheses seem to deserve evaluation.

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2 METHODOLOGICAL CONSIDERATIONS IN PSYCHOENDOCRINE RESEARCH

By Lennart Levi

2.1 Objectives of this review

As mentioned in Chapter 1, a perusal of current psychoendocrine literature confronts the reader with a confusing variety of controversial data, not to speak of the interpretations of and the hypotheses built on these data. Very probably, at least some of this controversy is due to the failure of a number of authors to take into account the numerous extraneous influences and other sources of error found in this field. Some of these factors will be reviewed and discussed in the present chapter. Their relative importance may vary from one investigation to another. If, for example, the stimulus situation is very intense and dramatic, the effects of extraneous stimuli may be swallowed up in the intense reactions precipitated by the experimental stimulus. If, on the other hand, one is concerned with the effects of relatively subtle stimuli, as in the case of many of the stimuli of every-day life, the effects of extraneous influences may completely confuse the resulting picture and practically rule out an evaluation of the results.

These extraneous "sources of error" are usually categorized as primarily psychological and primarily physiological. However, there are many occasions when the category is not clear. The following perusal, which is not of course exhaustive, reviews and discusses, on the basis of current literature and own studies, the effects of some sources of error considered to be important and relevant in the context of the present book.

For reasons mentioned above, the categorization is based on the factor's quality of (a) a stimulus, (b) a determinant of the psychobiological program, (c) an interacting variable, or (d) a problem related to the measurement of the response (cf. figure 1:1). A preliminary account of some of these problems has been published earlier (Levi, 1967).

2.2 Control conditions acting as extraneous stimuli

A problem bordering between psychology and physiology is that of the so-called control periods. These periods are usually expected and often automatically assumed to be completely neutral, characterized as they should be by baseline conditions and relaxation. Nevertheless, although the subjects are not exposed to the experimental stimuli, they may well be subjected to a variety of other stimuli during these periods, without the experimenter being aware of it. In general, psychologists seem to be prone to disregard extraneous physiological stimuli, whereas physiologists tend to disregard psychological factors. The following are some examples of both types.

In some investigations, *needles* or *catheters* are placed in the subject's veins, arteries or various orifices immediately before or even during the control period. It is perfectly conceivable that such stimuli may evoke psychological reactions. Less attention is paid to the fact that procedures like these may induce physiological reactions as well (Havel and Goldfien, 1959; Stone et al., 1968), e.g. a rise in plasma free fatty acids, this reaction being modified if the subject is allowed to verbalize his experiences in this setting (Stone et al., 1968). If subjects are reassured as to the benign nature of a laboratory procedure, the physiological (and psychological) reactions provoked by it can be considerably attenuated, as reflected in the ballistocardiogram, blood pressure and heart rate (Reiser et al., 1955). Single or repeated *venipunctures* have been shown to activate the adrenal gland (Cleghorn and Graham, 1949/50; Bayliss, 1955). If the venipuncture is accompanied by a withdrawal of considerable quantities of blood, a physiological stimulus is added to the psychological one, leading among other things to a stimulation of the sympathoadrenomedullary system, as manifested in a release of catecholamines (de Schaepdryver, 1958; Schmid et al., 1964).

Cardiovascular reactions have been demonstrated to occur even during what are usually regarded as trivial procedures, such as blood pressure recordings by the cuff method (Davis et al., 1955), a finger prick (Ship, 1960), or even presumably neutral verbal reports concerning name, rank, etc. (Weiner et al., 1962).

The various ingredients of the experimental situation are especially effective as stimuli if the subject is facing them for the first time (Curtis et al., 1968). This threatening quality of a *novel experience* may further be enhanced (or diminished) by several psychosocial factors, which accordingly must be taken into account. These include, among others, (a) extent of previous acquaintance with experimenters and co-subjects; (b) sexual composition of the group; (c) extent of specific preparation for the procedure; (d) previous volunteer experience; and (e) confidence of staff at time of admission (Fishman et al., 1962).

It has furthermore often been taken for granted that only those stimuli that evoke unpleasant emotional reactions may evoke physiological reactions. However, some studies do indicate that stimuli evoking what is usually described as *pleasurable* emotional responses like joy, pride and love, may likewise be accompanied by rather pronounced psychophysiological reactions (Stevenson, 1950; Davis, 1956/57).

As pointed out by Clynes (1964) psychophysiological systems often display a sensitivity to the *rate of change* of the stimulus rather than to its (steady state) quantity. Accordingly, every change in the experimental setting, although not considered by the experimenter as a stimulus (and especially not so if the change is a pleasant one), may evoke psychophysiological responses in the subjects. Pre-experimental and/or extraneous procedures may thereby evoke equivalent or even stronger emotional and endocrine responses than do the intentional stimuli applied during the experiment proper (Persky et al., 1959; Corson et al., 1963; Cook and Wherry, 1950).

It is conceivable that some subjects come to the experiment after a quarrel with their husbands or wives. Others may be worried about their children or about extraneous factors unknown to the experimenter. Some people report to the laboratory e.g. after a *sleepless night,* an experience that has been shown to be accompanied by an increase in adrenaline excretion (Hasselman et al., 1960). Others report to the laboratory when *fatigued* after duty, the higher average values of e.g. total 17-hydroxycorticosteroids (17-OHCS), 17-ketosteroids and mucoproteins in urine reported to occur under such conditions as compared to off-days (Ishihara and Kamori, 1960) rarely being taken into account. The potency of such every-day environmental events has also been demonstrated by Mason (1959), who found a 30 per cent fall of urinary 17-OHCS in monkeys over the weekend, when the animals experienced less contact with the laboratory personnel.

Similarly, the *characteristics of the social environment* and the number of exposures to it may influence the psychophysiological reactions (Mason and Brady, 1964). During hospitalisation, adrenal hormone excretion levels have usually been found to be highest during the first day and then tend to diminish (Tolson et al., 1965, Pekkarinen et al., 1960). Rats, too, exhibit a higher catecholamine excretion during the first few days in a new cage (Crawford and Law, 1958).

In some cases there may be a *habituation* to such environmental stimuli, resulting in a gradual decrease in reaction intensity (cf. Levi, 1963). In others, a repetition of the stimulus may, in contrast, lead to increasing reactions, depending in part upon how the stimulus was perceived during previous exposures.

Some experimenters have made use of sleep and night rest as reference periods, assuming these conditions to be truely basal. However, this cannot be taken for granted, partly because many subjects dream quite a lot, and dreams may be accompanied by rather pronounced reactions in physiological variables like heart-rate and blood-pressure as demonstrated by e.g. MacWilliam (1923), cf. also Böttiger (1971).

2.3 Stimulus duration and timing of measurements

As pointed out by several authors, physiological reactions elicited by a certain stimulus may vary very considerably with the *duration* of the stimulus, because there is often a difference between the reaction to a stimulus that is acute rather than chronic.

If, for instance, the stimulus condition is *prolonged* and of *high intensity*, there may well be an initial increase in the secretion of adrenaline followed by a decrease due to adrenomedullary exhaustion. This type of reaction sequence has been said to occur e.g. in experiments with very high population densities in natural and confined animal populations (cf. review by Thiessen, 1964). Similarly, Sourkes et al. (1959) described a gradual fall-off in the increase of adrenaline output in response to repeated administration of insulin in mental patients, interpreting this fall-off as due to adrenomedullary *depletion*. As pointed out by Butterworth and Mann (1957), cited by Schümann (1960), the catecholamine content is restored in about 6 or 7 days after a nearly complete depletion, i.e. a rather slow rate of resynthesis. This mechanism as an alternative to or combined with the process of *habituation*, may explain the gradual decline in psychoendocrine response on repeated stimulation (cf. Rasmus, 1936/37; Persky et al., 1966; Pekkarinen et al., 1960), as well as the relatively low adrenal hormone levels found in soldiers exposed to *prolonged* combat action (Pace et al., 1956; Bourne, 1969 and 1970) and in chronically anxious patients (Levi, unpublished results).

A similar sequence of events has been described for other endocrine systems. In his study of thyroid function, Ramey (1966) found that prolonged exposure to intense light, noise, or electric stimulation in rats produces an initial phase of "hyperthyroidism" which lasts for about 10 days and is then followed by hypofunction of the gland. Similarly, Weltman et al. (1962), exposing albino mice to solitary confinement, found suggestions of an initial stimulation in thyroidal activity; this was followed by signs of reduced thyroid function towards the end of a 4-month confinement.

A similar sequence of thyroidal events has been reported in response to infectious diseases. Reichlin and Glaser (1958) review a number of studies and interpret the results as indicating an acute stimulation of the thyroid gland followed by "functional exhaustion", cf. also Shambaugh and Beisel (1967). Multiphasic thyroidal responses have also been reported by Goldenberg et al. (1959), Zingg and Perry (1953), Schwartz and Roberts (1957), and Gejrot and Notter (1962).

2.4 Bodily posture and physical activity

A change in the subject's posture may act as a rather potent physiologic stimulus, affecting several of the reactions often studied in psychophysiological experiments, like kidney function (Ni and Rehberg, 1931), urinary catecholamine excretion (Sundin, 1958), and plasma noradrenaline (Adkins et al., 1961; Munro and Robinson, 1960). Physical activity also influences sympathoadrenomedullary function; for a review see Euler (1969).

2.5 Dietary stimuli

The intake of food has been shown by numerous investigators to influence adrenal and related physiological variables. The list of such stimuli comprises glucose ingestion (Dunér, 1953; Weil-Malherbe and Bone, 1954), intake of ascorbic acid (Eidelman, 1958; Oserova, 1957), vitamin-P-like compounds (Clark and Geissman, 1949), deficiency of vitamin B 1 (McGoodall, 1951) and riboflavin (Sourkes et al., 1960), a diet rich in protein (Abelin et al., 1957; Pitkänen, 1956), blood-flow to the liver (Carlsson and Waldeck, 1963) and to the gastrointestinal system following a meal (Häggendahl, 1963 b).

Catecholamine production has also been said to be influenced by starvation (Leduc, 1961) and by dietary deficiences of tryptophan and niacin (Woodford and Barthwal, 1964). Finally, it must be remembered that the various dietary sources of exogenous urinary amines must be kept in mind, including as they do several fruits, beverages and flavouring agents (Waalkes et al., 1958; Crout and Sjoerdsma, 1959; and Perry et al., 1965), including sodium cyclamate (Marquardt and Classen, 1971), although most of these compounds have been reported to influence catecholamine metabolites and conjugates only, and not the free catecholamines (see, however, Cardon and Guggenheim, 1970).

2.6 Drugs, tobacco, alcohol, caffeine-containing beverages

The measures of adrenal hormones may further be transiently as well as chronically influenced by a variety of *drugs* (cf. e.g. Woods et al., 1956; Axelrod, 1962; Domino, 1962; Leanderson and Levi, 1967; Klingenström, 1960; Manninen and Pekkarinen, 1966; Pletscher, 1963).

It may be noted that these drugs include not only psychotrophic substances, oral sympathomimetics and sympatholytics but also tetracycline (Neill et al., 1961) as well as inhaled vasoconstrictor substances for nasal stuffiness or asthma (Roth et al., 1958).

Urinary catecholamine excretion is also affected by moderate or low quantities of *ethanol*, and long periods of ethanol ingestion (Perman, 1958 and 1961; Abelin et al., 1958; Kliewe and Gillissen, 1955; Wartburg et al., 1961), by *tobacco* (Westfall, 1965; Ewer et al., 1959; Watts and Bragg, 1956; Watts, 1960; Silvette et al., 1961; Kershbaum and Bellet, 1964; Beckett et al., 1965; Frankenhaeuser et al., 1970) and caffeine-containing beverages.

A recent study conducted at our laboratory has shown that a large single dose of ethanol not only provoked pronounced increases in adrenaline and noradrenaline excretion during and soon after the ethanol ingestion, but also augmented adrenaline, noradrenaline and 17-hydroxycorticosteroid excretion during next day's hang-over. Moreover, this increase in the urinary excretion of adrenal hormones tended to persist for a whole week after the ethanol ingestion (Brohult et al., 1970). As to the effects of caffeine-containing beverages, the reader is referred to two other studies conducted at our laboratory, focused on the endocrine effects of moderate (Levi, 1967 a) and high single doses of caffeine (Fröberg et al., 1969), both demonstrating significant effects of caffeine ingestion on the urinary excretion of adrenaline and noradrenaline.

2.7 Extrinsic and intrinsic biological rhythms; environmental temperature

A large number of psychological and physiological variables have been shown to exhibit rhythmic changes with various amplitudes, phases and cycle lengths (cf. Conroy and Mills, 1970). Accordingly, the level may vary considerably between various hours of the day. In addition, it may be noted that these rhythms may be different in different subjects, affecting not only levels but reactivity as well. Examples of such inter-individual differences are to be found in shift-workers, variously at various intervals after shift change, as recently demonstrated at our laboratory (Fröberg et al., 1971), as well as in those who are habitually more alert in the evening and morning, respectively (Pátkai, 1971). Of less importance but still with significant effects on endocrine function, are the weekly hormonal near-rhythms described by Halberg et al. (1965). In females, the menstrual cycle must be taken into account (Elmadjian, 1963; Piliego et al., 1964). There is also a seasonal variation (Hale et al., 1963), which may be different in different countries depending on climatological conditions (Montagu, 1959; Sulman et al., 1962; Feller and Hale, 1964; Johansson et al., 1968). This must be taken into account e.g. when evaluating differences between different groups, between control and experimental periods, and between studies carried out at different hours of the day (cf. Kärki, 1956; Euler et al., 1955; Mills, 1966; Curtis et al., 1966).

What has been said above also applies to the *climate* present in the laboratory. Many experiments have been carried out on nude or nearly nude subjects without allowing for the possibility that a change in environmental temperature may have pronounced influence on biochemical variables. As shown by Euler (1960), Rodahl et al. (1962), Arnett and Watts (1960), and Suzuki et al. (1967), exposure to even a moderately cold environment is accompanied by a diuretic response and by an increased excretion of catecholamines. For a recent review and original data on the endocrine effects of cold, see Lennquist (1972).

2.8 The initial "neuroendocrine tone"

According to Dykman et al. (1959) and Klein et al. (1961), natural servo control systems usually have non-linear responses. As the severity of the stressor increases, the response will approach the limits and will decrease progressively, cf. Wilder (1950, 1957 a and b). According to other authors (e.g. Lacey and Lacey, 1962; Hutt and Hutt, 1970) it seems that while this "law of initial values" holds for some variables in some experimental settings, it has no general validity (cf. Edgren, 1971).

Differences in initial neuroendocrine tone may further be manifest in a *different sensitivity to the catecholamines*. Accordingly, some individuals may be more affected by the same amounts of adrenaline and noradrenaline than others (Beyth and Gutman, 1965; Doyle and Fraser, 1961; Lifshits, 1961; Ugoleva, 1960; Axelrod, 1965). This may depend upon the *catecholamine interaction* with the corticosteroids and ACTH (cf. Roston, 1961; Lecomte et al., 1960; Euler, 1955; Panisset et al., 1961) and thyroid hormones (Kuschke et al., 1960; Wurtman et al., 1963; d'Iorio and Mavrides, 1963; McDonald et al., 1935; Sumbajev, 1961; Dawidowicz, 1961; Brewster et al., 1956; Harrison, 1964) or upon increased tissue sensitivity (Swan, 1952; Zhmakin, 1957; Yoshinaga et al., 1960; Raab and Krzywanek, 1965).

Such an increased tissue sensitivity may be caused by *hyperventilatory alkalosis* (Nash and Heath, 1961; Baisset and Montastruc, 1960; Campbell et al., 1958; Blumenthal et al., 1961). This alkalosis may in turn be suspected to influence the excretion of amphetamine, norephedrine, ephedrine and methylephedrine (Beckett and Rowland, 1965 a and b; Wilkinson and Beckett, 1968). Such a hyperventilation and alkalosis may be induced by phychosocial stimuli (Lowry, 1967).

The catecholamine excretion level and consequently also its reactivity may further be changed if the subject is studied after a period of insomnia (Myager and Gochev, 1964) and sleep deprivation (Hasselman et al., 1960). Acute muscular work (Gray and Beetham, 1957; Ishihara et al., 1959), at least at higher work loads (Frankenhaeuser et al., 1969), also induces an increased catecholamine output, cf. paragraph 2.4.

2.9 Diseases possibly affecting catecholamine levels and responses

Similarly, it is known that various diseases may affect catecholamine excretion, which might complicate the interpretation of experimental results obtained e.g. with patients suffering from hypertension (Møller et al., 1957; Yoshinaga et al., 1960), acute myocardial infarction and acute cerebrovascular disease (Rossini, 1965), various vascular diseases (Kazantsev, 1961), liver cirrhosis (McGoodall et al., 1964; Warter et al., 1961), acute infections (Dengler et al., 1959), Addison's disease (Zefirova and Matlina, 1960), various neurotic and psychosomatic complaints (Myager, 1971), and cardiac insufficiency (Pekkarinen et al., 1960).

As already mentioned, conditions leading to a shift of the blood flow to the *liver* might affect catecholamine metabolism (Vendsalu, 1960; Philpot and Cantoni, 1941; Warter et al., 1961). There has further been speculation about disorders that are probably accompanied by a sympathoadrenomedullary hyporeactivity. Such a deviation in reactivity has been described e.g. in patients with *vestibular dysfunction* (Colehour and Graybiel, 1964; Colehour, 1965; Gejrot et al., 1967).

2.10 Age

The age of the subjects must be taken into account in comparing the results of various investigators. Pincus (1956) and West and al. (1961) have demonstrated a progressive decrease in the urinary excretion of steroids with aging. In the case of catecholamine excretion, no significant differences in excretion levels have been found between groups of young and old subjects in a study conducted at our laboratory (Carlson et al., 1970) and by Johansson (1968), but Cohen and Shmavonian (1964) have reported significant differences in catecholamine reaction in a vasomotor conditioning experiment.

2.11 Direct and indirect effects of sensory stimuli

A confusing factor in many studies making use of non-specific stimuli, such as noise and flickering light, is that such stimuli may affect the endocrine equilibrium of the subject not only by inducing emotional responses, as the investigators usually assume, but also through reflex stimulation of the optic and auditory nerves and on to the hypothalamic-hypophyseal system. An example of this phenomenon is the fact that any noise above the level of 70 phon can evoke vegetative (and possibly endocrine) reactions even in the absence of any detectable emotional reaction in the individual, e.g. during sleep (Lehmann and Tamm, 1956; Jansen and Schulze, 1964). Finally, the noise may be strong enough to stimulate the vestibular part of the 8th nerve. Such a stimulation may result in endocrine and autonomic reactions, mediated by the reticular formation and the hypothalamus (Bugard, 1960). For a review of physiological effects of noise see Kryter (1970), Nitschkoff and Kriwizkaja (1968), Welch and Welch (1970) and Karlsson and Levi (1971).

Light, too, has been claimed to influence hypothalamic-hypophyseal function in a reflex way without the subject being emotionally affected (Landau and Feldman, 1954; Hofman-Credner, 1953). Such a *reflex* reaction to sensory stimuli might possibly overshadow the emotion-correlated physiological effects of these environmental stimuli.

2.12 Biochemical individuality

As mentioned above, variations in "neuroendocrine tone", be they physiological or due to pathological states or processes, do affect the levels and reactivity of various psychophysiologically relevant parameters. This tone may further be determined by biochemical individuality, which in turn may be due to genetic or environmental factors, e.g. nutritional state. Clinical as well as subclinical, inborn or acquired "errors of metabolism" may in turn influence the initial "neuroendocrine tone" as well as the quality and quantity of reaction to diverse stimuli, cf. Corson (1971) and Wolf (1971).

2.13 Renal function, bladder emptying, catecholamine breakdown or hydrolysis

In interpreting differences in the urinary excretion of catecholamines it should be remembered that this excretion may be—and probably is—a non-linear progressive function of the production of these hormones in the organism (Elmadjian et al., 1956).

In addition there are good reasons to assume a considerable inter-subject as well as an intra-subject variance in *renal function* during the changes in autonomic activity that accompany different emotional reactions (Miles et al., 1952; Miles and de Wardener, 1953; O'Connor and Verney, 1946; Verney, 1946; Kelsall, 1949; Rydin and Verney, 1938; Chalmers et al., 1949; Corson et al., 1962; Corson, 1971; Pfeiffer and Wolff, 1950; Schottstaedt et al., 1956; Mirsky, 1955; Schwartz and Shields, 1954), with changes in renal blood flow, glomerular filtration, and tubular secretion and reabsorption, which, in turn, conceivably could affect the catecholamine clearance (Pekkarinen & Pitkänen, 1955; Dawson and Bone, 1963; de Schaepdryver and Leroy, 1961; Perman, 1961; Menshikov, 1962).

The matter is further complicated by the fact that the catecholamines are capable of influencing renal function (small amounts increasing and greater amounts reducing the diuresis) and thereby possibly also their own renal clearance (cf. Handley and Moyer, 1954; Botting and Lockett, 1961; Gaunt et al., 1945; de Schaepdryver et al., 1959; de Schaepdryver and Leroy, 1961).

The possibility of urine *retention in the bladder* during emotional stress should also be mentioned (Straub et al., 1950; Stutzin, 1926). When catheterization is used instead of voluntary voiding, a new psychophysiological stimulus is introduced, which may affect different individuals in quite different ways (Miles et al., 1952; Miles and de Wardener, 1953). Further, we should not forget what may happen to the urine samples before analysis. Different urines contain different amounts of substances able to hasten or retard the breakdown of the catecholamines, at least prior to acidification. Ascorbic acid and phosphates in the urine increase the durability of the catecholamines (Mann, 1953), whereas metals in ionic form, particularly manganese, copper, nickel and iron, by catalysing their oxidation, decrease the durability (Harthon, 1959; Mörch, 1958; Chaix et al., 1950; Häggendahl, 1963 a). This catalytic action may be fortified by such substances as uric acid and creatine (Bouvet, 1951), and repressed by sulphur-containing amino-acids (cf. Fors, 1964). The urinary pH, too, is of importance (Finholt & Stokke, 1952); a shift to the alkaline side caused by e.g. emotional hyperventilation (Jankovska, 1931; Wood, 1941) accelerating the catecholamine oxidation.

There is a further source of error acting in the opposite direction, i.e. by increasing the levels of free catecholamines in the urine samples, namely the routine used in many laboratories of collecting e.g. 24-hour samples in containers used by the patient and carried by him. Usually these containers hold a certain amount of acetic or hydrochloric acid, in order to ensure the proper acidification of the urine. As a consequence, the amount of acid is calculated to ensure a urinary pH of about 3 when the *total* sample has been collected. Accordingly, the urine collected in these containers during, say, the first half of the collection period may become too acid, possibly resulting in a hydrolysis of conjugated catecholamines and, accordingly, in an increase of free catecholamines (cf. Häggendahl, 1963; Euler and Lishajko, 1961).

2.14 Urinary and plasma catecholamines as indices of sympathoadrenomedullary function

Euler's original proposal (1964) of using the urinary catecholamine excretion as a measure of sympathoadrenomedullary activity and "stress" has been criticized by several authors. Thus it has been said that the urinary excretion of free catecholamines provides but a rather poor picture of catecholamine release (Kety, 1966) because only some few per cent of the amount released is excreted in this form (cf. e.g. Cohen et al., 1962). It has further been claimed that the catecholamine *turnover* and not only the release might be influenced by the stimuli used.

These objections must be assessed, however, in relation to the use to which urinary catecholamine measurements are to be put. While it may be true that the free catecholamines in urine do not provide a *quantitative* measure of catecholamine release, they do at least probably indicate whether or not the release has been augmented or reduced. Taking this argument one step further, the rank order correlation is presumably rather high between release into the blood stream and excretion with the urine, the excretion probably giving us at least an impression of the magnitude of the release. We know the approximate range for normal variation in catecholamine excretion and the ranges where we begin to suspect a pheochromocytoma. Urinary catecholamines, moreover, have the great advantage of yielding an *integrated* measure of sympathoadrenomedullary activity over a certain period of time, say some hour or hours. Also, studies (cf. Frankenhaeuser, 1971) have demonstrated a high positive correlation between self-rated "subjective stress" and adrenaline excretion. Thus, it seems probable that even though the excretion of free catecholamines does not give an exact and detailed picture of catecholamine release and turnover, it does at least provide an index of "subjective stress", as well as a semiquantitative index of catecholamine release. For these reasons, inter alia, it was considered to be a useful tool for a validation of some aspects of the "stress (Selye)" construct.

A proposed alternative for measuring sympathoadrenomedullary activity is to analyze the excretion of some of the major catecholamine *metabolites,* i.e. metanephrine, normetanephrine or 3-methoxy-4-hydroxymandelic acid (cf. e.g. Studnitz, 1960). True, these metabolites constitute a considerably higher proportion of the total catecholamine release than do the free catecholamines, although nothing is known about the *constancy* of this proportion. But a detailed study of sympathoadrenomedullary activity and metabolism would no doubt be facilitated by serial, simultaneous measurements of *all* free and conjugated catecholamines and catecholamine metabolites (and enzymes involved in O-methylation and oxidation). This, however, fell outside the scope of the present study.

Although a study comprising the measurement of all agents mentioned above offers obvious advantages, a number of difficulties remain in evaluating the various excretion data. One of these can be described as follows.

The adrenal medulla contains a store of catecholamines, which are released during periods of increased demand, whereas the *formation of new hormone* is mainly, though not entirely, relegated to the recovery period (Blaschko, 1960; cf. also Bygdeman et al., 1960). Nothing is known about the magnitude of these stores in people of different psychophysiological make-up. The possibility exists that some individuals have a smaller store and, because of this or for some other reason, may be unable to release hormones above a certain limit (cf. Pincus and Elmadjian, 1946; Pincus et al., 1949).

Considering all these sources of error in the evaluation of catecholamine release by measuring the excretion of urinary catecholamines and catecholamine metabolites it may be asked whether the determination of plasma catecholamines (Häggendahl, 1963 a; Weil-Malherbe and Bigelow, 1968; O'Hanlon et al., 1970) would not provide a better index of sympathoadrenomedullary activity. This is probably so in the study of very *acute* reactions to short term stimuli, like those utilized by Holmberg et al. (1967) in collaboration with our laboratory, demonstrating rapid increases in plasma catecholamines in response to short term exposures to noise and to forced mental arithmetic. However, it should be kept in mind (cf. Kety, 1962) that the plasma catecholamine level is affected by much the same type of factors as is the level of urinary catecholamines, like production, storage, release, "utilization", O-methylation, oxidation, and renal excretion. If one or more of these factors change, the plasma level certainly does not reflect the *release* rate (cf. Manger, 1962). Second, the half-time of the catecholamines in plasma has been estimated to be approximately 1 3/4 min (Cohen et al., 1959; Vendsalu, 1960) and the turnover time (= the time required for complete replacement of circulating hormone by a fresh endogenous supply) to be approximately 30 seconds (Cohen et al., 1959). This makes the time factor very critical, much depending on the minute of the experimental procedure in which the blood sample is to be drawn. Third, if we try to compensate for this by drawing serial blood samples, the bleeding itself may act as a powerful stimulus (Walker et al., 1959:, Fowler et al., 1961). Fourth, and most important, the Euler model allows measurements to be made on the unrestricted human subject or group of subjects in their normal environment, without inducing any discomfort or pain whatsoever.

By reflecting, albeit only approximately, the sympathoadrenomedullary function over a defined period of time, say 1—3 hours, the urinary catecholamines present obvious advantages over the plasma catecholamines for the estimation of the organism's reaction to stimuli of moderate or long duration, i.e. to the majority of the psychosocial stimuli of every-day life.

Accordingly, the urinary catecholamines have been considered clearly more practicable in a great number of laboratory situations and in nearly all situations that are identical or close to "real life", even though the mechanisms underlying their relation to sympathoadrenomedullary activity, "stress (Selye)" and psychological phenomena should still be regarded as something of a physiological "black box".

2.15 Biased selection of subjects

Many psychophysiological studies make use of so-called normal volunteers. However, the subjects who participate in an investigation because of the payment offered to them, the wish to be explored, or as a manifestation of "arousal seeking" behaviour, usually form a heavily biased sample at least from the psychological and possibly also from the physiological point of view, being anything but "normal" (Lasagna and Felsinger, 1954). In a psychiatric evaluation of 56 volunteers for hallucinogen studies, Esecover and Wilkens (1961) found 41 per cent to be in need of psychiatric treatment. Pollin and Purlin (1958) described a similar incidence in a group of 29 volunteers, mentioning a desire for new experiences, feelings of obligation linked to their religious convictions and avoidance of difficult or unpleasant situations (i.e. in jail or in military service) as motivating factors. Subjects who indicated that they would volunteer for a psychological experiment were further found to report significantly more coffee and caffeine-pill usage and cigarette smoking than non-volunteers and to score significantly higher on the following MMPI scales: paranoia, schizophrenia, hypomania, control, and social participation (Schubert, 1964). Briefly, then, these and numerous other studies do indicate that volunteer populations are, in general, selected samples, and not representative of the general population.

2.16 Attitude and motivation: the experimental subject and the experimenter

Whatever the selection of subjects for an experiment, we have to be aware of the existence of important differences in the subject's motivation and attitude to the laboratory environment and to the investigators (Pollin, 1962), e.g. if the experimental group includes patients (as it often does). For obvious reasons such subjects often are rather dependent upon the medical staff, whom they may be anxious to please, and they may have difficulties in expressing aggressive feelings towards the medical investigator, especially if he happens to be the doctor in charge of their medical care (Reiser, 1961) whereas e.g. psychologists are more readily attacked.

If in-patients, the subjects may be quite familiar with the research environment and with the investigator. They may even project *therapeutic implications* into the experimental setting to such a degree that the situation becomes completely deprived of the threatening significance possibly presupposed by the investigators (Grinker et al., 1956, 1957).

The "normal control group" in psychophysiological studies may include a variety of categories —experimenters, paid and unpaid undergraduate and graduate students, hospital personnel, military personnel, industrial workers, office clerks, and others (Levy, 1962). It is obvious that the familiarity with and attitude towards the laboratory environment and experimental setting may vary quite a lot, depending upon which category you choose. Such factors are potent in modifying the attitudes and the psychological reactions induced by the experiment (Kaplan, 1956), and, consequently, the physiological concomitants of these reactions (Sabshin et al., 1957; Handlon et al., 1962; Hamburg, 1962; Korchin and Herz, 1960; Fishman et al., 1962; Elmadjian, 1963; Haggard, 1943; Malmo et al., 1951).

The medical student is often said to be the ideal laboratory animal for psychophysiological research. Presumably psychology students are looked upon in the same positive way. These two categories are very often utilized as so-called normal, healthy controls. But all these subjects are usually quite familiar with the research setting, and with the investigator. Most control groups of other composition are not. Medical and psychological students, by virtue of their professional interest in the investigation, are motivated to cooperate fully, and by virtue of their intelligence are able to produce accurate and carefully considered data, in contrast to some other groups of volunteers (Goldstein, 1964).

Some of these groups may further be inclined to trust the experimenters, while others may not. Such feelings may also influence and be influenced by the attitude and behaviour of the experimenters. Most of us usually feel some apprehension when deliberately inducing unpleasant reactions in a fellow man. In some experiments there may even be some potential risks involved. In such cases the experimenter would be inclined to watch closely and with concern for what may happen. This, in turn, might bias his observation and, in addition, influence the attitudes of his subjects. And what happens to the experimenter-subject relationship if the experimenter—or the subject—is an attractive girl or a dull-looking male? One can only guess.

Psychophysiological research usually depends on the willingness of the subject to participate, to be controlled, to be observed, to report what he feels, etc. However, there are not only many degrees but also many styles of willingness, of which the following are a few examples (Levy, 1962).

A subject may for instance,

— agree to try it for a while,
— agree to try it as long as he can,
— assume that he will just plain "do it",
— eagerly enter into this interesting new experience,
— agree in order to humor the peculiar people who asked him.

In adopting a style of willingness it is as if the subject were to say, singly or in combination:

— I want to do this because . . . (any number of things could be inserted)

or,

— I don't want to do it, but I will because I must,
— I don't want to do it, but I will because I ought to,
— I don't want to do it, but I will because they want me to,
— I don't want to do it, but I will, to see if: (a) it will get me, (b) I can do it.

Also *group dynamics* including pressure towards conformity and pressure towards assumption of leadership may affect various subjects in different ways, providing either arousal or reassuring connotations (Back and Bogdonoff, 1963).

Group dynamics may further modify the psychophysiological response to an experimental stimulus by providing the subject with group support and group belonging, but may e.g. equally well lead to competition between group members.

The effects on the motivation, and, presumably, on the physiological reactions may be significantly different depending upon whether a subject is motivated by (a) intrinsic interest, (b) social incentive, (c) feedback about performance encouraging improvement, (d) monetary incentive, (e) importance, (f) social competitive incentive, (g) progressive piece-wage incentive, (h) threat of punishment, and (i) administration of punishment (Surwillo, 1958).

Factors like those mentioned above may influence not only attitudes, observable behaviour, and answers given in questionnaires and interviews, but also the physiological variables we are to measure in our subjects.

2.17 Defences, coping behaviour, cognitive factors

Various types of psychological defence and coping behaviour in response to an experimental situation constitute another research problem, because they are difficult to predict and still more difficult to estimate, and because they affect both psychological and physiological reactions (Lazarus et al., 1962; Lazarus, 1967 and 1971), complicating the evaluation of such data. As repeatedly pointed out by Lazarus, it probably makes a great difference whether the stressor is seen as something inevitable that we cannot do anything about or whether it is something for which direct action is possible in altering the environment-person relationship, e.g. by attack or avoidance or planning in some way to mitigate the disturbances. When the stressor is considered to be inevitable, the person engages in various "defences", including various means of changing his own perception. Even though there might be, objectively, a real threat, as in the case of exposure to actual combat (Bourne, 1969) or to fatal disease in their own children (Wolff et al., 1964), the subjects may deny the danger. When the threat is generated in a laboratory situation, the subject often realizes that he is in an experiment and that it is quite unlikely that the experimenter, in view of his ethical responsibility, would actually expose him to real danger.

The tendency to project a therapeutic meaning into the procedure has already been mentioned. Other subjects may treat the procedure as a joke, tell socially inappropriate stories and make pejorative or personal remarks about the experimenter, while others may be listless, and do not look at, respond to, comply with, or interact at all with the experimenter (Weiner, 1962). They may refuse to work with the task presented in the situation, stating "I have never worked such a problem" or "this is a silly thing to do". Some subjects intellectualize the situation, e.g. by working out the statistical probability of something really unpleasant or dangerous happening. Others try to cope actively with the situation, by concentrating on each move, keeping their attention on what they are doing, or seeking out additional information by scanning or by questioning the experimenter, developing expectant hypotheses or pleasing or placating the experimenter to gain support and reassurance (Oken, 1962; Rioch, 1971).

Cognitive factors affecting experimental results have also been discussed by Blatz (1925), Landis and Hunt (1932), Schachter and Singer (1962) and Frankenhaeuser et al. (1964). The same stimulus can be threatening or not depending upon the interpretation a person makes about its personal significance. Very often, the interpretation of the input is made in terms of the goal. The same psychophysiological reactions, e.g. increases in heart rate, can be interpreted by the subject in terms of anxiety, aggression or elation, depending in part on his own expectations and on his knowledge of the expectations of the experimenter or the behaviour of the group.

These interpretations are heavily influenced by cultural factors (cf. Mechanic, 1970). One man's meat is another man's poison—groups of different age, sex, social and cultural background differ widely in their definition of e.g. what is a stressor, a threat, an open-ended situation, distress, disease, etc.

2.18 Data from questionnaires and observations

Limitations of questionnaires and rating scales in the quantification of psychological reactions (cf. Winter et al., 1963) should also be mentioned in the present context. In some cases subjects are expected just to *classify* their feelings and experiences in nominal scales, e.g. whether or not they have reacted with anxiety, aggression, dejection, elation etc. For various reasons, including those mentioned in the previous paragraph, this may be rather difficult. Emotional states and reactions are usually not very simple or clearcut, more often constituting what has been called "affective territories". Many subjects report predominantly those emotional reactions which are most obvious and assumed by them to be expected by the experimenter (Azrin et al., 1961), whereas more subtle and above all "paradoxical" reactions tend to be forgotten, repressed or denied.

In *ordinal* scales the subject has to choose between alternative answers indicating the intensity of his reaction, such as "extreme" anxiety, depression etc., or "moderate" anxiety etc., or "no anxiety at all". The assumption that "extreme" is more than "moderate" probably holds true for each subject and during a rather limited period. But different individuals no doubt imply different amounts even when they use the same words to quantify their experiences and even a single individual may have difficulty in using the same frame of reference consistently to describe reactions that occur several weeks apart. Another drawback with such scales is that they yield data on an ordinal level only. We do not know whether the distance from "extreme" to "moderate" is the same as from e.g. "moderate" to "not at all", etc., as is the case in an *interval* scale.

The scaling methods mentioned above are *indirect* (Thurstone, 1927; Ekman, 1967), in contrast to the *direct* methods (cf. Stevens, 1957; Ekman, 1967) such as magnitude estimation. As pointed out by Björkman and Ekman (1962), the direct methods are based on the fundamental assumption that subjects are able to quantify their own experiences on a ratio scale. The use of such scales in psychophysiological research has been

urged by Ekman (1969). In the typical case the subject is told that by definition his experiences and reaction—say, his anxiety—in a certain situation have the value of, say, 100. He is then asked to rate any subsequent or previous experiences in per cent of this standard. If he feels twice the amount of anxiety, he is expected to report that he is "200 anxious". If he feels half the amount, his rating should be 50 etc.

The direct methods do furnish data that are more easy to translate into numerical symbols. On the other hand, they also probably demand greater sophistication from the subjects under study. For a comparison between results obtained by direct and indirect methods, see Ekman (1967), and for a comprehensive review of advantages and disadvantages with various rating scales, see Guilford (1959).

What has been said about "emotional" reactions also applies to the self-ratings of "physical" reactions, i.e. the subject's proprioceptive impulses. Some individuals, e.g. hypochondriacs, have high awareness of their autonomic activity, whereas the perception of this activity, its interpretation, and, consequently, the report of it, may be quite poor (or different) in other subjects, although the autonomic activity itself may be the same in both cases (cf. Mandler and Kremen, 1958).

Even more difficult is a proper interpretation of the intensity and the particular quality or type of emotion merely from observations of the subject in an experimental situation (Abercombie, 1964; Ackner, 1956).

2.19 Optimal design of psychophysiological studies

2.19.1 Some general considerations

A great many psychological and physiological sources of error have been described above. For obvious reasons, such a description can never be exhaustive. On the other hand, the inclusion of a factor in this compilation does not imply that it is necessarily of great practical importance in every psychoendocrine experiment, calling for specific standardization or control. In some cases the effects of several of these factors seem to be minor, in others possibly even non-existent. The result may very well be due to the signal-noise relationship, which may vary from experiment to experiment. True, it may be prudent to account for as many as possible of these sources of error but one should be equally aware of the risk of going too far in attempts to standardize the experimental conditions and to control extraneous factors, because the standardization and control procedures may themselves have psychoendocrine effects by introducing routines that may be highly artificial to the subject and, conversely, prohibit other routines, for which the subject has a high motivation. Thus, the question of standardization and control is tricky, and the rules and regulations outlined in this chapter should not be regarded as rigid but rather as a check list for the psychophysiological experimenter.

2.19.2 Some ethical considerations

When conducting research in the psychophysiological field, it is essential that the experimenter strictly adheres to the ethics of the medical profession. As regards clinical research, several sets of recommendations have been issued, the so-called Declaration of Helsinki (J. Clin. Invest. 46: 1140, 1967) being one of the most recent and most widely accepted. As regards subject groups like patients, children and prisoners, there is considerable controversy about the borderline between ethical and non-ethical research. On one central issue, however, all are agreed. The design must be acceptable from the purely scientific point of view. If it is not, research on and experimentation with human subjects are never justified (Freund, 1969); neither are they if the studies are conducted in a negligent manner.

Further problems arise if a human study or experiment is of scientific value but of no therapeutic benefit to the subjects involved. Some of these studies do not entail any discernible harm to the subject, while others involve pain and still others possible hazards to health and well-being. Here, a cost-benefit analysis must be made, balancing possible unpleasantness and risk against the knowledge gained, knowledge that may eventually benefit society and ultimately, perhaps, the subject himself (Blumgart, 1969).

Much psychophysiological research is conducted on so-called normal volunteers. It is usually recommended that the subjects should be informed in advance as fully as possible about "what they are letting themselves in for" in deciding to participate (Parsons, 1969). The term usually used in this context is "informed consent". However, as pointed out by this author, nobody in the system can ever be *fully* informed, except in the more trivial kinds of situation. "Full" information presupposes the preparation of a long and complex document, part of which would probably not be understood, in addition to increasing the burden on the subject and introducing undesirable effects on his motivation and attitudes. Therefore, in the end, the question of "informed consent" is, in part, a matter of mutual trust. Even so, one way to safeguard the individual should be to inform the subject of his freedom to resign his status as an experimental subject at any time or to use the threat of doing so as a source of leverage for the protection of his rights (Parsons, 1969).

The information given should provide the subject with a fair explanation of pertinent information concerning the procedure, and its possible risks and/or unpleasant aspects, taking into consideration the subject's well-being and ability to understand the nature, expected duration, and purpose of the investigation, the hazards involved and the likely benefits (Jaffe, 1969). One major protection of the subject comes from the review of protocols by peer and non-peer groups. If possible, the protocol should be approved by a properly organized ethical committee, if available.

In many studies, monetary remuneration is used to motivate the subjects to participate. Often such a remuneration substantially increases the possibilities to recruit healthy volunteers. This way of recruiting subjects has been criticized by some authors, but one may ask, with Lasagna (1969), whether such volunteering—provided it is not tantamount to coercion—is generically different from the case of the test pilot who takes certain risks in return for money, excitement, or both.

As emphasized by Moore (1969), experiments exist where there is no means of becoming informed other than through the experiment itself, even when there is a desire to give—or take—consent. The very fact that the procedure has not previously been carried out in man indicates that the scientist himself lacks at least some of the critical information required for "informed consent".

Moreover, one may question the necessity of informing potential subjects of *all* inconveniences in the study before they consent to participate. For one thing, it may be rather tricky to determine what an "inconvenience" is in a given case. For another, the inconveniences will be revealed anyhow, as the experiment proceeds. They will not remain a secret to the subject. If these inconveniences prove too great, the subject can protest and have them changed, or he can withdraw from the investigation (Curran, 1969).

Briefly, then, whenever possible, the subject should be accepted as a member of the research team, making him and the investigators colleagues in a joint enterprise.

2.19.3 Choice of subjects

Experimental and control groups should be chosen with great care. They should be random samples of the populations they are intended to represent. They should be instructed and informed in a uniform way, preferably both orally and in writing. In all cases where the experiments do involve unpleasurable sensations or medical risks, the subjects should be informed in proper detail about these aspects, and care should be taken to ensure they know what they have agreed to before consenting to participate in the study (informed consent), in general agreement with the Helsinki Declaration.

Attention must be paid to any possible additional differences between the experimental and control groups, other than the major variable under study, which might significantly affect the physiological or psychological parameters concerned (Pollin, 1962). Attitudes, motivation, cognitive factors, therapeutic implications, defences, and extraneous influences should be controlled, or at least recorded. Large consumers of tobacco or of caffeine-containing beverages should be avoided, inter alia because of the possible occurrence during the study of withdrawal symptoms. Whenever possible, the subjects should serve as their own controls, preferably in a cross-over design.

2.19.4 Procedure during control periods and prior to the experiment proper

Control conditions should promote relaxation and equanimity. The subjects should report at the laboratory well in advance of the experiment proper, in order to allow them to settle down, become attached to measurement devices etc. or exposed to venipunctures before the control period proper begins. In order to minimize apprehension and anticipatory anxiety, the subjects can be provided with weekly magazines, and soft music of moderate volume may be played, unless the subjects indicate that they dislike such music. The subjects should be conveniently seated. If the experiment is to take place in a hospital or in locations, where other activities are carried out, one should ensure that the subjects are prevented from seeing, hearing or generally being disturbed or influenced by such activities.

The subjects should be told well in advance to refrain from taking drugs (except in case of emergency), alcoholic and caffeine-containing beverages and tobacco. They should further be told to fast, or to eat standard meals at standard intervals, before reporting to the laboratory. The instructions should further comprise information concerning when to go to bed the night before the experiment, to avoid unusual physical and mental exertion and to report anything unusual in their reactions or anything clearly deviating from their daily routine. They should be encouraged to call the experimenter if anything is not clear of if they are in any doubt how to act.

If the subjects are sub-divided into several groups, one should make sure that the group dynamics, if any, are similar.

2.19.5 Some precautions relating to the experiment

Hour of day, physical climate, bodily posture, the amount and type of food and fluid, the intervals between the servings, the prohibition against walking around, smoking, coffee drinking etc., all should be strictly controlled.

Consideration should be paid to whether or not the subjects are to be familiarized with the control and/or experimental settings by introducing pre-experimental sessions.

In females, the position in the menstrual cycle, if any, should be registered. Minor disease processes like common colds, migraine attacks etc. should be asked about in the pre-experimental questionnaires. The subjects should be encouraged to report whether or not they have followed the instructions in all their details. After the end of the study, the subjects should be asked whether they have been disturbed by any extraneous influences, or whether anything worth mentioning has occurred in their reactions that had not been asked about in the questionnaires.

The urine or blood samples should be collected at pre-determined intervals and immediately treated (e.g. acidified and/or frozen) in such a way that breakdown of the compounds to be studied is avoided. The assays should be made in a random sequence and the laboratory personnel should not be informed whether the samples were from the control or the experimental periods.

Until they have completed the questionnaires, the subjects should not be allowed to communicate with each other. They should be provided with enough space to fill in their questionnaire without risk of being overlooked by their neighbours.

Subjects should be informed about the experimenter's professional secrecy.

In selected cases, subjects can be paid for participating in the study, in order to ensure maximal co-operation.

For further discussion of methodological issues, the reader is referred to e.g. Ingle (1958), Maxwell (1958), Witts (1964), Humphrey (1963), Sainsbury and Kreitman (1963) and Enger (1966). An excellent, comprehensive and stimulating guide to research methodology is to be found in Selye (1964).

2.20 General design of and methods used in the present studies

2.20.1 Some general considerations

Most of the rules presented in the above paragraph have been followed in the studies to be reported in the following chapters and in other ones carried out at our laboratory, unless stated otherwise, either below or in the particular chapter.

2.20.2 Experimental and control conditions

The first three studies to be reported (cf. Chapters 3—5) comprised an experimental period, preceded and followed by a control period of the same length. During the two control periods, the subjects were comfortably seated, listening to soft light music and being allowed to read weekly magazines, or else just doze. The control periods of the two studies involving films were spent in the room where the films were shown. In the study involving simulated industrial work, the control periods were spent in a rest room adjacent to the room in which the work was performed. The study reported in Chapter 6 was performed in the offices of the Swedish Board of Telecommunications and did not include any control periods. The long-term vigil (Chapter 7) started with a three-hour control period (spent in an adjacent rest room) followed by 24 experimental periods. In all studies, attempts were made to protect the subjects from noises, sights and other disturbing influences possibly to be encountered in the various environments. The physical climate was kept reasonably constant throughout the study. The subjects were not allowed to discuss their experiences until after completion of the questionnaires. They were not allowed to leave their seats or to walk around except when told to do so. Urine samples were obtained simultaneously, a private, numbered location being provided for each subject. During the control periods, everything was done to ensure a pleasant, relaxed and comfortable atmosphere. The subjects were instructed to leave for the laboratory in good time and to report there at least some 10-15 minutes before the start of the first control period, in order to avoid rush and hurry and to have time to settle down and to acquaint themselves with the prevailing environmental conditions. The subjects who had difficulty in getting to or from the laboratory by public transport were given taxi money. In all group studies, each of the subjects was given an individual number by which to identify himself in questionnaires, urine and blood samples etc., and enabling him to find the seat and the lavatory reserved for him.

At the beginning of each period, the subjects were served fluid and food at points of time and in amounts indicated in each report. The amounts of fluid were chosen to secure sufficient diuresis and to avoid thirst, and the amounts of food to avoid hunger but also surfeit. In this way the level of food and fluid intake was controlled throughout each experiment.

In the simulated industrial work study (Chapter 5), however, no food was served, because the study comprised parameters easily influenced by food.

Prior to each study save the last-mentioned one, the subjects were told to eat and drink at predetermined intervals and in predetermined amounts, to abstain from drugs and from alcoholic beverages from the morning before the study and caffeine-containing beverages and tobacco from bedtime on the previous night. They were told to go to bed on the evening of the preexperimental day early enough to secure a good night's sleep, and to avoid on the preexperimental day, whenever possible, physical or mental exertion.

2.20.3 Ethical aspects

Before consenting to participate, the subjects were thoroughly informed about the aim of the study, the procedure and measurements involved, the timetable to be followed, and the necessary precautions to be taken. This information was given orally as well as in writing. The subjects were given a fair chance to ask for additional information and were completely free not to participate, or, alternatively, to withdraw from the study at any time.

Accordingly, an attempt was made to comply with the rules put forward in the Declaration of Helsinki. After the foundation of an Ethical Committee at the Karolinska institute, all studies considered to imply potentially unpleasant reactions or potential risks to the subjects were cleared with this Committee.

2.20.4 Selection of subjects

In all studies but one (cf. Chapter 5), the subjects were so-called normal, healthy volunteers, who received a comparatively modest sum as compensation and as an additional incentive for their participation.

Needless to say, and for reasons given in paragraphs 2.15 and 2.19.2, our groups did not constitute random samples from the general, healthy, adult population of Sweden. On the other hand, within the limits posed by ethical considerations, attempts were made to avoid as far as possible an overrepresentation of the extremes from the normal distribution curve in various respects.

For the film study reported in Chapter 3, the subjects were recruited by personal invitation from a population of office clerks known to the experimenter. The subjects of the piece-wage study (Chapter 6) constituted the entire invoicing unit of the Swedish Board of Telecommunications. With a few isolated exceptions, all those approached agreed to participate.

In contrast, the subjects for the sex film study (Chapter 4) no doubt form a biased sample from several points of view, as reported and discussed in Chapter 4. In view of the type of stimuli to which they were to be exposed, this was considered unavoidable for ethical reasons.

Similarly, the subjects for the long-term vigil did not constitute random samples from the population of officers and soldiers. Because of the anticipated unpleasantness and even some conceivable risks implied in the exposure, only subjects considered to be in good physical and mental health were selected. The bias of this selection was probably further enhanced by the information given to the population approached, namely that only those who knew that they were in good health were to be selected for the study proper.

The subjects of the study reported in Chapter 5 differred from those of the other studies in one essential aspect, namely that they were outpatients of the medical department at the Karolinska hospital. All had been referred for examination because of suspected cardial abnormalities but no such abnormalities had been found in any case. These subjects were motivated primarily by the possibility of learning about their physiological reactions to psychosocial stimuli. They received no remuneration apart from this information. The examination routine which they had undergone before participating in this study had probably to some extent habituated them to the conditions of measurement to be used. This was why it was considered to be an advantage to use this type of subjects and not a sample of the usual population of "normal healthy volunteers".

2.20.5 Selection of stimuli

The specific reasons for selecting the various stimuli will be presented and discussed in each chapter. In general, an attempt was made to use short-term as well as long-term stimuli, stimuli usually evoking predominantly pleasant and predominantly unpleasant emotional reactions, specific and non-specific stimuli and stimuli characteristic of laboratory situations and of "real life".

2.20.6 Selection of variables

The reasons for selecting urinary catecholamine excretion as one of the main variables of the studies to be presented have been given in paragraphs 1.7.5 and 2.14. The choice of additional variables will be commented in each chapter.

2.20.7 Methods of measurement

2.20.7.1 Some general considerations

In order to permit comparisons between the results of the studies to be presented in the following five chapters, attempts have been made to use similar or identical research strategies and methods of measurement. It must be remembered, however, that these studies were carried out over a period of four years, during which time the ex-

Have you felt expectant during the first rest period?

☐ very expectant (6 points)
☐ rather expectant (5 points)
☐ not that much expectant (4 points)
☐ rather little expectant (3 points)
☐ very little expectant (2 points)
☐ not at all expectant (1 point)

How have you felt during the first rest period?

	extremely		very		rather		somewhat		slightly		not at all
Pleasurable sensations	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Unpleasant sensations	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
General emotional arousal	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 2:1. General lay-out of rating scales used in the studies presented in Chapters 3—7. The 4, 5 and 6 point scales furnish data primarily on the ordinal level. The lay-out of the 11-point scales borders to that of an interval scale.

perimenters could not avoid making use of experience gained from their own work and from that reported by others. This helps to explain why the studies nevertheless differ in design and methods of measurement, in spite of the desirability of keeping these aspects constant.

2.20.7.2 Rating scales

The earlier studies (Chapters 3—6) all made use of indirect methods of measurement, cf. paragraph 2.18 above. The simple ordinal scales had either 4, 5, 6 or 11 points.

The 4-point scales ranged from "not at all" anxious, etc. (= 1 point) to "very" (= 4 points), over "slightly" (= 2 points) and "fairly" (= 3 points).

The 5-point scale used in Chapter 5 ranged from "the most unpleasant experience I ever had" (= 5 points), over "very pressing and unpleasant" (= 4 points), "rather pressing and unpleasant" (= 3 points), to "it did not bother me on the whole" (= 1 point).

The 6-point scales ranged from "not at all" (= 1 point) to "great" anxiety, etc. (= 6 points), the intermediary points being denoted "very little" (= 2 points), "fairly little" (= 3 points), "not all that much" (= 4 points), and "moderate" (= 5 points).

In the 11-point scales ranging between "not at all" (= 1 point) to "extremely" (= 11 points), intermediary points were denoted "slightly" (= 3 points), "somewhat" (= 5 points), "rather" (= 7 (points), and "very" (= 9 points).

Examples of how these scales were actually presented are given in figure 2:1. Although these scales are primarily ordinal, at least the 11-point variety comes rather close to the characteristics of a graphic interval scale.

The reason for successively increasing the number of steps in these scales from 4 and 6 to 11 was the initially rather small dispersion of the answers over the various steps.

Much criticism can be levelled against the use of such scales (cf. paragraph 2.18). The variables are poorly defined. The ordinal scales are not equidistant, and a particular score may have rather different meanings to different individuals. On the other hand, as already pointed out, these scales were used solely for the very limited purpose of ordinal or semi-quantitative assessments. Thanks to their simplicity, they were probably readily understood by the subjects. According to some reports such rather crude ratings may sometimes even be superior to formalized assessments in well-defined variables (cf. discussion in Cronholm, 1969).

Thus, it was hoped that the scales would serve to check whether or not a stimulus had evoked any psychological response in a subject or a group of subjects, and whether any such response was predominantly of a type usually described as

Table 2:1. Analyses of 32 duplicate urine samples for adrenaline and noradrenaline.

	Adrenaline ng/min	Noradrenaline ng/min
Range	1.00—36.28	4.23—103.6
Mean difference	0.96	1.98
Standard deviation for mean difference	0.72	2.16
Mean per cent deviation	16.11	7.95

pleasant or unpleasant. Clearly, the scales were not primarily intended for the study of psychophysiological *relationships*.

On the other hand, the more recent study, reported in Chapter 7 made use of a direct method, namely magnitude estimation (cf. paragraph 2.18), with the intention of studying such relationships. The sensitivity and reliability of the ordinal scales were not examined; probably they are rather crude. In these respects, the magnitude estimations were probably more satisfactory. For one thing, they were found to demonstrate a marked circadian rhythm in some of the variables. Had their sensitivity and reliability been very low, this would probably not have been the case.

Briefly, then, although the ordinal rating scales used are open to much criticism, they were introduced with the rather restricted aim of demonstrating whether or not psychological reactions had been induced, the accompanying physiological phenomena of which we wanted to study. In addition to this information on a nominal level, they furnish ordinal data, in some cases even bordering to semiquantitative ones. Even so, these data are not collected for the study of psychophysiological *relationships*. Only one of the studies (Chapter 7) was designed primarily to assess such relationships. In this study, direct measurement methods were used, namely magnitude estimations.

2.20.7.3 Physiological methods

In all the studies, the assay of free adrenaline and noradrenaline has been performed in accordance with the fluorimetric method described by Euler and Lishajko (1959, as modified 1961). In consultation with these authors, it was decided that the pH of the filtered urine sample should be adjusted to 8.3 (the original paper mentions 8.2—8.5) and that of the eluate to pH 6.3 (the authors propose 6.2—6.3).

In general, if in the hands of experienced and well-trained laboratory assistants, this method has been found to function very satisfactorily. The reliability of the assays as performed by us is illustrated in table 2:1 and in figures 2:2—3. The recovery of added catecholamines was similar to that reported by Euler and Lishajko (1959).

In view of the very considerable number of samples to be analyzed, attempts have recently been made at our laboratory to semiautomatize the analytic procedure (Andersson et al., 1972). However, all catecholamine data presented in this volume have been obtained by the manual method mentioned above.

Before the urine samples were acidified and deep-frozen aliquotes were separated for creatinine analysis, which was performed according to Lieb and Zacherl (1934) in the first of our five studies (reported in Chapter 6) and in all other studies according to the AutoAnalyzer method described by Chasson et al. (1965).

As mentioned above, several of the studies comprised the assay of other variables as well. The methods used will be reported in the chapter concerned.

2.20.7.4 Statistical methods

The main class of problems under study relates to the human organism's reactions, if any, to various psychosocial stimuli. As mentioned in the introduction, we are concerned here chiefly with differences in reactions to sets of psychosocial stimuli. To analyze such differences, the t-test

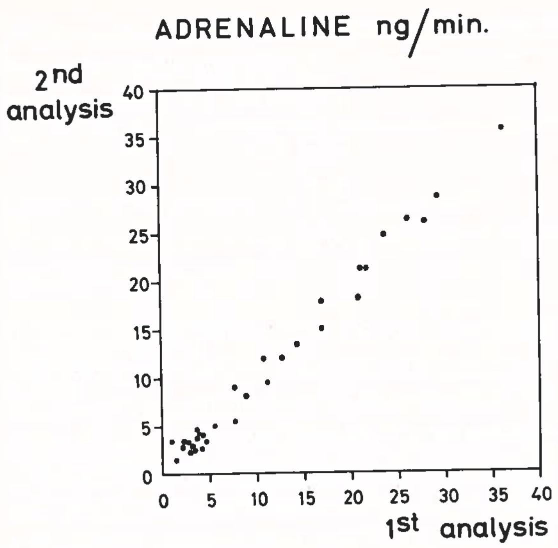

Figure 2:2. Relationship between analyses of urinary adrenaline in duplicate samples at various excretion levels, obtained by the fluorimetric method of Euler and Lishajko (1961).

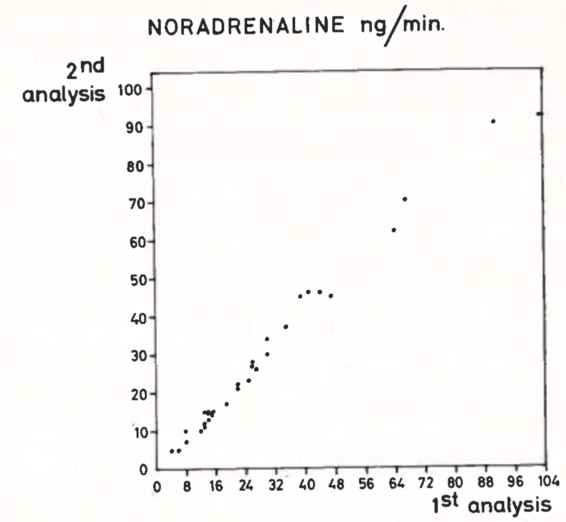

Figure 2:3. Relationship between analyses of urinary noradrenaline in duplicate samples at various excretion levels, obtained by the fluorimetric method of Euler and Lishajko (1961).

(two-tailed) has been used throughout the studies to be presented, partly because it is simple and comprehensible. Each difference to be tested as to reactions to experimental stimuli was calculated separately for each individual; the mean of these differences was then calculated and its significance tested by the t-test, using the variation between individuals for estimation of the error.

The study presented in Chapter 6 was designed as a factorial experiment with the factors (a) salary versus piece-wages, (b) first versus second day of presentation of each mode of remuneration, and (c) morning versus afternoon. Five differences of special interest were calculated as described above.

The correlation coefficients presented are product-moment correlations. These calculations and those of the t-test and chi-square test were carried out in accordance with standard procedure (Snedecor and Cochran, 1967). The variables under study do not display a strictly normal distribution in each case. However, as pointed out by Ferguson (1966), empirical evidence suggests that even for quite small samples, say, of the order of 5 or 10, reasonably large departures from normality will not seriously affect the estimation of probabilities for a two-tailed t-test.

As mentioned above (pp. 44—45), ordinal scales have been used in most of the studies for the assessment of subjective reactions. For ordinal data, non-parametric statistical tests (order statistics or ranking statistics) have been recommended (cf. Siegel, 1956). On the other hand, as pointed out in the presentation of the scales used, at least some of our ordinal scales have the characteristics of graphic *interval* scales, for which parametric statistical tests, like the t-test, are considered to be most efficient.

In addition, proponents of the so-called measurement-independent position (cf. Burke, 1964) hold that choosing a distribution-free test involves difficult statistical problems, the tests being distribution-free only when the hypotheses being tested are true, and that adherence to the measurement-independent position leads to greater statistical efficiency. Against this background, and in order to permit a uniform statistical presentation of all types of data from all studies, we chose to treat data from rating scales in the same way as data obtained from magnitude estimations and

physiological measurements, and to use parametric tests (t-test and product-moment correlation) throughout.

Throughout this book *, **, and *** indicate that $p \leqslant 0.05$, 0.01, and 0.001, respectively.

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2.22 References

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3 SYMPATHOADRENOMEDULLARY RESPONSES TO "PLEASANT" AND "UNPLEASANT" PSYCHOSOCIAL STIMULI

By Lennart Levi

3.1 The problem

According to Selye, "stress" may be defined as the generality of the organism's reaction to *all* types of environmental stimuli.

Until recently, however, the psychosomatic literature has regarded disease-provoking physiological stress reactions — "stress (Selye)" — almost exclusively as concomitants of conflict, dissatisfaction and frustration, i.e. generally of *unpleasant* emotional experiences (distress).

Against this background, we should like to introduce the hypothesis that the phylogenetically old, stereotyped reaction pattern called "stress (Selye)", inter alia presumably reflected in the urinary catecholamine excretion, may be induced not only in response to stimuli usually evoking distress but *also* in response to psychosocial stimuli generally classified as "pleasant", e.g. those evoking pleasant excitement and enthusiasm (Figure 1:2).

It seems reasonable to assume that life changes of a pleasant character *also* confront the human organism with the necessity to adapt, and that the organism reacts to this with the same old preparation for increased physical activity that has been described to occur when facing conditions requiring fight or flight, i.e. with "stress (Selye)". Should this be so, "stress (Selye)" can also be induced in response to e.g. promotion, wage increase, success, praise, etc.

This hypothesis finds some support from the recent demonstration by Holmes, Rahe and others (for review, see Rahe, 1968, 1969 a and b, 1972) that the greater the degree of change in a subject's life during a certain period of time, the higher is his risk of undergoing a significant decrease in health status. The life changes mentioned by these authors include some that are usually classified as pleasant, like engagement, marriage, gain of a new family member, personal success etc.

True, no distinct dichotomy can always be made between "pleasant" and "unpleasant" life *events*. The psychological reaction to *both* types of events may often be characterized by considerable ambivalence. However, although many borderline and mixed cases exist, it is probably feasible to predict with considerable certainty the classification in these terms of a large number of life events in a large number of people. For example, although it is conceivable that bereavement may evoke joy and marriage may evoke distress and sorrow, no one would deny that the reverse is probably considerably more frequent.

Similarly, it may sometimes be rather difficult to categorize psychological *reactions* into "pleasant" and "unpleasant". As emphasized by Freud and other authors (for review, see Bergler, 1956), laughter for instance may comprise considerable elements of conscious or subconscious aggression and/or anxiety. But even in such cases most of us are usually able to report whether the *predominant* quality of our psychological reaction is pleasant or not. In the present context, we shall focus on emotional reactions not in the sense of their hypothetical underlying variable but on the subjects' qualitative (and sometimes also quantitative) *report* of their reactions.

Our second hypothesis in the present context is that stimuli evoking a decrease in the intensity of emotional reactions, whatever their quality, also evoke a decrease in catecholamine excretion.

3.2 Choice of methodology

As already pointed out, *real-life settings* no doubt often induce predominantly pleasant, or unpleasant, subjective reactions and accordingly, the physiological concomitants of these reactions. On the other hand, these settings are almost invariably very complex and often defy physiological and psychological measurement.

In a *laboratory setting,* the study of psychological and physiological reactions and psychophysiological interrelations is considerably easier, partly because of the greater ease in standardizing measurements, controlling extraneous factors, and eliciting more "pure" emotional reactions, in subjects with well-trained ability for introspection. On the other hand, the relevance of such data has been questioned with respect to their applicability to "real life" on the grounds that the setting in which they have been collected tends to be artificial.

Our first problem therefore was to arrive at a type of stimulus that combines the advantages of "purity" and specificity with those of reproducibility, potency and realism. According to the literature, showing various types of films provides these advantages in the experimental induction of emotional reactions in man (Dale, 1935; Mirams, 1951; Bouman, 1954; Ås, 1958; Lazarus and Opton, 1965).

Globus and Shulman (1963) call attention to certain formal characteristics of the film stimulus situation. The film provides a partially structured visual and auditory stimulus which captures major sensory avenues. The darkness, immobility, relative lack of distractions, and isolation from objective reality-oriented interpersonal events all facilitate the provocation of affective arousal. Motion pictures as experimental psychosocial stimuli have the advantages of being standard, largely repeatable, analyzable, and manipulatable, are available in many varieties and reproduce effectively natural life conditions, the very "flow of life". These were considered powerful arguments for the choice of motion pictures as stimuli in the present context.

Our second problem, discussed in some detail in Chapter 2, was to choose a physiological variable which might be assumed to be closely related to emotional processes and to "stress (Selye)" but which at the same time would be easy to measure in a non-interfering way.

As emphasized in the previous chapters, the excretion of urinary catecholamines, as an index of sympathoadrenomedullary activity and an estimate of "stress (Selye)", offers several advantages: (a) the collection of urine from a certain period of time is a very non-interfering procedure, (b) the catecholamine output during a given period provides an *integrated* measure of the sympathoadrenomedullary activity during this period, and (c) this variable is less complex and more "basic" than, say, heart rate or blood pressure. On the other hand, no information was available as to whether a film show of 1—2 hours would induce sympathoadrenomedullary reactions that were sufficiently strong and persistent to be accompanied by measureable changes in catecholamine excretion. Therefore, a logical first step was to find out whether or not the urinary catecholamine excretion was at all influenced by viewing films.

This was accomplished in a study (Euler et al., 1959) in which 10 medical students were shown a 1-hour film program comprising scenes from fictional and documentary moving pictures depicting the various forms of violence usually encountered in such contexts. This program was found to induce, in addition to increased self-reported emotional arousal, a statistically significant increase of adrenaline and noradrenaline excretion, by 70 and 35 per cent respectively. An increase in adrenaline excretion of the same magnitude was also found in a similarly designed, subsequent study, in which a group of soldiers was exposed to a 2-hour film program (Levi, 1963). Accordingly, the type of stimulus used, namely watching film programs, was found to be effective in eliciting not only an emotional, cardiovascular and neuromuscular response as demonstrated by other authors (for review, see Levi, 1967), but an increased excretion of free catecholamines as well. Following this demonstration, it was decided to use film programs to study the hypotheses mentioned above. A preliminary account of this study that was conducted in 1963, has been published (Levi, 1965).

3.3 Choice of film stimuli

When selecting the films for this study, the author was looking for specimens that would fit the following criteria: (a) each program should be of about 90 minutes, (b) it should be of good filmatic quality, and (c) *one* program should serve as a "control", being as pastoral and "calm" as possible, offering no more than a modicum of entertainment, and the *other* three programs should, in contrast, be of a type which presumably induces rather pronounced emotional arousal, although each of a different quality.

These objectives were accomplished by perusing lists of current films for hire from several leading film distributors. This perusal was performed in close cooperation with the staff of these companies and with one of Sweden's most experienced professional film critics, Mr. Gunnar Oldin. The films deemed worthy of consideration were subsequently viewed and a final decision arrived at. The films selected for the four evenings are described in the following.

The choice for the *first* evening of the experiment was a composite program of four bland natural-scenery films, produced by the Swedish National Railway Company and depicting beautiful pastoral scenes mainly from four Swedish provinces (Dalsland, Medelpad, Scania and Dalecarlia). All films had a sound track with a speaker commenting on the beauty etc. of the provinces in question to the accompanyment of film music. This program was intended to be a "neutral" stimulus (as concerns emotion-arousing). The reason for starting the series with this program was that the subjects in spite of our attempts to minimize such effects, could conceivably be somewhat more tense and anticipative on the first evening of the study than on subsequent evenings. Thus, this order of presentation works against the hypothesis that there would be more pronounced reactions to the "arousing" films than to the relatively neutral "control" films. Although a rotated design would have furnished some advantages, it was considered unfeasible for practical reasons.

A further reason for including it in our study was that some or all of our subjects could be expected to react primarily to the "cinematographic situation" per se, and not to the "emotional quality" of the various film stimuli.

The film selected to be shown on the *second* evening was Stanley Kubrick's "Paths of Glory", considered to be agitating and anger-provoking. A French infantry regiment near the end of the first world war is ordered on an almost impossible mission. When the mission breaks down, the entire regiment is accused of cowardice in combat. As a lesson to the other soldiers, three men are arbitrarily picked and courtmartialled. Following a most unjust trial, a judicial murder is committed, the three men being executed by a firing squad.

The program for the *third* evening was a comedy, "Charley's Aunt", directed by Hans Quest and considered to be charming and very amusing. The Oxford students Charley and Jack are expecting a visit by Charley's aunt, Donna Lucia. Two beautiful girls, Amy and Katty, have accepted their invitation for lunch provided that Charley's aunt is present as chaperon. However, Donna Lucia cables that she will be late. In order to save the lunch, Charley and Jack persuade a perpetual student, Lord Babberly, to dress up as Donna Lucia. Following a variety of complications, the real Donna Lucia appears and reveals the plot. However, all ends well: Jack and Charley become engaged to the girls, as does Donna Lucia to Lord Babberly.

The film for the *fourth* evening was Mario Bava's gruesome ghost story "The Mask of Satan", based on a novel by Gogol. In the 17th century a witch is burnt but her cremation is incomplete. Due to this, when—200 years later—two physicians come to the castle where she lies buried, she rises from the dead, and transforms the older of the physicians into a werwolf. Together they ravage the castle, occasionally drinking the blood of its inhabitants, thereby transforming them into vampires and distorted monsters. The chief target for their persecution is a lovely young girl who is relentlessly hunted and, in the end, falls victim to the blood-sucking activities mentioned above. However, the younger physician, by a combination of witchcraft and muscular strength, succeeds in conquering the monsters, and the witch is burnt again, this time resulting in a complete cremation.—In spite of this somewhat trashy plot, the film has been considered by film critics to contain obvious artistic qualities and to be a beautiful and quite effective hair-raiser.

Briefly, then, the four film programs were hypothesized to differ from each other in the following respects: (a) the first program was hypothesized to be considerably less arousing than the control periods preceding and following the program, by virtue of equanamity-inducing and attention-distracting qualities, (c) the last three programs were hypothesized to be more arousing than the control periods preceding and following each film, and (d) the comedy was hypothesized to induce emotional reactions of a pleasant type rather different from those possibly evoked by the hair-raiser and by the war film.

3.4 Material and methods

The 20 subjects participating in this study were all female office clerks (age range 17—55, mean 26 years). All were clinically in good health, physically and mentally, as judged from interviews and questionnaire returns. An attempt was made to choose subjects who in one way or another were somewhat familiar with this type of study, in order to avoid reactions due to the novelty of the entire experimental setting: 14 of those chosen for this study had participated in other psychophysiological studies performed by our laboratory (Levi, 1964, 1967). Four were their work-mates, and the remaining two belonged to the clerical staff of the Department of Medicine of Karolinska hospital and, hence, were rather well informed about the experimenters and the general outlines of their studies. All who were approached by the experimenters consented to participate in this study, being motivated partly by interest and curiosity, partly by being paid the equivalent of $16 for their participation.

They were explicitly informed that the aim of this study was to investigate how different types of film programs affect the individual urinary excretion of adrenaline and noradrenaline. During four consecutive evenings, four different film programs would be shown that had been selected from the ordinary story film repertoire. The programs would *not* include any films prohibited by the Film Censor Board, only ordinary movies of good quality. This detailed information was also given with the intention further to reduce any apprehension concerning the experimental setting per se. Thus, every subject knew in detail all objectives and routines of the study save one, namely the specific films or even types of film that would be shown (cf. Bringmann, 1966). In this way, the subjects were made maximally cooperative, and all routines ran smoothly and essentially as planned by the experimenter.

The study was performed on four consecutive evenings (Tuesday through Friday). The subjects were instructed not to take any drugs or alcoholic beverages whatsoever from the day before the start of the study (i.e. from Monday morning) until its end. As concerns the four experimental days, the subjects were instructed not to smoke between 10.00 a.m. and 10.45 p.m., to eat lunch as usual approximately at noon and then not to eat anything except the food served in the laboratory.

They were further asked not to drink anything after lunch save two glasses (approximately 300 ml) of tap water at 4.00 p.m., to void as completely as possible at approximately the same hour, and to report at the laboratory at 5.20 p.m., the experiment proper starting at 5.30 p.m. At 5.30 p.m., the subjects were instructed to empty their bladders as completely as possible, again to drink 300 ml of tap water and to eat two sandwiches that were served to them. This procedure was repeated at 7.10 p.m. and 8.50 p.m.

The urine samples produced on the last two occasions and at 10.30 p.m. were collected for analysis. Accordingly, the urine samples were collected at the end of three consecutive 100-minute periods, one preceding the film show (*control period A*, 5.30—7.10 p.m.), one comprising the 90-minute film program (*film period B*, 7.10—8.50 p.m.), and one after the performance (*control period C*, 8.50—10.30 p.m.).

As mentioned in paragraph 2.7 (page 31), psychological and physiological variables are known

Table 3:1 A. Means ± S.E.M. and changes in self-rated psychological variables before, during and after four different film programs shown on four consecutive evenings (day 1: neutral film, bland natural-sceneries; day 2: the war film "Paths of Glory"; day 3: the comedy "Charley's Aunt"; day 4: the hair-raiser "The Mask of Satan"). Number of subjects as indicated in left column. The ratings were made on six-point scales ranging between "very" (6 points) and "not at all" (1 point). *A* stands for the period 0—100 minutes; *B*, 101—200 minutes; and *C*, 201—300 minutes.

Day No.	Period	Expectant	Engaged and carried away	Frightened	Uneasy	Agitated
1	A	2.50±0.37	2.15±0.35	1.00±0.00	1.26±0.20	1.00±0.00
	B	2.05±0.34	2.15±0.37	1.00±0.00	2.15±0.40	1.15±0.00
N = 20	C	1.60±0.24	1.45±0.22	1.00±0.00	2.10±0.35	1.00±0.00
	$B-\frac{A+C}{2}$	0.00^{ns}	0.35^{ns}	0.00^{ns}	0.47^{ns}	0.15^{ns}
	A−C	0.90*	0.70*	0.00^{ns}	−0.84^{ns}	0.00^{ns}
2	A	2.05±0.34	1.90±0.33	1.00±0.00	1.05±0.05	1.00±0.00
	B	4.84±0.31	5.00±0.36	2.80±0.45	3.21±0.44	4.80±0.29
N = 20	C	1.30±0.16	1.85±0.32	1.10±0.10	1.35±0.22	1.30±0.16
	$B-\frac{A+C}{2}$	3.17***	3.13***	1.75***	2.01***	3.65***
	A−C	0.75*	0.05^{ns}	−0.10^{ns}	−0.30^{ns}	−0.30^{ns}
3	A	2.60±0.39	1.95±0.37	1.00±0.00	1.10±0.07	1.00±0.00
N = 20	B	4.75±0.33	5.85±0.11	1.00±0.00	1.00±0.00	1.00±0.00
	C	1.45±0.22	2.20±0.38	1.00±0.00	1.05±0.05	1.00±0.00
	$B-\frac{A+C}{2}$	2.72***	3.77***	0.00^{ns}	−0.07^{ns}	0.00^{ns}
	A−C	1.15**	−0.25^{ns}	0.00^{ns}	0.05^{ns}	0.00^{ns}
4	A	2.58±0.40	2.47±0.39	1.00±0.00	1.21±0.21	1.00±0.00
	B	4.84±0.41	5.32±0.24	5.00±0.37	4.58±0.45	4.47±0.37
N = 19	C	1.33±0.19	2.22±0.36	1.84±0.34	1.72±0.30	1.61±0.29
	$B-\frac{A+C}{2}$	2.89***	2.97***	3.58***	3.111***	3.17***
	A−C	1.25**	0.25^{ns}	−0.84*	−0.51^{ns}	−0.61*

to exhibit a circadian rhythm. Keeping this in mind, we choose the measure

$$B - \frac{A+C}{2}$$

for the study of the effects of the films shown, because there was reason to expect e.g. adrenaline excretion to exhibit a circadian decrease and fatigue ratings to increase between the first and the second control period. If this change is reasonably linear, the measure mentioned above represents the effect of the experimental stimuli used during the film period. Furthermore, the random error of the mean of (A) and (C) is smaller than for either of them taken separately. For this procedure to be fully effective, the three periods should be pure, clear cut and characterized by control and experimental conditions, respectively. As mentioned above, attempts were made to attain precisely such conditions. On day 4, N = 19 because one of the subjects failed to come due to headache.

During all four evenings, all details in the experimental setting were strictly standardized, including instructions, stimuli, posture, time scheme, food, fluid intake, and urine collection, in accordance with the rules outlined in Chapter 2. No communication was allowed between the subjects during the film show or in connection with the completion of the questionnaires.

The design of the 6-point scales used in this study is shown in figure 2:1. Within this framework, the subjects were asked whether they had felt expectant (förväntansfull), engaged and carried away (engagerad och medryckt), frightened (uppskrämd), uneasy (orolig), agitated (upprörd), aggressive and angry (agressiv och arg), despondent (nedstämd), amused, happy and cheerful

Table 3:1 B. Means±S.E.M. and changes in self-rated psychological variables before, during and after four different film programs shown on four consecutive evenings (day 1: neutral film, bland natural-sceneries; day 2: the war film "Paths of Glory"; day 3: the comedy "Charley's Aunt"; day 4: the hair-raiser "The Mask of Satan"). Number of subjects as indicated in left column. The ratings were made on six-point scales ranging between "very" (6 points) and "not at all" (1 point). *A* stands for the period 0—100 minutes; *B*, 101—200 minutes; and *C*, 210—300 minutes.

Day No.	Period	Aggressive and angry	Despondent	Amused, happy and cheerful	Laughing	Bored	Tired
1	A	1.00±0.00	1.20±0.20	3.30±0.40	3.50±0.18	1.20±0.16	2.10±0.32
	B	1.00±0.00	1.20±0.12	3.55±0.34	2.95±0.29	2.55±0.35	3.75±0.42
N = 20	C	1.00±0.00	1.35±0.18	2.90±0.33	3.10±0.28	2.15±0.26	4.80±0.30
	$B-\frac{A+C}{2}$	0.00^{ns}	-0.07^{ns}	0.45^{ns}	-0.35^{ns}	0.88*	0.30^{ns}
	A−C	0.00^{ns}	-0.15^{ns}	0.40^{ns}	0.40^{ns}	−0.95***	−2.70***
2	A	1.00±0.00	1,05±0.05	2.95±0.29	2.45±0.23	1.40±0.18	2.20±0.34
	B	2.95±0.44	4.00±0.42	1.40±0.27	1.15±0.08	1.05±0.05	1.55±0.26
N = 20	C	1.16±0.11	1.50±0.21	2.95±0.29	2.75±0.24	1.30±0.18	3.90±0.35
	$B-\frac{A+C}{2}$	1.87***	2.72***	−1.55***	−1.45***	-0.30^{ns}	−1.50***
	A−C	-0.16^{ns}	−0.45*	0.00^{ns}	-0.30^{ns}	0.10^{ns}	−1.70***
3	A	1.00±0.00	1.20±0.12	3.05±0.34	2.15±0.20	1.45±0.18	2.50±0.34
	B	1.00±0.00	1.00±0.00	5.95±0.05	5.70±0.13	1.00±0.00	1.20±0.16
N = 20	C	1.00±0.00	1.15±0.11	3.45±0.31	3.53±0.22	1.45±0.18	4.26±0.34
	$B-\frac{A+C}{2}$	0.00^{ns}	-0.17^{ns}	2.70***	2.86***	−0.45**	−2.18***
	A−C	0.00^{ns}	0.05^{ns}	-0.40^{ns}	−1.38***	0.00^{ns}	−1.76***
4	A	1.00±0.00	1.26±0.18	3.21±0.34	2.63±0.23	1.32±0.22	2.11±0.34
	B	1.56±0.27	2.53±0.44	1.42±0.30	1.00±0.00	1.16±0.16	1.11±0.11
N = 19	C	1.00±0.00	1.28±0.18	2.61±0.29	2.84±0.23	1.56±0.29	3.42±0.41
	$B-\frac{A+C}{2}$	0.56^{ns}	1.26*	−1.49***	−1.74***	-0.28^{ns}	−1.66***
	A−C	0.00^{ns}	-0.01^{ns}	0.60^{ns}	-0.21^{ns}	-0.24^{ns}	−1.32**

(road, glad och munter), whether they had laughed (skrattat), and whether they had felt bored (uttråkad) and tired (trött). These ratings were performed with respect to the first rest period, the film period and the second rest period.

3.5 Results

3.5.1 Psychological variables

3.5.1.1 Expectancy and engagement

Self-rated expectancy and engagement both exhibited significant increases during all three story films but not during the natural-scenery program (cf. table 3:1 A). Expectancy ratings decreased significantly from control period A to control period C, as did the engagement ratings of the first evening but not of the subsequent evenings.

3.5.1.2 Fright, uneasiness; agitation

The mean questionnaire "fright" scores increased significantly during "Paths of Glory" and "The Mask of Satan" but did not change significantly during the other two film programs. This also applied to self-rated "uneasiness" and "agitation" scores. No changes occurred between the two control periods during any of the evenings for any of these variables save a small but significant increase in "fright" and "agitation" during the fourth evening, cf. table 3:1 A.

3.5.1.3 Aggression and despondence

"Aggression" rates increased significantly during "Paths of Glory" only, cf. table 3:1 B. During this film but also during "The Mask of Satan" there was an increase in "despondence" ratings.

Table 3:2. Means±S.E.M. and changes in urinary adrenaline, noradrenaline, creatinine, urine volume and specific gravity before, during and after four different film programs shown on four consecutive evenings (day 1: neutral film, bland natural-sceneries; day 2: the war film "Paths of Glory"; day 3: the comedy "Charley's Aunt"; day 4: the hair-raiser "The Mask of Satan"). Number of subjects as indicated in left column. *A* stands for the period 0—100 minutes; *B*, 101—200 minutes; and *C*, 201—300 minutes.

Day No.	Period	Adrenaline ng/min	Noradrenaline ng/min	Creatinine mg/min	Urine volume ml/min	Spec. gravity (N−1)×1000.
1	A	5.89±0.97	14.83±1.95	0.90±0.06	2.43±0.25	8.68±0.79
N = 20	B	2.82±0.29	10.83±1.01	0.89±0.05	3.07±0.10	4.75±0.25
	C	3.88±0.45	13.47±1.48	1.00±0.06	2.30±0.10	7.05±0.35
	$B-\frac{A+C}{2}$	−2.06***	−3.32*	-0.05^{ns}	0.71***	−3.12***
	A−C	2.01*	1.36^{ns}	-0.10^{ns}	0.13^{ns}	1.63*
2	A	6.07±0.49	15.21±1.23	0.89±0.07	2.81±0.26	9.35±1.39
N = 20	B	7.60±0.78	16.42±1.31	1.01±0.06	4.38±0.29	4.75±0.40
	C	4.49±0.53	16.59±1.36	0.88±0.06	1.87±0.17	9.80±0.78
	$B-\frac{A+C}{2}$	2.32**	0.52^{ns}	0.13^{ns}	2.04***	−4.82***
	A−C	1.58*	-1.38^{ns}	0.01^{ns}	0.94**	-0.45^{ns}
3	A	5.48±0.34	16.47±1.20	0.69±0.04	2.69±0.25	8.95±1.44
N = 20	B	7.05±0.73	18.03±1.27	1.06±0.05	4.06±0.18	4.85±0.26
	C	3.81±0.61	17.53±1.15	0.75±0.04	1.46±0.14	10.16±0.74
	$B-\frac{A+C}{2}$	2.41***	1.03^{ns}	0.33***	1.98***	−4.70***
	A−C	1.67**	-1.06^{ns}	-0.06^{ns}	1.23***	-1.21^{ns}
4	A	7.48±0.57	14.61±1.08	0.78±0.04	2.65±0.20	7.72±0.57
N = 19	B	10.56±1.45	19.57±1.60	1.04±0.07	4.47±0.28	4.63±0.23
	C	5.50±0.53	18.64±1.49	0.78±0.07	1.28±0.08	13.00±0.96
	$B-\frac{A+C}{2}$	4.07**	2.95**	0.26**	2.50***	−5.73***
	A−C	1.98**	−4.02***	0.00^{ns}	1.36***	−5.28***

No changes occurred from the first to the second control periods save for "despondence" on the second evening.

3.5.1.4 Amusement and laughter

"Amusement" as well as "laughter" ratings (table 3:1 B) increased significantly during "Charley's Aunt", decreased significantly during "Paths of Glory" and "The Mask of Satan", and did not change significantly during the natural-scenery films. No significant changes occurred between the first and the second control periods except for a significant increase in "laughter" ratings following "Charley's Aunt".

3.5.1.5 Boredom and fatigue

"Boredom" ratings (table 3:1 B) increased significantly during the natural-scenery films and decreased significantly during "Charley's Aunt". A significant increase was also found during the control period following the natural-scenery films. Fatigue ratings decreased significantly during all films but the natural-scenery film period (table 3:1 B) throughout the study.

3.5.2 Physiological variables

3.5.2.1 Adrenaline excretion

As shown in figure 3:1 and Table 3:2, adrenaline excretion decreased significantly during the natural-scenery films but increased significantly during the films of the three subsequent evenings. During all four evenings there was a significant fall in adrenaline excretion from the first to the second control period.

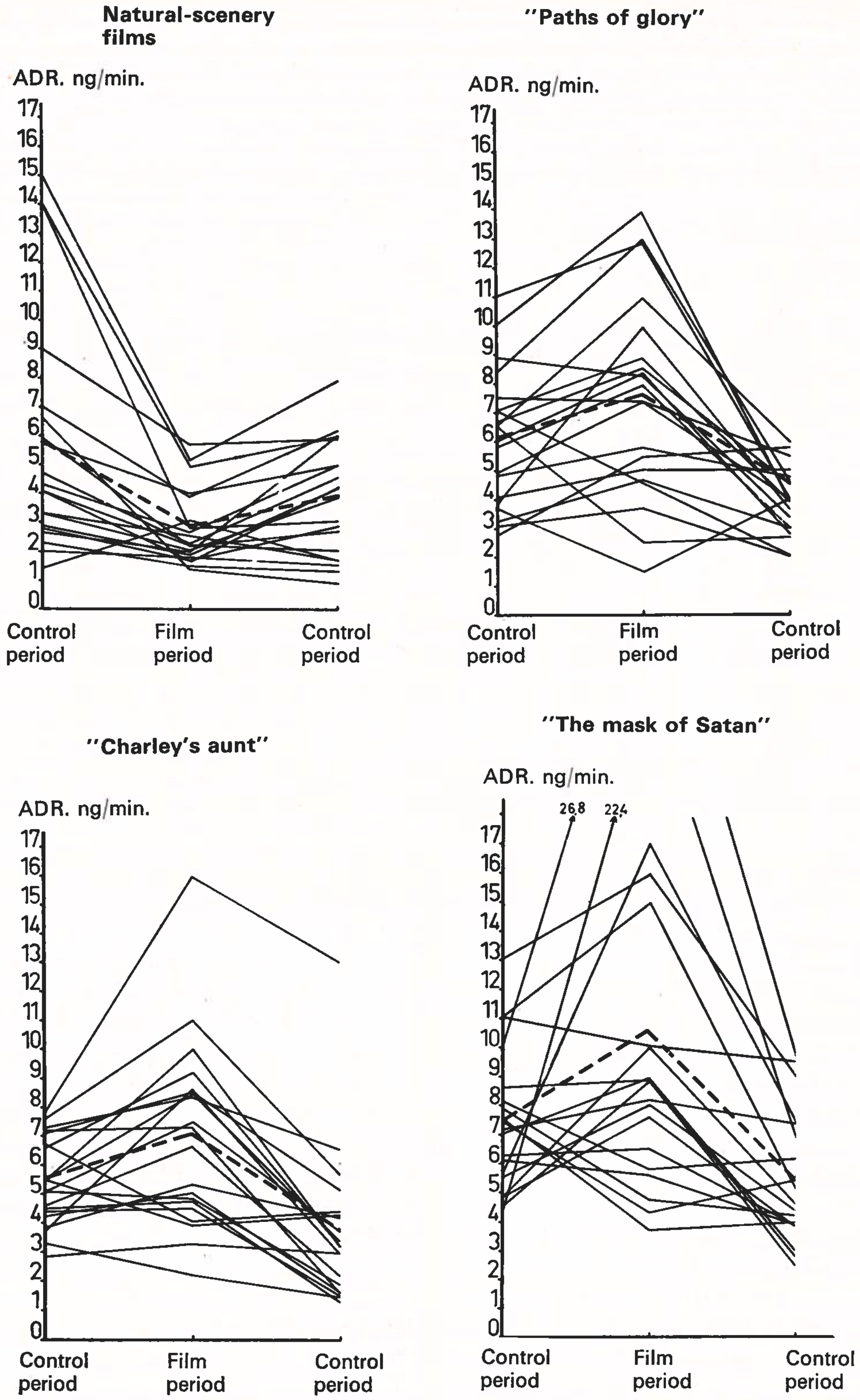

Figure 3:1. Urinary excretion of adrenaline (ADR) before, during and after viewing (a) bland natural scenery films, (b) the war film "Paths of Glory", (c) the comedy "Charley's Aunt" and (d) the hair-raiser "The Mask of Satan". Short-dash line indicates mean values.

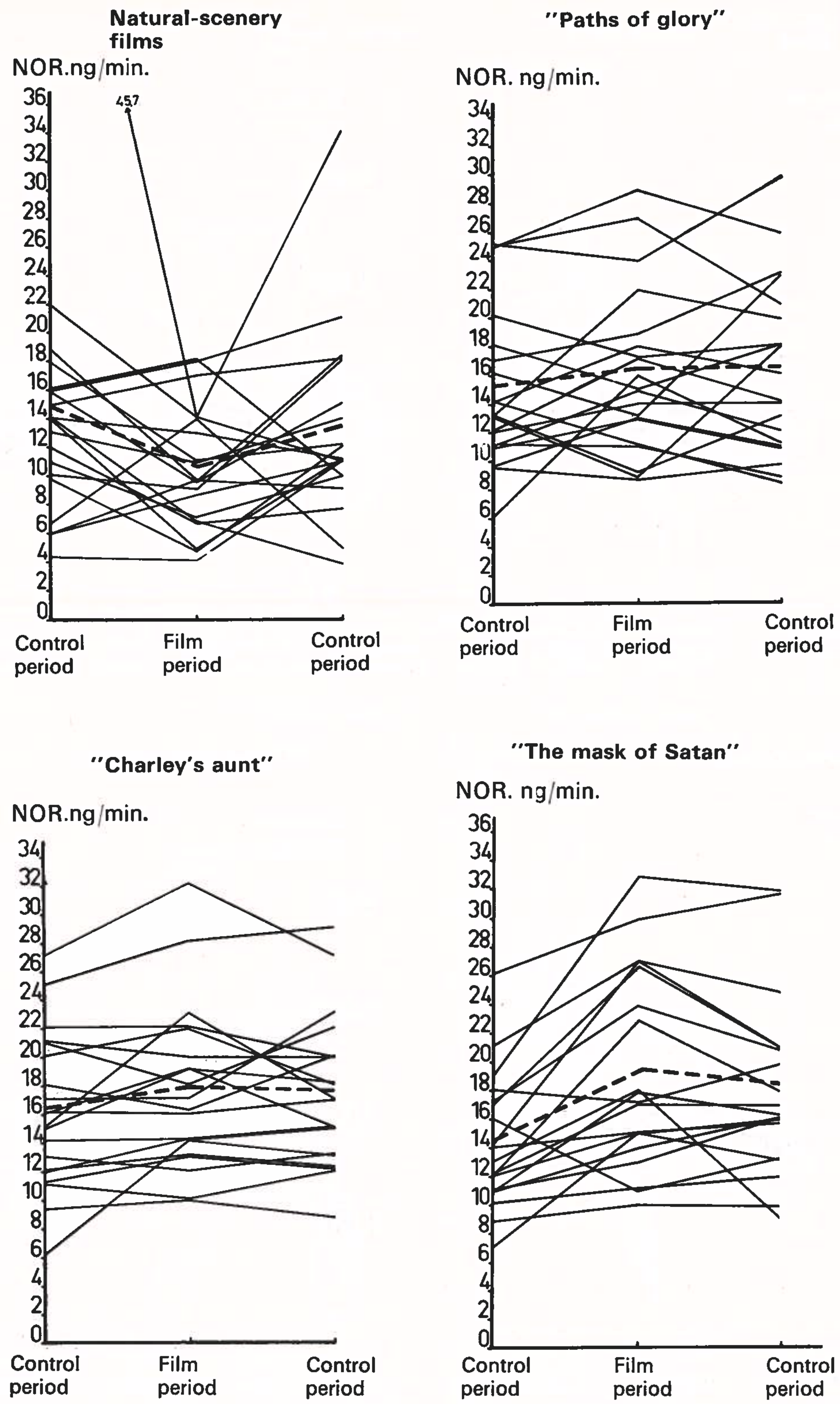

Figure 3:2. Urinary excretion of noradrenaline (NOR) during conditions indicated in Figure 3:1.

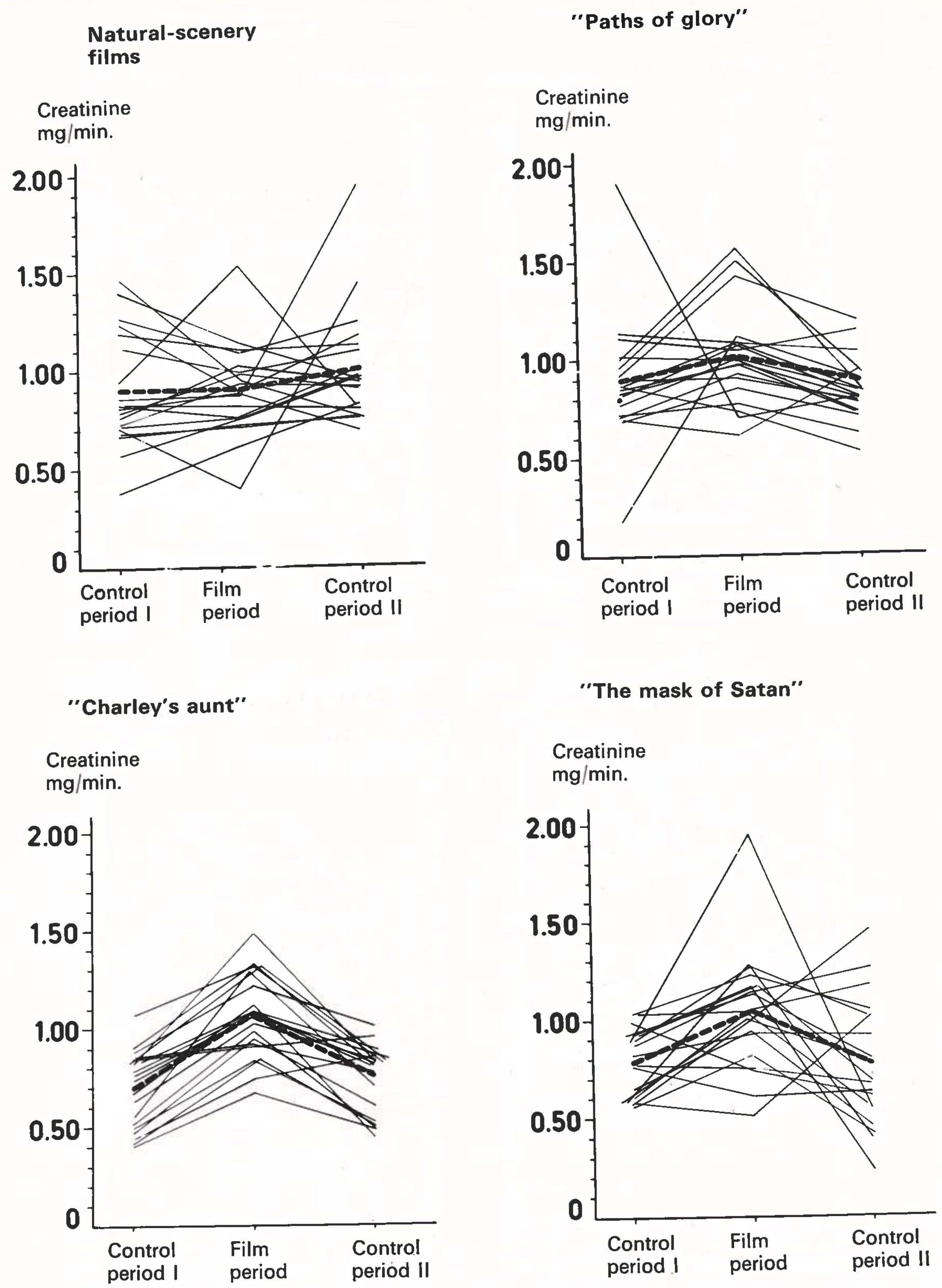

Figure 3:3. Urinary excretion of creatinine during conditions indicated in Figure 3:1.

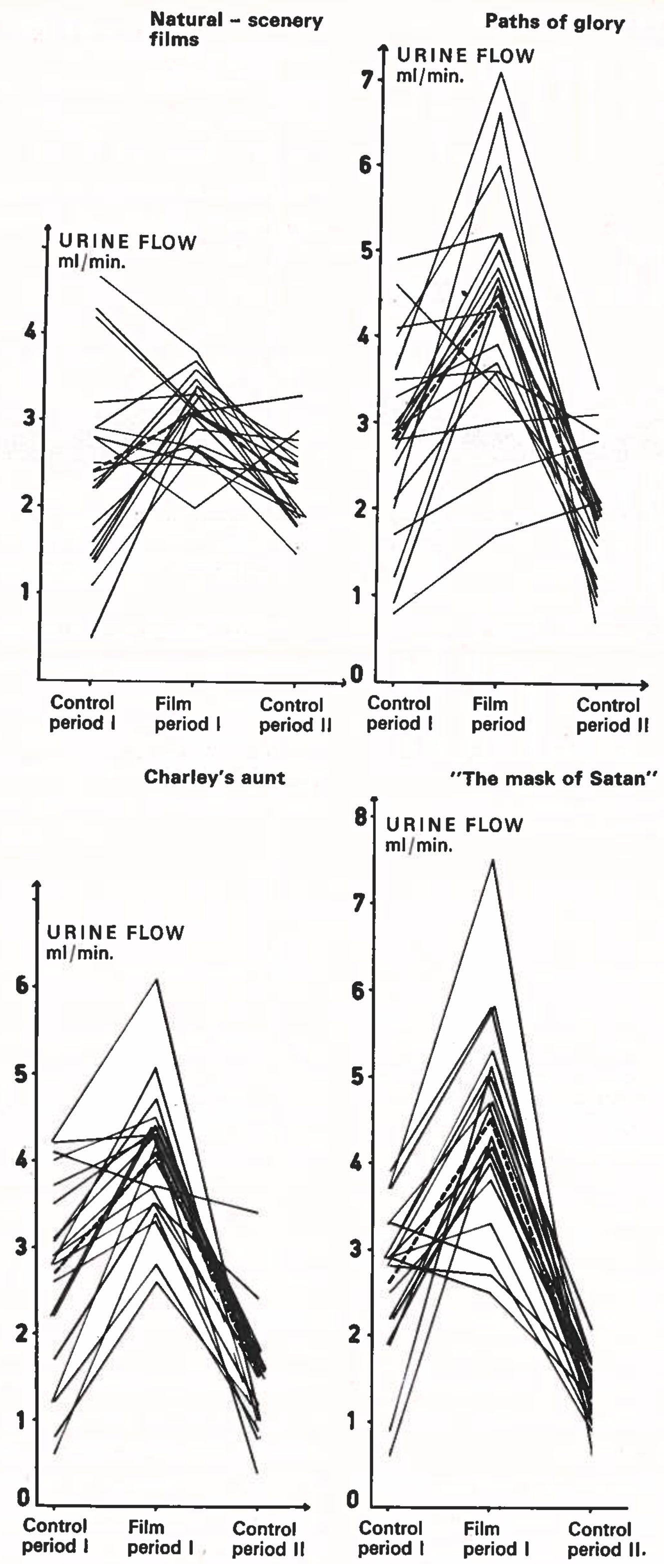

Figure 3:4. Urine flow during conditions indicated in Figure 3:1.

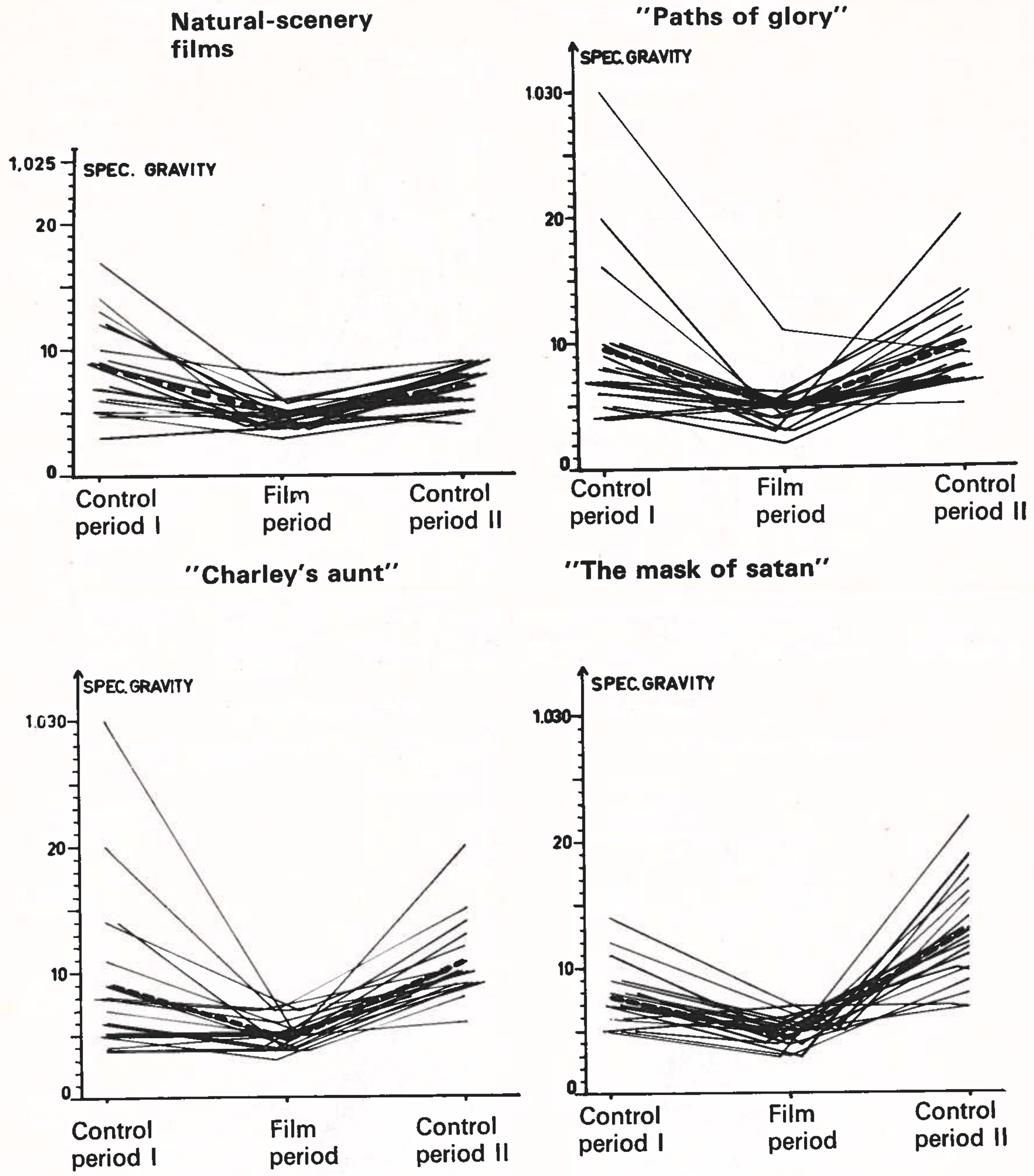

Figure 3:5. Urinary specific gravity during conditions indicated in Figure 3:1.

3.5.2.2 Noradrenaline excretion

Figure 3:2 and table 3:2 demonstrate a significant fall in noradrenaline excretion during the natural-scenery films. In contrast, there was a nonsignificant rise during "Paths of Glory" and "Charley's Aunt" and a significant rise during "The Mask of Satan". No significant changes occurred from the first to the second control periods apart from a rise on the fourth evening, when the last-named film was shown.

3.5.2.3 Urinary creatinine

As shown in figure 3:3 and table 3:2, significant increases in creatinine excretion were noted during the film periods of "Charley's Aunt" and "The Mask of Satan" but not of the other two programs. No significant changes occurred during any of the evenings from the first to the secand control period.

3.5.2.4 Urine volume

The film periods of all four evenings were accompanied by a significant increase in urine volume (cf. figure 3:4 and table 3:2). On the second and subsequent evenings there was a significant decrease from the first to the second control period, whereas the corresponding change on the first evening was non-significant.

3.5.2.5 Specific gravity

Urinary specific gravity decreased significantly during the film period of all four evenings, and from the first to the second control period of the first evening and increased significantly the first to the second control period of the last evening (cf. figure 3:5 and table 3:2).

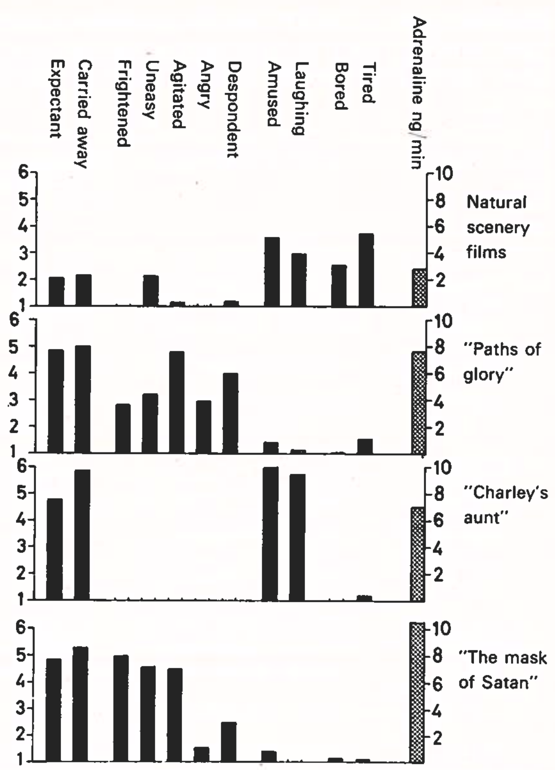

Figure 3:6. Questionnaire scores and adrenaline excretion in response to the film stimuli indicated in Figure 3:1.

3.6 Discussion

3.6.1 Comparison between subjective reactions to different films

Almost no significant differences were found between the subjective reactions reported for the *first control period* on the four evenings. This supports the assumption that the psychological "starting position" of our subjects remained similar throughout the study.

As to the *film period,* the natural-scenery films would—according to the experimenter's assumption—induce feelings of calmness and equanimity (and possibly boredom). "Paths of Glory" was selected for its assumed aggression-provoking properties, "Charley's Aunt" was assumed to be primarily comical and amusing, and "The Mask of Satan" was picked for its assumed fright-inducing properties. The author is well aware that emotional reactions are unlikely to be entirely clear-cut and "pure". On the other hand, the four programs were assumed to be very different from each other and to evoke emotional reactions which likewise clearly differ. This assumption finds support in the self-ratings of our subjects: the natural-scenery films were accompanied by a significant increase in "boredom" ratings, "Paths of Glory" was accompanied by feelings of "aggression" (but also of several other types of emotional reactions), "Charley's Aunt" was characterized by increased "amusement" and "laughter" ratings, and "The Mask of Satan", finally, was primarily reported to induce feelings of "uneasiness" and "fright", cf. figure 3:6 and tables 3:1 A&B, 3:3 A&B and 3:4 A&B.

3.6.2 Quality of emotional reaction and changes in sympathoadrenomedullary and renal function

In general, it was found that both types of emotional reactions, "pleasant" as well as "unpleas-

Table 3:3 A. Statistical comparisons of means for self-rated psychological variables between day 1 and days 2, 3 and 4. (N = 19.) The ratings were made on six-point scales ranging between "very" (6 points) and "not at all" (1 point). *A* stands for the period 0—100 minutes; *B*, 101—200 minutes; and *C*, 201—300 minutes.

Diff. betw. days No.	Period	Expectant	Engaged and carried away	Frightened	Uneasy	Agitated
1—2	A	0.26^{ns}	0.26^{ns}	0.00^{ns}	0.21^{ns}	0.00^{ns}
	B	−2.89***	−2.74***	−1.68**	−1.05^{ns}	−3.58***
	C	0.32^{ns}	−0.42^{ns}	−0.11^{ns}	0.79^{ns}	−0.32^{ns}
	$B-\frac{A+C}{2}$	−3.18***	−2.66***	−1.63**	−1.55*	−3.42***
	A—C	−0.05^{ns}	0.68^{ns}	0.11^{ns}	−0.58^{ns}	0.32^{ns}
1—3	A	−0.16^{ns}	0.21^{ns}	0.00^{ns}	0.16^{ns}	0.00^{ns}
	B	−2.84***	−3.68***	0.00^{ns}	0.95*	0.16^{ns}
	C	0.16^{ns}	−0.79*	0.00^{ns}	1.11**	0.00^{ns}
	$B-\frac{A+C}{2}$	−2.84***	−3.39***	0.00^{ns}	0.32^{ns}	0.16^{ns}
	A—C	−0.32^{ns}	1.00*	0.00^{ns}	−0.95*	0.00^{ns}
1—4	A	−0.21^{ns}	−0.26^{ns}	0.00^{ns}	0.05^{ns}	0.00^{ns}
	B	−2.95***	−3.11***	−4.00***	−2.63***	−2.84***
	C	0.32^{ns}	−0.74^{ns}	−0.84*	0.42^{ns}	−0.63*
	$B-\frac{A+C}{2}$	−3.00***	−2.61***	−3.58***	−2.87***	−2.53***
	A—C	−0.53^{ns}	0.47^{ns}	0.84*	−0.37^{ns}	0.63*

Table 3:3 B. Statistical comparisons of means for self-rated psychological variables between days 2, 3 and 4. (N = 19.) The ratings were made on six-point scales ranging between "very" (6 points) and "not at all" (1 point). *A* stands for the period 0—100 minutes; *B*, 101—200 minutes; and *C*, 201—300 minutes.

Diff. betw. days No.	Period	Expectant	Engaged and carried away	Frightened	Uneasy	Agitated
2—3	A	−0.42*	−0.05^{ns}	0.00^{ns}	−0.05^{ns}	0.00^{ns}
	B	0.05^{ns}	−0.95*	1.68**	2.00***	3.74***
	C	−0.16^{ns}	−0.37^{ns}	0.11^{ns}	0.32^{ns}	0.32^{ns}
	$B-\frac{A+C}{2}$	0.34^{ns}	−0.74^{ns}	1.63**	1.87***	3.58***
	A—C	−0.26^{ns}	0.32^{ns}	−0.11^{ns}	−0.37^{ns}	−0.32^{ns}
2—4	A	−0.47^{ns}	−0.53^{ns}	0.00^{ns}	−0.16^{ns}	0.00^{ns}
	B	−0.05^{ns}	−0.37^{ns}	−2.32***	−1.58*	0.74^{ns}
	C	0.00^{ns}	−0.32^{ns}	−0.74*	−0.37^{ns}	−0.32^{ns}
	$B-\frac{A+C}{2}$	0.18^{ns}	0.05^{ns}	−1.95**	−1.32*	0.89^{ns}
	A—C	−0.47^{ns}	−0.21^{ns}	0.74*	0.21^{ns}	0.32^{ns}
3—4	A	−0.05^{ns}	−0.47^{ns}	0.00^{ns}	−0.11^{ns}	0.00^{ns}
	B	−0.11^{ns}	0.58**	−4.00***	−3.58***	−3.00***
	C	0.16^{ns}	0.05^{ns}	−0.84*	−0.68*	−0.63*
	$B-\frac{A+C}{2}$	−0.16^{ns}	0.79*	−3.58***	−3.18***	−2.68***
	A—C	−0.21^{ns}	−0.53^{ns}	0.84*	0.58^{ns}	0.63*

Table 3:4 A. Statistical comparisons of means for self-rated psychological variables between day 1 and days 2, 3 and 4. (N = 19.) The ratings were made on six-point scales ranging between "very" (6 points) and "not at all" (1 point). *A* stands for the period 0—100 minutes; *B*, 101—200 minutes; and *C*, 201—300 minutes.

Diff. betw. days No.	Period	Aggressive and angry	Despondent	Amused, happy and cheerful	Laughing	Bored	Tired
1—2	A	0.00^{ns}	0.16^{ns}	0.32^{ns}	0.95***	−0.21^{ns}	−0.05^{ns}
	B	−1.84***	−2.68***	2.00***	1.74***	1.58***	2.26***
	C	−0.16^{ns}	−0.16^{ns}	0.05^{ns}	0.32^{ns}	0.84***	0.89**
	$B-\frac{A+C}{2}$	−1.76**	−2.68***	1.82***	1.11**	1.26**	1.84***
	A—C	0.16^{ns}	0.32^{ns}	0.26^{ns}	0.63^{ns}	−1.05**	−0.95^{ns}
1—3	A	0.00^{ns}	0.00^{ns}	0.21^{ns}	1.32***	−0.26^{ns}	−0.32^{ns}
	B	0.00^{ns}	0.21^{ns}	−2.53***	−2.79***	1.63***	2.63***
	C	0.00^{ns}	0.16^{ns}	−0.53^{ns}	−0.53^{ns}	0.68**	0.58*
	$B-\frac{A+C}{2}$	0.00^{ns}	0.13^{ns}	−2.37***	−3.18***	1.42***	2.50***
	A—C	0.00^{ns}	−0.16^{ns}	0.74^{ns}	1.84***	−0.95**	−0.89*
1—4	A	0.00^{ns}	−0.05^{ns}	0.05^{ns}	0.84*	−0.11^{ns}	−0.05^{ns}
	B	−0.53^{ns}	−1.32**	2.00***	1.89***	1.47**	2.58***
	C	0.00^{ns}	0.05^{ns}	0.37^{ns}	0.26^{ns}	0.63*	1.32**
	$B-\frac{A+C}{2}$	−0.53^{ns}	−1.32*	1.79***	1.34***	1.21**	1.95***
	A—C	0.00^{ns}	−0.11^{ns}	−0.32^{ns}	0.58^{ns}	−0.74^{ns}	−1.37**

Table 3:4 B. Statistical comparisons of means in self-rated psychological variables between days 2, 3 and 4. (N = 19.) The ratings were made on six-point scales ranging between "very" (6 points) and "not at all" (1 point). *A* stands for the period 0—100 minutes; *B*, 101—200 minutes; and *C*, 201—300 minutes.

Diff. betw. days No.	Period	Aggressive and angry	Despondent	Amused, happy and cheerful	Laughing	Bored	Tired
2—3	A	0.00^{ns}	−0.16^{ns}	−0.11^{ns}	0.37^{ns}	−0.05^{ns}	−0.26^{ns}
	B	1.84***	2.89***	−4.53***	−4.53***	0.05^{ns}	0.37^{ns}
	C	0.16^{ns}	0.32^{ns}	−0.58^{ns}	−0.84*	−0.16^{ns}	−0.32^{ns}
	$B-\frac{A+C}{2}$	1.76**	2.82***	−4.18***	−4.29***	0.16^{ns}	0.66*
	A—C	−0.16^{ns}	−0.47^{ns}	0.47^{ns}	1.21**	0.11^{ns}	0.05^{ns}
2—4	A	0.00^{ns}	−0.21^{ns}	−0.26^{ns}	−0.11^{ns}	0.11^{ns}	0.00^{ns}
	B	1.32*	1.37**	0.00^{ns}	0.16^{ns}	−0.11^{ns}	0.32^{ns}
	C	0.16^{ns}	0.21^{ns}	0.32^{ns}	−0.05^{ns}	−0.21^{ns}	0.42^{ns}
	$B-\frac{A+C}{2}$	1.24*	1.37*	−0.03^{ns}	0.24^{ns}	−0.05^{ns}	0.11^{ns}
	A—C	−0.16^{ns}	−0.42^{ns}	−0.58^{ns}	−0.05^{ns}	0.32^{ns}	−0.42^{ns}
3—4	A	0.00^{ns}	−0.05^{ns}	−0.16^{ns}	−0.47^{ns}	0.16^{ns}	0.26^{ns}
	B	−0.53^{ns}	−1.53**	4.53***	4.68***	−0.16^{ns}	−0.05^{ns}
	C	0.00^{ns}	−0.11^{ns}	0.89^{ns}	0.79*	−0.05^{ns}	0.74*
	$B-\frac{A+C}{2}$	−0.53^{ns}	−1.45**	4.16***	4.53***	−0.21^{ns}	−0.55*
	A—C	0.00^{ns}	0.05^{ns}	−1.05^{ns}	−1.26**	0.21^{ns}	−0.47^{ns}

ant", were accompanied by significant and similar changes in sympathoadrenomedullary activity as reflected in the urinary excretion of adrenaline and noradrenaline, and in renal function as indicated by changes in urine volume, specific gravity and creatinine excretion. These changes are evident in the individual film experiments but are best demonstrated by comparing the reactions during the three psychologically "arousing" films with each other and with those during the bland, psychologically "non-arousing" control program.

In spite of the experimenter's attempt to find stimuli that would evoke relatively specific emotional reactions, the reactions turned out to be rather composite and complex, although very probably different on the different days. For this reason, the experiment does not provide optimum conditions for a study of *quantitative* psychophysiological relationships. However, *qualitative* relationships may be studied with greater accuracy.

Comparing "Charley's Aunt" with "Paths of Glory", there are very conspicuous differences in *psychological* reaction as reported by the subjects, cf. figure 3:6 and tables 3:3&4. In contrast, no significant differences were found in the *physiological* reactions to the two films as represented by our measurements save in creatinine excretion (cf. tables 3:5 A&B). Accordingly, one might conclude that most of the physiological reactions measured are not specifically related to the *quality* of the reaction but to its *intensity,* in support of the hypothesis presented in figure 1:2.

According to the Funkenstein (1956) hypothesis, aggressive feelings are related to increases in noradrenaline release, whereas anxiety is related to release of adrenaline. In the original experiments forming the basis for this hypothesis, no direct measurements were made of these hormones in one or another of the body fluids. True, some authors who have made use of such measurements, claim that the results confirmed the hypothesis. However, some recent, well controlled studies have failed to corroborate this (cf. Frankenhaeuser, 1971), an opinion that is further supported by the finding that although "Paths of Glory" was accompanied by a significant increase in "aggression" ratings, while "The Mask of Satan" was not, the noradrenaline excretion during the last-named film was significantly higher, as was the increase during the film period over the control levels.

Similarly, "fright" rating levels and increases were significantly higher during "Paths of Glory" and "The Mask of Satan" than during "Charley's Aunt", but no significant differences existed between these films with respect to adrenaline excretion.

3.6.3 Quantity of emotional reaction and changes in sympathoadrenomedullary and renal function

As shown in table 3:1 B, the natural-scenery films were accompanied by a significant increase in "boredom" ratings. One might further hypothesize that these films, by diverting the attention of the subjects away from "arousing" stimuli of various kinds, actually induced feelings of relaxation and equanimity that were more pronounced during the film period than during the control periods before and after. It might well be that such an assumed decrease in psychological "arousal" level was reflected in the significant decrease in catecholamine excretion found during the natural-scenery films. It should be noted that this decrease occurred in relation to the *mean* of *both* control periods, so that the probable circadian decrease in adrenaline excretion during evening hours would seem to be less acceptable as an explanation of this phenamenon, cf. paragraph 3.6.4 below.

Mason et al. (1957) have suggested that the central nervous system exerts a tonic influence on hypophyseo-adrenocortical activity, and the same group of authors has later demonstrated that viewing Disney nature-study films significantly lowers the levels of plasma 17-hydroxycorticosteroids (Handlon, et al., 1962). Our findings support the hypothesis that adrenaline excretion reacts in a similar way, and further that it reflects not the quality but the intensity of the simultaneous psychological "arousal" (cf. also discussion in Chapter 4).

Table 3:5 A. Statistical comparisons of means for adrenaline, noradrenaline and creatinine excretion, urine volume and specific gravity between day 1 and days 2, 3 and 4. (N = 19.) *A* stands for the period 0–100 minutes; *B*, 101–200 minutes; and *C*, 201–300 minutes.

Diff. betw. days No.	Period	Adrenaline ng/min	Noradrenaline ng/min	Creatinine mg/min	Urine volume ml/min	Spec. gravity (N–1)×1000
1–2	A	-0.17^{ns}	-0.18^{ns}	0.03^{ns}	-0.37^{ns}	-0.32^{ns}
	B	-4.59^{***}	-4.03^{*}	-0.11^{ns}	-1.30^{***}	0.00^{ns}
	C	-0.66^{ns}	-3.37^{*}	0.18^{ns}	0.42^{**}	-2.74^{**}
	$B-\frac{A+C}{2}$	-4.18^{***}	-2.26^{ns}	-0.21^{ns}	-1.32^{***}	1.53^{ns}
	A–C	0.49^{ns}	3.19^{*}	-0.15^{ns}	-0.78^{*}	2.42^{ns}
1–3	A	0.48^{ns}	-1.45^{ns}	0.22^{**}	-0.24^{ns}	0.00^{ns}
	B	-4.33^{***}	-6.84^{***}	-0.16^{**}	-1.05^{***}	0.05^{ns}
	C	-0.05^{ns}	-4.35^{***}	0.30^{**}	0.81^{***}	-2.89^{**}
	$B-\frac{A+C}{2}$	-4.55^{***}	-3.94^{ns}	-0.42^{***}	-1.34^{***}	1.50^{ns}
	A–C	0.53^{ns}	2.90^{ns}	-0.07^{ns}	-1.05^{**}	2.89^{*}
1–4	A	-1.46^{ns}	0.44^{ns}	0.14^{*}	-0.12^{ns}	1.00^{ns}
	B	-7.71^{***}	-8.66^{***}	-0.13^{ns}	-1.39^{***}	0.16^{ns}
	C	-1.62^{*}	-5.43^{***}	0.28^{*}	1.02^{***}	-5.84^{***}
	$B-\frac{A+C}{2}$	-6.17^{***}	-6.17^{**}	-0.34^{**}	-1.84^{***}	2.58^{**}
	A–C	0.17^{ns}	5.87^{***}	-0.14^{ns}	-1.13^{**}	6.84^{***}

Table 3:5 B. Statistical comparisons of means in adrenaline, nordrenaline and creatinine excretion, urine volume and specific gravity between days 2, 3 and 4. (N = 19.) *A* stands for the period 0–100 minutes; *B*, 101–200 minutes; and *C*, 201–300 minutes.

Diff. betw. days No.	Period	Adrenaline ng/min	Noradrenaline ng/min	Creatinine mg/min	Urine volume ml/min	Spec. gravity (N–1)×1000
2–3	A	0.65^{ns}	-1.27^{ns}	0.19^{*}	0.13^{ns}	0.32^{ns}
	B	0.25^{ns}	-2.81^{ns}	-0.05^{ns}	0.25^{ns}	0.05^{ns}
	C	0.61^{ns}	-0.97^{ns}	0.12^{*}	0.39^{**}	-0.16^{ns}
	$B-\frac{A+C}{2}$	-0.38^{ns}	-1.68^{ns}	-0.21^{*}	-0.02^{ns}	-0.03^{ns}
	A–C	0.04^{ns}	-0.30^{ns}	0.07^{ns}	-0.26^{ns}	0.47^{ns}
2–4	A	-1.29^{*}	0.62^{ns}	0.11^{ns}	0.25^{ns}	1.32^{ns}
	B	-3.12^{*}	-4.63^{*}	-0.02^{ns}	-0.09^{ns}	0.16^{ns}
	C	-0.97^{ns}	-2.06^{ns}	0.10^{ns}	0.60^{**}	-3.11^{**}
	$B-\frac{A+C}{2}$	-1.99^{ns}	-3.91^{ns}	-0.13^{ns}	-0.52^{ns}	1.05^{ns}
	A–C	0.32^{ns}	2.68^{*}	0.01^{ns}	-0.35^{ns}	4.42^{*}
3–4	A	-1.94^{**}	1.89^{**}	-0.08^{ns}	0.12^{ns}	1.00^{ns}
	B	-3.38^{*}	-1.83^{*}	0.03^{ns}	-0.34^{ns}	0.11^{ns}
	C	-1.58^{ns}	-1.08^{ns}	-0.01^{ns}	0.21^{ns}	-2.95^{*}
	$B-\frac{A+C}{2}$	-1.62^{ns}	-2.23^{*}	0.07^{ns}	-0.51^{ns}	1.08^{ns}
	A–C	-0.36^{ns}	2.98^{**}	-0.07^{ns}	-0.08^{ns}	3.95^{*}

3.6.4 Psychosocial stimuli and physiological responses

Although the physiological reactions demonstrated in this study are in no way extreme, it is obvious that experimental psychosocial stimuli of relatively short duration and of an every-day character are capable of evoking significant reactions in every one of the physiological parameters investigated here. The catecholamine data corroborate our earlier findings demonstrating increases in the excretion of urinary catecholamines in response to film shows. The data on urine flow, specific gravity and urinary creatinine similarly demonstrate significant effects of psychosocial stimuli on renal function. When evaluating these reactions it should be remembered that adrenaline excretion and urine flow have been found to *decrease* in the evening because of the circadian variation—as demonstrated by Leanderson and Levi (1966) and Levi (1969)—in subjects undergoing a similar procedure to that used in the present study but not being exposed to film shows.

The differences found in the present study between the first and the second control period (A—C, cf. table 3:2) in adrenaline excretion and urine flow confirm these observations. This means that the reactions found as to these variables are probably more pronounced than appears from a comparison between the levels during the film period and first control period, only.

3.7 Summary

Against the background of theoretical considerations presented in Chapter 1, a study is described, in which 20 healthy female office clerks were shown four different film programs on four consecutive evenings in order to study whether (a) not only fright- and aggression-evoking psychosocial stimuli but amusement- and laughter-evoking too would be effective in provoking the same type of sympathoadrenomedullary and renal reactions, and (b) whether stimuli evoking feelings of calmness, equanimity and possibly boredom would be effective in decreasing urinary catecholamine output. It was found that viewing bland natural-scenery films was accompanied by a significant increase in "boredom" ratings, with no other sigificant emotional reactions reported. Concomitantly, significant decreases were found in adrenaline and noradrenaline excretion. The aggression-evoking "Paths of Glory" and the amusement-evoking comedy "Charley's Aunt" were *both* accompanied by similar increases in adrenaline excretion, with no change in noradrenaline excretion. The most fright-provoking of the four programs, "The Mask of Satan", was accompanied by significant increases in the excretion of both catecholamines. It is proposed that the natural-scenery films produced a decrease in emotional arousal that was reflected in a decrease in the catecholamine excretion. The three "arousing" films were all accompanied by significant increases in adrenaline excretion in spite of the great differences between the emotional reactions provoked. It was further found that the emotionally "arousing" films evoked significant renal reactions as reflected in changes in urine volume, specific gravity and creatinine excretion.

3.8 Acknowledgements

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4 SYMPATHOADRENOMEDULLARY ACTIVITY, DIURESIS AND EMOTIONAL REACTIONS DURING VISUAL SEXUAL STIMULATION IN FEMALES AND MALES

By Lennart Levi

4.1 The problem

As already repeatedly pointed out, it has long been known that sympathoadrenomedullary reactions accompany the emotional reactions of anger and fear (Cannon, 1929). A similarity between the physiological concomitants of these emotions and those accompanying sexual arousal has been noticed by several authors (MacLean, 1965). For example, tachycardia, hyperventilation, pupillary dilatation, perspiration, and increased arterial blood pressure have been shown to occur not only in anger and fear but also during sexual arousal (Bartlett, 1956; Bernick et al., 1968; Klumbie and Kleinsorge, 1950; Landis and Gulette, 1925; Marston, 1928; Masters and Johnson, 1966; Scott, 1930; Wenger et al., 1968), in spite of the generally pleasant character of the last-mentioned response. It may be noted that such a stereotyped reaction to widely different influences is suggested by Selye's (1960, 1971) concept of *stress* and by the results presented in Chapter 3. One of the main characteristics in this reaction pattern seems to be an increased sympathoadrenomedullary activity, which according to Schachter and Wheeler (1962) in turn seems to be closely related to what these authors call "emotionality". On this basis one would expect an increased secretion of adrenaline and noradrenaline (perhaps as a preparation for muscular activity) to be a common denominator of these three otherwise so dissimilar emotional states—anger, fear, and sexual arousal. While such an increased secretion, as reflected by an increased excretion of urinary catecholamines has been demonstrated repeatedly during anger and fear (for review, see Chapter 1) and also during amusement (cf. Chapter 3), nothing is known about catecholamine excretion during sexual arousal, probably because of the difficulties of inducing such feelings in controlled experiments.

Further indications of a possible relationship between sympathoadrenomedullary and sexual function can be derived from the experiments in rabbits reported by Markee et al. (1952) suggesting that "an adrenergic substance is liberated following mating", because "if certain of the activities of adrenaline are blocked during the first minute after mating, ovulation is prevented". Finally, there is some scanty evidence that a chronic increase in sympathetic tone (e.g. evoked by unreleased sexual tension?) may play a role in the genesis of certain functional genital disorders (Brundin, 1965; Cieciorowska and Telko, 1961; Harris, 1948; Husslein, 1964; Read, 1951; Sjöstrand, 1965; Wengraf, 1953). Such dysfunction has been said to occur as a physiological concomitant of longstanding emotional disturbances, at least in predisposed individuals (Artner, 1964; Arvay and Nyiri, 1958; Clark, Jr. and Treichler, 1950; Dunbar, 1954; Selye, 1961; Shanan et al., 1965). Similar reactions have been reported in animals subjected to crowding, frustration, or strong sensory stimulation (e.g. Árvay et al., 1956; Sackler et al., 1960; Christian, 1960; Sai-Halasz, 1960; Mason et al., 1961; Thiessen and Rodgers, 1961; Calhoun, 1962; Sackler and Weltman, 1963; and Zondek and Tamari, 1964). In a relatively limited number of studies, genital reactions have been experimentally induced in man, most of the studies being centered on the experimental induction of unpleasant emotional states and the simultaneous measurement of uterine motility (Bickers, 1956; Garret, 1960; Kelly, 1962; Robertson, 1939).

Accordingly, in addition to their relevance for the evaluation of the "stress (Selye)" construct, findings in this field may have implications for the theory and practice of gynecology and obstetrics. In addition to these psychosomatic implications, there are also somatopsychic aspects. It is nowadays generally accepted that sexual functions are closely interrelated with neurotic disturbances, a view that rests mainly on clinical observations. However, a few investigators have shown that problems of this kind may be studied experimentally with sophisticated tools of measurement (Lazarus, 1966; Sines, 1957; Ås, 1958). Briefly, then, the relationships between sexual arousal, arousal of a different character, and reactions within the sympathoadrenomedullary system deserve further study. This formed part of the background to the present experiment.

According to the Kinsey report (Kinsey et al., 1953), the human male has a much greater propensity to respond to "psychosexual stimuli" (erotic pictures and literature) than the female, whose "distance receptors" are claimed to be relatively less important for sexual arousal (cf. Sherman, 1971). In contrast to the on-the-spot responses of the male to perceptual images (Money, 1961), the female is claimed to respond primarily to direct bodily contact (Beach, 1961). True, responses to psychosexual stimulation do occur in the female also, but only after considerable latency, as demonstrated in the experiments reported by Masters and Johnson (1965). Of course, such a difference in reactivity may be ascribable primarily to education and other social influences (cf. Sigusch, 1972), but there is some scanty evidence that such differences exist in infrahuman mammalian species as well (Beach, 1961; Kinsey et al., 1953), thus possibly speaking in favour of a biological origin. It has also been proposed that this phenomenon may be related to a difference in male and female dependence upon the cerebral cortex for sexual behaviour (Gorbman and Bern, 1962).

Briefly, then, the *primary object* of the present study was to determine whether: (a) experimentally induced sexual arousal in man is accompanied by changes in sympathoadrenomedullary activity as reflected in the urinary excretion of adrenaline and noradrenaline; (b) changes in catecholamine excretion during sexual arousal bear any relation to the intensity of the arousal as rated by the subjects; and (c) females and males react differently to the stimuli used, psychologically and physiologically. The present chapter is based, in part, on a preliminary account published some years ago (Levi, 1967) and on a more comprehensive version published recently in another context (Levi, 1969).

4.2 Choice of methodology

Showing various types of films provides an effective, convenient, and easily reproducible method for the experimental induction of emotional reactions in man (cf. Chapter 3). This method has been used by the present author in a series of studies of psychophysiological responses during various experimentally induced emotional states in healthy subjects (Levi, 1963; Levi, 1965; Levi, 1967). For reasons mentioned above, it was considered warranted to extend the study to include sexual arousal, using the same general experimental design.

To induce sexual arousal we made use of a film program composed of four short-length silent films (duration 11, 5, 11 and 14 minutes, respectively), two of them in colour, realistically displaying human intercourse, with the sex organs clearly visible. The monochrome films depicted middle-aged actors and were probably of rather ancient date, whereas the two colour films were rather new and displayed young actors of both sexes. The audience comprised both sexes who, however, were seated on different rows.

In order to avoid the satiety likely to occur when viewing a consecutive series of intercourses, these films were separated by bland, silent natural scenery films (duration 6, 8 and 17 minutes, respectively). Films of the latter kind have been found not to induce any emotional or sympathoadrenomedullary stimulation (cf. Chapter 3).

The first-named films had been confiscated by the legal authorities, who placed them at the author's disposal for the purpose of this study. It may be noted, however, that this study was carried out in 1964. Today, the National Swedish Board of Film Censors no doubt releases even considerably more advanced films of this type for public display without any legal restrictions.

4.3 Material and methods

The 103* subjects participating in the experiment were all healthy students: 53 females (mean age 24, range 22—30) and 50 males (mean age 27, range 23—40). All the male subjects and 10 of the females were medical students attending clinical courses. The remaining 43 females, who were senior physiotherapy students, were included to make up for the uneven sex distribution among the medical students, only some 20 per cent of whom were women.

Prior to volunteering for the experiment, all the subjects were informed about the type of stimuli to which they would be exposed and that the intention was to study some of the physiological reactions to such stimuli in the two sexes. They were explicitly told not to participate if likely to be distressed by the type of stimuli in question. For this or other reasons, 50 of the 153 subjects originally registered withdrew from the experiment (5 female and 11 male medical students, and 34 female physiotherapy students).

Needless to say, this way of selecting subjects produces a biased sample. However, since some of the stimuli might be psychologically harmful to sensitive subjects, such a procedure was judged to be necessary for ethical reasons. Furthermore, the original recruitment of subjects from these two professions itself resulted in a sample that is highly selected, particularly in view of such a student's familiarity with looking at and handling the naked human body. Thus, the resulting bias cannot be assessed readily in its effects on the reaction pattern and must be considered in drawing conclusions.

Urine samples were collected at the end of three consecutive 90-minute periods, one preceding the film showing (*control period A,* 6.30—8.00 p.m.), one including the entire 72-minute film program (*film period B,* 8.00—9.30 p.m.), and one after the performance (*control period C,* 9.30—11.00 p.m.). The subjects were instructed to empty their bladders 90 minutes before the start of the experiment, i.e. at 5.00 p.m., and to drink 300 ml of tap water. This procedure was repeated every 90 minutes, with a total fluid intake of 1,200 ml for the period concerned. The subjects were served two standard sandwiches at about 6.30, 8.00 and 9.30 p.m. The use of drugs was prohibited from the pre-experimental day onwards, alcoholic beverages for the entire experimental day, smoking from 10.00 a.m., and caffeine-containing beverages from 1.00 p.m. on the day of the experiment.

Subjective reactions were reported with the aid of self-rating scales on a questionnaire (see paragraph 2.20.7.2) administered toward the end of each period. Some of the estimates were obtained with the aid of 6-point self-rating scales (same as those reported in Chapter 3). Other estimates were obtained with 11-point scales. The exact wording (translated here, Swedish wording given in brackets) of the last-named items was: "How have you felt during the first rest period (film period, second rest period): (a) *pleasureable* sensations (lustkänslor), (b) *unpleasant* sensations (olustkänslor), and (c) *general emotional arousal* (allmänt känslomässigt berörd)", and "Did you feel *sexually stimulated* (sexuellt stimulerad) during the first rest period (film period, second rest period)?", cf. figure 2:1.

Based on the considerations mentioned in Chapter 3, the measure

$$B - \frac{A+C}{2}$$

was computed for all variables as an expression of the effects of the films shown.

* In the presentation of results, N is often < 103. This is explained by the following circumstances: (a) A number of urine samples were used for a study outside the scope of this paper and, accordingly, were not available for the catecholamine or creatinine assays. (b) Due to an error in the verbal instructions, 18 of the male subjects left the laboratory without having been given the opportunity to complete a series of questions administered at the end of the second control period. (c) In addition, a few questions were occasionally answered ambiguously or not at all.
The subjects whose data were affected by the circumstances mentioned under (a) and (b) were distributed at random. Point (c) concerned a few subjects only and thus does not add appreciably to the selection bias mentioned below.

Table 4:1. Statistical comparisons (Chi-square test) between the groups concerning answers to a question about previous sexual experience.

	Answers to respective alternatives			
	Males		Females	
Alternatives	No.	%	No.	%
Lived intimately with someone	37	77.1	31	59.6
Had isolated instances of consummated sexual contacts	9	18.8	7	13.5
Not had any instances of consummated sexual contacts	2	4.1	14	26.9
Total	48	100	52	100

Chi-square = 9.66; $p < 0.01$
Questionnaire returns were obtained from 48 males and 53 females. One of these female subjects refused to supply the requested information.

Table 4:2. Means and S.E.M. of self-rated psychological variables for male and female groups and for group differences (sexual arousal, pleasurable and unpleasant sensations, and general emotional arousal), and tests of significance between periods and between group means.

		Male group (M)		Female group (F)		Diff. betw. gr. (M−F)	
Variable	Period[1]	Mean ±	S.E.M.	Mean ±	S.E.M.	Mean ±	S.E.M.
Sexual arousal	A	1.42	0.16	1.28	0.15	0.14^{ns}	0.21
Males: N = 45	B	6.69	0.33	4.66	0.42	2.03^{***}	0.54
Females: N = 53	C	1.84	0.23	1.40	0.15	0.44^{ns}	0.26
	$B-\frac{A+C}{2}$	5.06^{***}	0.32	3.32^{***}	0.40	1.74^{**}	0.52
	A−C	-0.42^{*}	0.16	-0.12^{ns}	0.19	-0.30^{ns}	0.25
Pleasurable sensations	A	2.63	0.39	2.15	0.26	0.48^{ns}	0.39
Males: N = 29	B	6.43	0.57	4.47	0.42	1.96^{*}	0.60
Females: N = 51	C	2.20	0.26	1.96	0.20	0.24^{ns}	0.28
	$B-\frac{A+C}{2}$	4.01^{***}	0.55	2.41^{***}	0.44	1.60^{**}	0.60
	A−C	0.43^{ns}	0.29	0.19^{ns}	0.20	0.24^{ns}	0.30
Unpleasant sensations	A	1.46	0.23	1.59	0.18	-0.13^{ns}	0.25
Males: N = 28	B	3.37	0.45	4.55	0.40	-1.18^{*}	0.53
Females: N = 52	C	1.33	0.15	1.88	0.21	-0.55^{*}	0.25
	$B-\frac{A+C}{2}$	1.97^{***}	0.45	2.81^{***}	0.36	-0.84^{ns}	0.50
	A−C	0.13^{ns}	0.13	-0.29^{ns}	0.24	0.42^{ns}	0.27
General emotional arousal	A	2.19	0.22	3.04	0.26	-0.85^{**}	0.32
Males: N = 30	B	6.17	0.45	6.00	0.37	0.17^{ns}	0.51
Females: N = 52	C	2.24	0.27	2.68	0.26	-0.44^{ns}	0.34
	$B-\frac{A+C}{2}$	3.95^{***}	0.46	3.14^{***}	0.37	0.81^{ns}	0.51
	A−C	-0.05^{ns}	0.32	0.36^{ns}	0.30	-0.41^{ns}	0.40

The ratings were made in 11-point scales ranging between "extremely" (11 points) and "not at all" (1 point).
[1] *A* stands for the period 0−1 1/2 hours; *B,* 1 1/2−3 hours; and *C,* 3−4 1/2 hours.

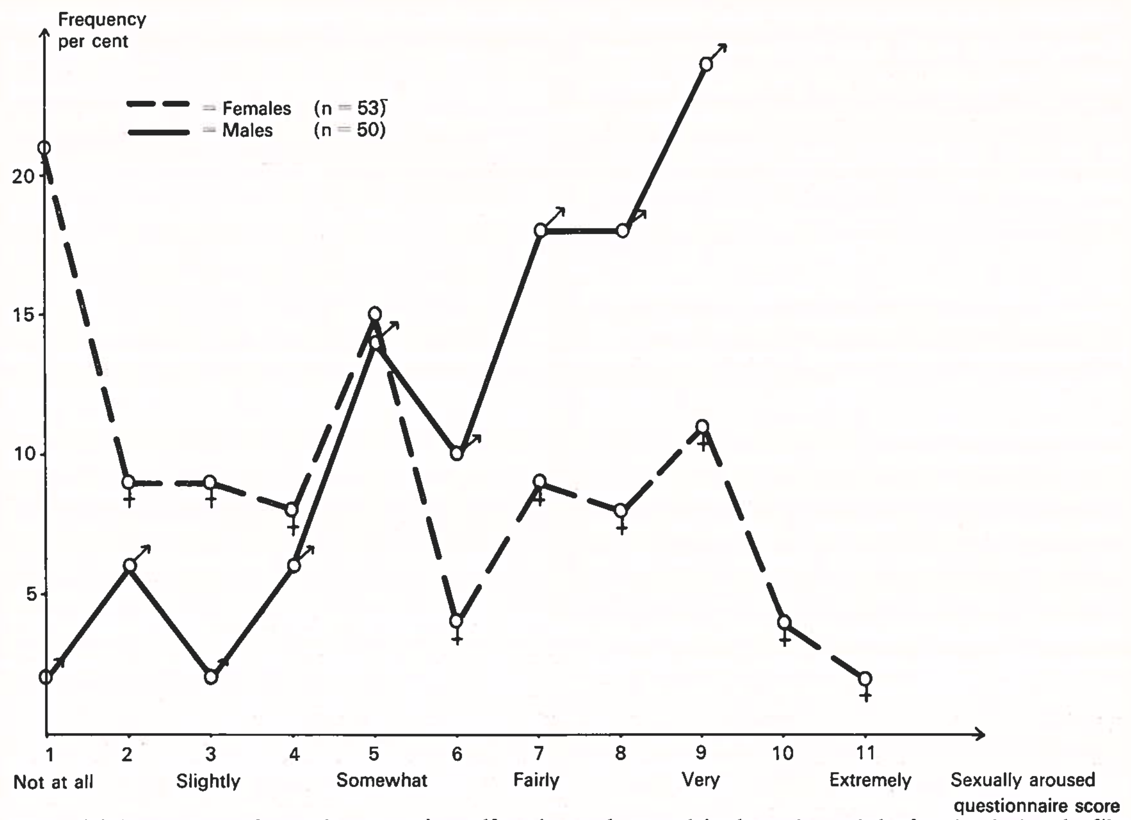

Figure 4:1. Frequence polygon demonstrating selfrated sexual arousal in the males and the females during the film showing.

No communication was allowed between the subjects during the film period. Briefly, the design of this study was rather similar to the one reported in Chapter 3.

A few months after the experiment, each subject was asked (by letter) about his or her sex life. The exact wording (likewise translated) of this question was: Have you, prior to this film study, ever

- ☐ lived intimately with someone (*stadigvarande* intimt förhållande)
- ☐ had isolated instances of consumated sexual contacts (*enstaka* fullbordade intima kontakter)
- ☐ not had any instances of consumated sexual contacts (*icke* haft fullbordade sådana kontakter)
- ☐ I do not wish to answer the question (jag önskar inte besvara frågan)

The male group turned out to be sexually somewhat more experienced than the female ($p < 0.01$) according to their questionnaire reports (table 4:1). The percentage of married subjects was the same in both groups, namely 6 per cent.

4.4 Results

4.4.1 Psychological variables

4.4.1.1 Sexual arousal

The film period was accompanied by a significant increase in mean self-rated sexual arousal in both sexes (table 4:2). The levels of this arousal as reported by the subjects are demonstrated in the frequency polygon of figure 4:1. This shows that 21 per cent of the females and only 4 per cent of the males reported a total absence of sexual arousal. Proceeding to the higher levels of sexual arousal, the males increase and the females de-

Table 4:3. Means and S.E.M. of self-rated psychological variables for male and female groups and for group differences (uneasiness, agitation and expectancy), and tests of significance between periods and between group means.

		Male group (M)		Female group (F)		Diff. betw. gr. (M−F)	
Variable	Period[1]	Mean ±	S.E.M.	Mean ±	S.E.M.	Mean ±	S.E.M.
Uneasiness	A	1.31	0.10	1.81	0.18	−0.50*	0.21
Males: N = 48	B	1.56	0.13	1.91	0.16	-0.35^{ns}	0.21
Females: N = 51	C	1.15	0.07	1.40	0.12	-0.25^{ns}	0.14
	$B-\frac{A+C}{2}$	0.33**	0.11	0.30^{ns}	0.18	0.03^{ns}	0.22
	A−C	0.16^{ns}	0.10	0.41*	0.19	-0.25^{ns}	0.22
Agitation	A	1.13	0.06	1.23	0.09	-0.10^{ns}	0.11
Males: N = 47	B	2.59	0.23	2.96	0.22	-0.37^{ns}	0.32
Females: N = 52	C	1.27	0.09	1.42	0.12	-0.15^{ns}	0.15
	$B-\frac{A+C}{2}$	1.39***	0.23	1.63***	0.20	-0.24^{ns}	0.30
	A−C	-0.14^{ns}	0.10	-0.19^{ns}	0.14	0.05^{ns}	0.18
Expectancy	A	3.44	0.22	2.73	0.21	0.71*	0.31
Males: N = 48	B	4.00	0.20	2.57	0.23	1.43***	0.30
Females: N = 51	C	1.29	0.09	1.40	0.12	-0.11^{ns}	0.15
	$B-\frac{A+C}{2}$	1.63***	0.17	0.50**	0.18	1.13***	0.25
	A−C	2.15***	0.25	1.33***	0.23	0.82*	0.34

The ratings were made on 6-point scales ranging between "much" (6 points) and "not at all" (1 point).
[1] *A* stands for the period 0−1 1/2 hours; *B*, 1 1/2−3 hours; and *C*, 3−4 1/2 hours.

crease in frequency, while at the extreme of sexual excitation we find a few females but no males. The mean *level* of sexual arousal is significantly higher in the male group compared with the female during the film period but not during the control periods. This sex difference also applies to the *increase* in sexual arousal that is reported to have occurred during the film showing as compared with the control periods (table 4:2).

4.4.1.2 Pleasurable sensations

Both groups reported a moderate significant increase in "pleasurable sensations" during the film period, the increases as well as the mean level reached being significantly higher in the male group (table 4:2).

4.4.1.3 Unpleasant sensations

A significant increase in "unpleasant sensations" was also reported by both sexes during the film period, the mean level but not the change being significantly higher in the female group. It may be noted that the absolute ratings were relatively low in both groups (table 4:2).

4.4.1.4 General emotional arousal

In their overall assessment of "emotional arousal", whatever its quality, both groups reported significant but similar increases during the film period, the female group also being slightly but significantly more aroused during the first control period, i.e. prior to the film (table 4:2).

4.4.1.5 Uneasiness; agitation

The mean questionnaire scores of "uneasiness" increased very moderately in both sexes during the film period, the increase reaching statistical significance in the male but not in the female group (table 4:3). This is a reflection of the fact that the mean questionnaire score was significantly higher in the female group during the first control period, i.e. before the start of the film period. There were no statistically significant dif-

Table 4:4. Means and S.E.M. for male and female groups and for group differences in catecholamine excretion, creatinine excretion, urine flow, and specific gravity. Tests of significance between periods and between groups.

		Male group		Female group		Diff. betw. gr. (M−F)	
Variable	Period[1]	Mean ±	S.E.M.	Mean ±	S.E.M.	Mean ±	S.E.M.
Adrenaline ng/min	A	8.67	0.55	5.50	0.31	3.17***	0.62
	B	14.37	1.57	6.09	0.51	8.28***	1.63
	C	5.69	0.68	3.86	0.33	1.83*	0.75
	$B-\frac{A+C}{2}$	7.19***	1.15	1.41***	0.28	5.78***	1.18
	A−C	2.98***	0.47	1.64***	0.26	1.34*	0.53
Noradrenaline ng/min	A	24.96	1.08	22.71	1.09	2.25ns	1.52
	B	35.68	1.62	29.57	1.73	6.11*	2.34
	C	28.28	1.26	22.39	1.36	5.89**	1.83
	$B-\frac{A+C}{2}$	9.06***	0.94	7.02***	0.94	2.04ns	1.31
	A−C	−3.31***	0.76	0.32ns	0.73	−3.63***	1.04
Urinary creatinine mg/min	A	1.25	0.03	0.88	0.02	0.37***	0.03
	B	1.29	0.04	0.82	0.03	0.47***	0.04
	C	1.33	0.06	0.82	0.03	0.51***	0.05
	$B-\frac{A+C}{2}$	0.00ns	0.03	−0.03ns	0.03	0.03ns	0.04
	A−C	−0.08ns	0.05	0.06*	0.03	−0.14**	0.05
Urine volume ml/min	A	1.20	0.10	1.66	0.18	−0.46*	0.20
	B	1.70	0.15	2.25	0.19	−0.55*	0.24
	C	0.80	0.05	0.71	0.07	0.09ns	0.09
	$B-\frac{A+C}{2}$	0.70***	0.13	1.06***	0.15	−0.36ns	0.20
	A−C	0.40***	0.10	0.95***	0.17	−0.55**	0.19
Specific gravity (N—1)×1000	A	20.96	0.99	12.80	1.19	8.16***	1.49
	B	15.37	1.03	8.69	1.00	6.68***	1.40
	C	22.02	0.76	18.50	0.94	3.52**	1.16
	$B-\frac{A+C}{2}$	−6.12***	0.73	−6.96***	0.91	0.84ns	1.12
	A−C	−1.06ns	0.92	−5.70***	1.28	4.64**	1.51

For each determination except the urinary creatinine levels (30 males and 26 females), there were 46 males and 45 females being tested.
[1] *A* stands for the period 0—1 1/2 hours; *B*, 1 1/2—3 hours; and *C*, 3—4 1/2 hours.

ferences between the groups as to changes in questionnaire scores during the experiment.

The questionnaire scores for "agitation" increased slightly but significantly during the film period, similarly in both groups. No significant differences were found between the groups (table 4:3).

4.4.1.6 Expectancy

The mean "expectancy" scores were significantly higher in the males prior to, as well as during, the film period. Expectancy increased significantly in both groups during the film period, the increase, however, being significantly more pronounced in the male group (table 4:3).

4.4.2 Physiological variables

4.4.2.1 Adrenaline excretion

As shown in table 4:4 and figure 4:2, the adrenaline excretion of the male group increased markedly and significantly during the film period. The corresponding increase in the female group, although reaching the same level of significance, was markedly and significantly smaller. Both sex-

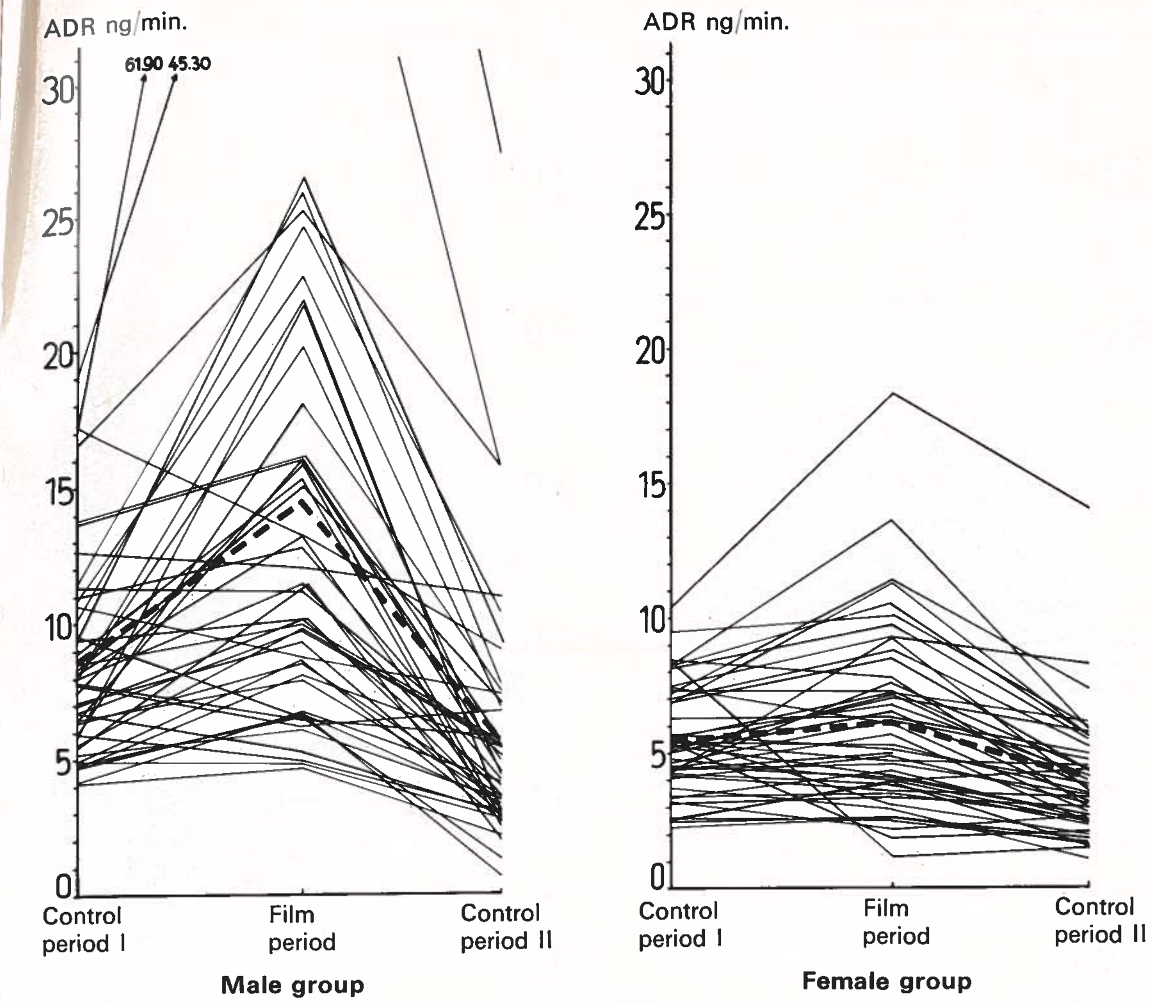

Figure 4:2. Individual values for urinary adrenaline excretion in males (left) and in females (right) during visual sexual stimulation and during control conditions. Dashed line indicates mean values.

es displayed a significant fall from the first to the second control period. The excretion levels of the males were significantly higher than those of the females throughout the experiment.

4.4.2.2 Noradrenaline excretion

Table 4:4 and figure 4:3 demonstrate that noradrenaline excretion increased markedly and significantly during the film period, the reaction being of the same magnitude in both groups. During the second control period, the noradrenaline excretion of the female but not of the male group returned to the level in the first control period. During the film period and during the second control period, the excretion level was significantly higher in the male group.

4.4.2.3 Urinary creatinine

The urinary creatinine excretion of the male group did not change significantly during the experiment. The female group, however, showed a significant decrease in creatinine excretion from the first to the second control period. The difference between the groups is significant in this respect. Throughout the experiment, the creatinine excretion of the female group was lower than that of the male (table 4:4).

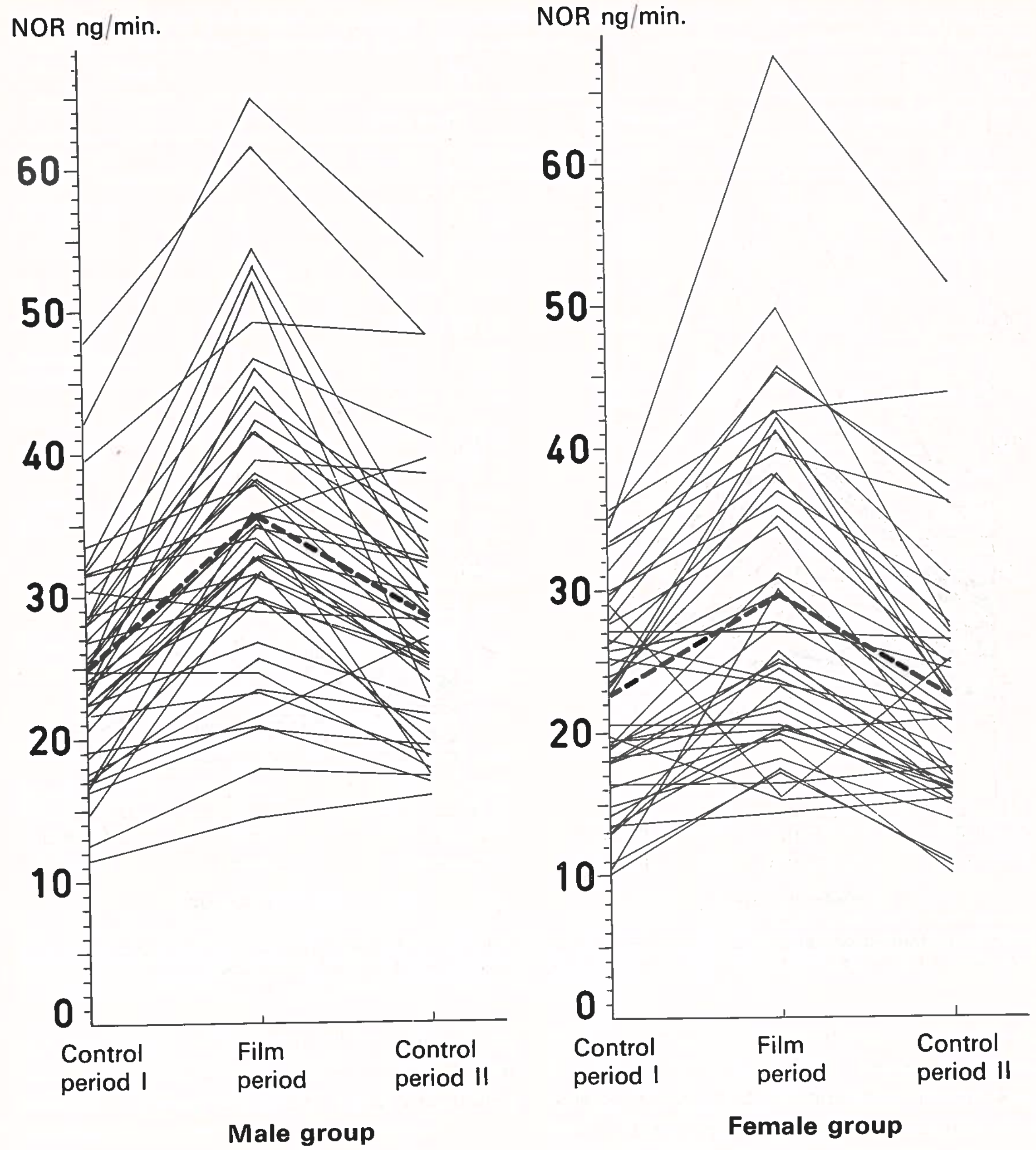

Figure 4:3. Individual values for urinary noradrenaline excretion in males (left) and in females (right) during visual sexual stimulation and during control conditions. Dashed line indicates mean values.

4.4.2.4 Urine flow

There was a marked and significant increase in urine flow during the film period, similar in both groups, and a marked and significant decrease from the first to the second control period, this being significantly more pronounced in the female group (table 4:4 and figure 4:4). During the first two periods, the urine flow was significantly higher in the female group.

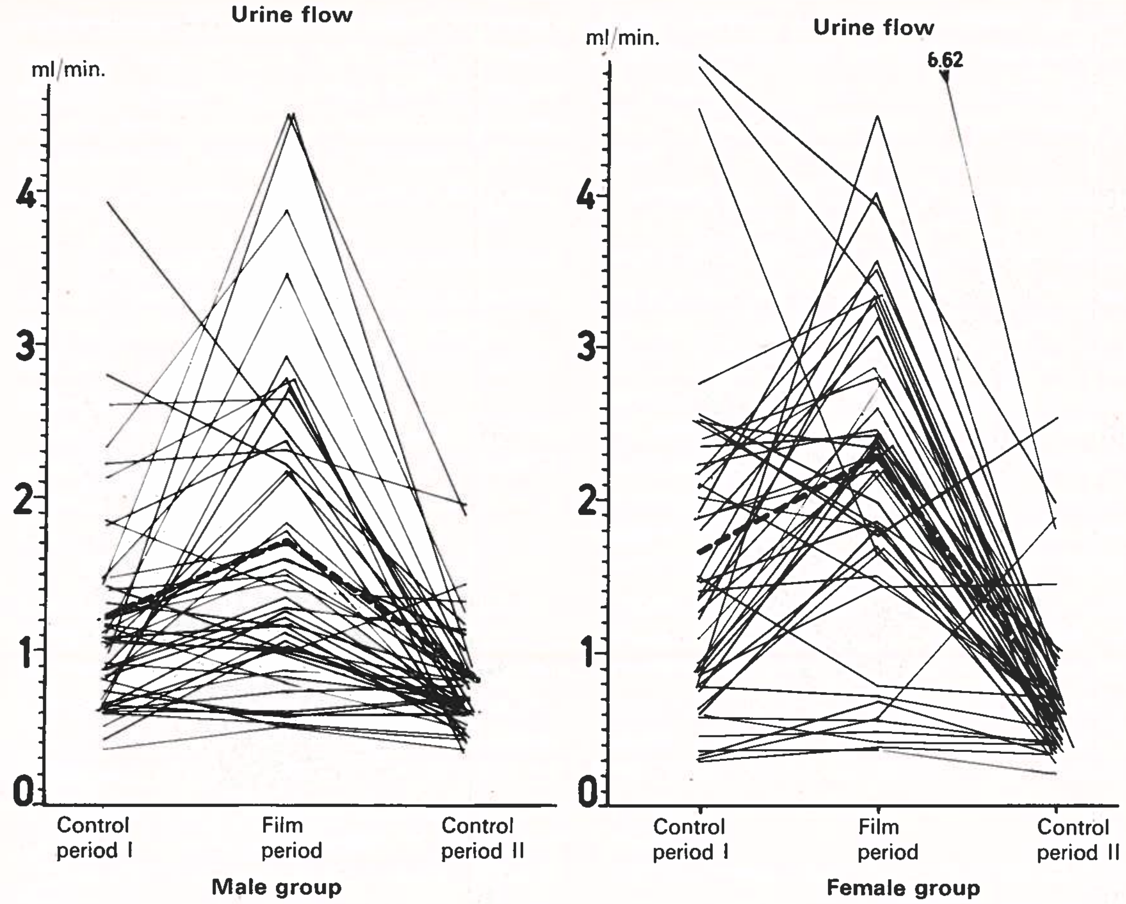

Figure 4:4. Individual values for urine flow in males (left) and females (right) during visual sexual stimulation and during control conditions. Dashed line indicates mean values.

4.4.2.5 Specific gravity

Urinary specific gravity decreased significantly and markedly during the film period, to a similar extent in both sexes. In the male group the increase in specific gravity from the first to the second control period was slight and nonsignificant. In the female group, however, there was a pronounced and highly significant increase, which was significantly higher than that of the male group. During the first two periods of the experiment, specific gravity was significantly lower in the female group than in the male (table 4:4 and figure 4:5).

4.5 Discussion

4.5.1 Sexual arousal and urinary excretion of adrenaline and noradrenaline

During the film period there was a significant rise in the urinary excretion of adrenaline as well as of noradrenaline in both sexes, probably reflecting an increase in sympathoadrenomedullary function (Euler, 1964).

The question is whether this rise is ascribable to an increase in sexual arousal. A number of alternative explanations should be considered.

Firstly, it might be argued that the catecholamine increases were a response, not to the

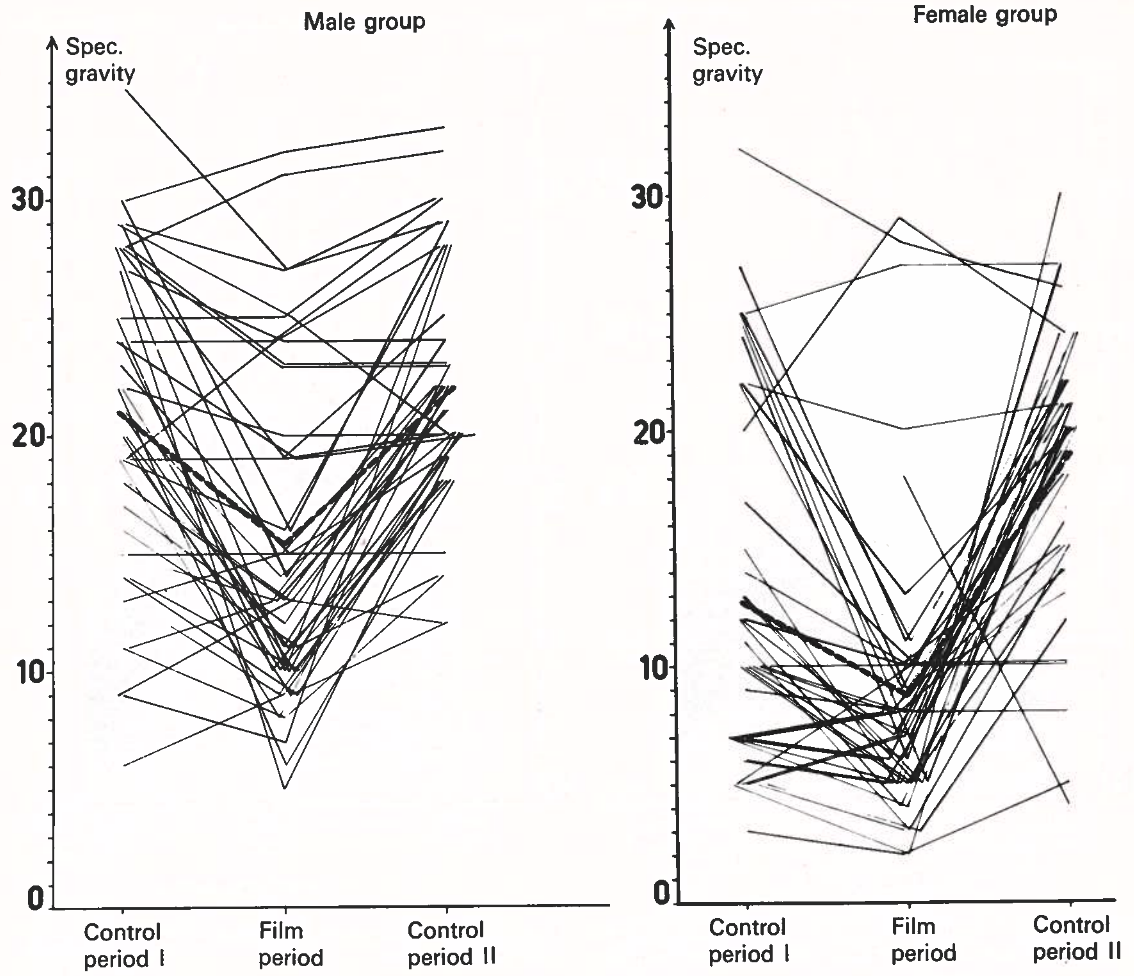

Figure 4:5. Individual values for urinary specific gravity in males (left) and females (right) during visual sexual stimulation and during control conditions. Dashed line indicates mean values.

specific qualities of the films shown, but to the cinematographic, experimental situation as such.

However, the results of an earlier experiment of similar design do not support this explanation (cf. Chapter 3): Bland natural-scenery films were shown to cause a significant *decrease* in the catecholamine excretion of healthy females. Thus, the *increases* found in the sex film experiment were probably not due to an unspecific influence of the cinematographic situation as such but to the emotional elements present in the film program.

Secondly, it is of course impossible to design a film program in such a way that sexual arousal is the only reaction to it in all subjects. Consequently, it may be argued that the changes in catecholamine excretion during the film period chiefly reflect emotional reactions other than the sexual ones. The film program, for instance, may have induced feelings of uneasiness. As seen from tables 4:2 and 4:3, such reactions were, indeed, reported to occur during the film period. However, if the catecholamine reactions are to be explained in terms of an emotional arousal of a predominantly non-sexual character, why did the male group react with a significantly stronger adrenaline increase than the female one, in spite of the fact that the few significant intergroup differences as to self-rated and reported non-sexual emotional reactions speak in favour of somewhat stronger unpleasurable feelings in the female group? There is no a priori reason to believe that the non-sexual reactions of the females—contrary to their report—were less pronounced than those of the males.

It is therefore considered more probable that the sexual arousal evoked by the experimental stimulus is, indeed, the main factor related to the increase in catecholamine excretion in both groups during the film showing.

The decrease in adrenaline excretion in both groups from the first to the second control period is probably at least in part due to diurnal variation (Levi, 1968).

4.5.2 Relationship between sexual arousal and sympathoadrenomedullary activity

For reasons mentioned in the introduction, our next problem concerns the *quantitative* relationship, if any, between sexual arousal and sympathoadrenomedullary activity. Needless to say, neither of these functions was accessible for direct measurement. The psychological reactions were presumably of a composite character and probably difficult to report correctly even for the rather sophisticated subjects participating in this study. Furthermore, such reports are bound to be influenced by the well-known disinclination or even disability of a number of people honestly to report reactions that are usually taboo or considered to be socially controversial. Finally, for reasons mentioned earlier, the subjects knew to what type of stimuli they were to be exposed and may have presumed that they were expected to react with sexual arousal. This cognitive factor may have contributed to this type of reaction at the expense of other types that were possibly experienced but perhaps less readily reported by the subjects. Accordingly, there is good reason why the subjects' self-ratings cannot be taken as a true index of what they actually experienced, and still less, of the total sexual arousal of the organism.

Neither can it be taken for granted that the urinary excretion of free catecholamines is a simple function of the total release of these hormones during the period of urine collection (cf. paragraph 2.14), even if this release is probably the major determinant of the amount excreted.

Against this background, it seemed unlikely that the correlation between these two sets of variables would be very high. Taking the correlation in the *female* group between the simultaneous changes in catecholamine excretion and sexual arousal during the film period in relation to the mean of the two control periods (B-[(A+C) $\div$ 2]), we found that $r = 0.27$ for adrenaline as well as for noradrenaline ($0.05 < p < 0.10$). The corresponding correlation coefficients were also calculated for the changes from the first to the second control period (A—C). Here, the product-moment correlation in the *female* group between sexual arousal and adrenaline was 0.34 ($p < 0.05$) and between sexual arousal and noradrenaline 0.38 ($p < 0.01$). The corresponding correlation coefficients for the changes from the first control period to the film period (B—A) were 0.38 ($p < 0.01$) and 0.29 ($0.05 < p < 0.10$) respectively.

The corresponding correlation coefficients in the *male* group were considerably lower, namely 0.11, 0.06, −0.16, 0.29, 0.13, and 0.13, respectively ($p > 0.05$), cf. table 4:5. The reason for this sex difference is not known. It is possible that the females gave more honest and reliable reports of their reactions than did the males. This would be in accord with the findings of Maslow (1965), indicating that "females were far more honest and open" and "found it easier . . . to talk about these things because their self-esteem is less involved". Of course, this need not be the only or even the main explanation. The matter no doubt deserves further study.

4.5.3 Sex differences in the reactions to visual sexual stimulation

Our data indicate that some individual females actually were more responsive to the stimuli used than any of the men in the sample, both with respect to psychological and to noradrenaline reactions. In general, however, the female group

Table 4:5. Correlation coefficients (r) between simultaneous changes in catecholamine excretion and self-rated sexual arousal in male and female groups.

Variable	Group	SEXUAL AROUSAL		
		$B-\frac{A+C}{2}$	A−C	B−A
Adrenaline	Males	0.11^{ns}	0.16^{ns}	0.13^{ns}
	Females	$0.27^{(*)}$	0.34^{*}	0.38^{**}
Noradrenaline	Males	0.06^{ns}	$0.29^{(*)}$	0.13^{ns}
	Females	$0.27^{(*)}$	0.38^{**}	$0.29^{(*)}$

A stands for the period 0−1 1/2 hours; *B* for 1 1/2−3 hours; and *C* for 3−4 1/2 hours.
(*) = $0.05 < p < 0.10$

reacted less than the male group, both with respect to reported sexual arousal (figure 4:1 and table 4:2) and to adrenaline excretion (figure 4:2 and table 4:4).

This might be explained by assuming that in females sexual arousal is not—as in males—related to the function of the sympathoadrenomedullary system. However, the fact that the catecholamine changes in the female group are positively and significantly correlated to the changes in sexual arousal runs counter to such an assumption.

A number of other possible or probable explanations of the sex difference in catecholamine excretion remain to be discussed. One hypothesis is that females are adrenomedullarily *less reactive,* at least in response to psychological stimulation. Such a female adrenomedullary "hyporeactivity" has, indeed, been demonstrated in response to mental work (Frankenhaeuser, 1972). True, both sexes have been shown to excrete similar amounts of 3-methoxy-4-hydroxy-mandelic acid—one of the major catecholamine metabolites—in response to stressor situations of a more potent type and with no performance involved, like exposure to cardiac catheterization (Schmid et al., 1965) and to dental treatment (Weiss et al., 1965). This, however, does not necessarily invalidate the "hyporeactivity" hypothesis.

A further possibility is that most females were not markedly aroused by the sex-film program because the stimulus situation lacked "romantic" elements. Such elements, however, were abundantly present in a study of similar design (Levi, 1967). In this study, 15 of the subjects who took part in the study reported in Chapter 3, were shown a program considered to be highly romantic and sensual, composed of love scenes from e.g. Dassin's "Fedra", Thomas' "The Wild and the Willing", Valcroze's "Le Coeur Battant", Schlesinger's "A Kind of Loving", and Malle's "Les Amants". The reason for selecting relatively short scenes from nine different films instead of choosing one complete normal-length film was the author's inability to find any single film that fulfilled the criteria of being exclusively characterized by joyous love and reasonably free from other elements such as tragedy, comedy and drama.

Briefly, this program proved still less effective in eliciting catecholamine responses in the group of 15 female office-clerks. However, this does not necessarily invalidate the explanation under discussion, because each of the nine film sequences might have been too short to allow identification and to provoke sexual arousal, or because what is needed to provoke such arousal in many females is the *combination* of "sexual" and "romantic" elements and not each element per se.

The sex differences might also be explained by arguing that the films were of a kind that primarily appeals to a male audience, in that the possibilities for identification are greater. However, the films used depicted the participation of both sexes to the same extent in a number of heterosexual activities, including undressing, nudity, petting, fellatio, cunilingus and coitus.

Thus, the identification possibilities were presumably much the same for subjects of both sexes.

Other hypothetical explanations of the sex difference with respect to changes in catecholamine excretion may include the factors of body weight and age (cf. paragraph 2.10). It has been shown, however, that the first of these factors is not significantly correlated to catecholamine excretion (Bergsman, 1959), while no significant difference existed between our two groups as regards the other.

The difference in sexual experience between the two groups, as presented in table 4:1, might also have contributed to this difference in reaction if one assumes that previous sexual experience "conditions" an individual to subsequent reactions to visual sexual stimuli. This assumption, however, is not supported by the results of a statistical comparison between the 31 "experienced" and 14 "inexperienced" female subjects as to changes (B-[(A+C) ÷ 2]) in sexual arousal and adrenaline excretion, the means and standard errors of the means being 3.6 ± 0.6 and 1.84 ± 0.41 for the "experienced" group and 3.2 ± 0.6 and 1.01 ± 0.40 for the "inexperienced" group, respectively ($p > 0.05$).

Thus, although *no firm conclusions* can be drawn, the author is inclined to interpret the present results as favouring Kinsey's hypothesis that females are generally less aroused than males in response to *visual* sexual stimulation (Dengrove, 1967; Sigusch et al., 1970).

4.5.4 Sexual arousal and renal function

Both sexes displayed a pronounced increase in urine volume during the film period as compared with the control periods, and a corresponding decrease in specific gravity. These changes cannot be ascribed to circadian variation or the hydration procedure, because a similarly designed control experiment without exposure to any experimental stimuli showed a steady decline in diuresis over time (Levi, 1968). Thus it seems reasonable to interpret the changes as being due to the stimuli presented in this experiment, i.e. the sex films. On the other hand, in another similary designed study (cf. Chapter 3), an increase in diuresis and a decrease in specific gravity were demonstrated in response to a number of other kinds of film programs.

Thus, the psychogenic diuresis (Miles et al., 1952) demonstrated in the film experiments (reported in Chapter 3) occurred in the present study as well (cf. table 4: 4).

The urine flow of the females was higher and the specific gravity lower than that of the males. This group difference is probably primarily a reflection of the females' significantly lower body weight (female and male means and S.E.M. being 56.8 ± 0.7 kg and 72.6 ± 0.8 kg, respectively), and consequently their higher intake of fluid/kg body weight.

However, one still has to explain the sex differences in *antidiuretic* reaction from the first to the second control period, when the decrease in urine flow and the increase in specific gravity were significantly more marked in the female group *in spite of* the higher degree of hydration. This might theoretically be due, in part, to a combined effect on renal haemodynamics of the catecholamines—which is different at different levels (cf. paragraph 2:13)—and of the antidiuretic hormone, the release of which is probably elevated during sexual excitation (Eränkö et al., 1953; Friberg, 1953).

The change in creatinine excretion between the two control periods is also significantly different in the two sexes, the males exhibiting a nonsignificant increase and the females a small but significant decrease, probably reflecting corresponding changes in glomerular filtration.

4.5.5 Non-sexual psychological reactions

The males' slightly higher scores of pleasurable feelings and slightly lower scores of unpleasurable ones are in accordance with the Kinsey hypothesis that men are more prone to sexual arousal from visual stimuli than women, there being a significant positive correlation between sexual arousal and pleasurability ratings (males: $r = 0.40$, $p < 0.05$; females: $r = 0.70$, $p < 0.01$). The higher expectancy ratings in the male group probably reflect the same general trend. Ratings of uneasiness, on the other hand, were generally very similar in both groups with respect to levels as well as to changes in levels. This runs counter to the common assumption that young females are disturbed more easily by the type of stimuli applied here than young males.

4.6 Summary

A total of 53 female and 50 male students were shown a 1 1/2-hour film program (comprising four short, silent, sexual films) preceded and followed by control periods of equal duration. Adrenaline and noradrenaline excretion increased significantly in both groups during the film period in relation to control levels before and after. During the film period, significant increases in sexual arousal were reported by both sexes, the self-rating scores as well as their increases, however, being significantly higher in the male group. This difference in reported sexual arousal was parallelled by a corresponding difference in the urinary excretion of adrenaline, both the excretion levels and the increases over the control levels being significantly higher in the males. Possible explanations for the sex differences are discussed. Changes that occurred in urine flow, specific gravity and creatinine excretion during and after this type of psychosexual stimulation are reported, as are some psychoendocrine relations. Their possible significance is discussed against the background of the Kinsey hypothesis that men are more prone than women to sexual arousal from visual stimuli.

4.7 Acknowledgements

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5 STRESSOR-INDUCED CHANGES IN PLASMA LIPIDS AND URINARY EXCRETION OF CATECHOLAMINES, AND THEIR MODIFICATION BY NICOTINIC ACID

By Lars A. Carlson, Lennart Levi and Lars Orö

5.1 The problem

Chronic exposure of man to various psychosocial stimuli leads to increased plasma concentrations of cholesterol (Friedman et al., 1958; Thomas and Murphy, 1958; Wertlake et al., 1958; Grundy and Griffin, 1959 a) and very low density lipoproteins (Grundy and Griffin, 1959 b). Little is known about the *mechanism* of this psychosocially induced rise in plasma lipoproteins. The relevant data may be summarized as follows.

Distress reactions are accompanied by a considerable increase in the urinary excretion of adrenaline and noradrenaline, probably reflecting a corresponding release of catecholamines from the sympathoadrenomedullary system (cf. Levi, 1961; Euler, 1964; Levi, 1967 a; Levi, 1967 b). Catecholamines stimulate the mobilization of free fatty acids (FFA) from adipose tissue (cf. Havel and Goldfien, 1959; Carlson et al., 1965 a). Short-term emotional arousal in man, such as fear, anxiety, and psychosexual stimulation, has also been found to be accompanied by increased plasma levels of FFA (Bogdonoff et al., 1959; Cardon and Gordon, 1959; Bogdonoff et al., 1960 a). Plasma FFA are rapidly incorporated into triglycerides of the liver and of the plasma lipoproteins (cf. Carlson et al., 1965 a). The liver is probably the main site of formation of endogenous plasma lipoproteins (cf. Carlson et al., 1965 a). In the fasting state, when lipogenesis is low, FFA are the main precursors of the hepatic and plasma triglyceride fatty acids. An increased mobilization of FFA from adipose tissue, e.g. by catecholamines, leads to a rise in the triglyceride content of the liver (Friedman and Byers, 1960; Feigelson et al., 1961; Carlson and Liljedahl, 1963; Carlson et al., 1965 b) and plasma (Friedman and Byers, 1960; Carlson et al., 1965 b). Prolonged treatment with catecholamines also leads to hyperlipoproteinemia.

These data suggest the following *hypothesis* for the mechanism underlying the hyperlipoproteinemia induced by psychosocial stimuli. Exposure to such stimuli can evoke an increase, mainly mediated by the sympathoadrenomedullary system, in the mobilization of FFA from adipose tissue. As a result, the amount of triglycerides in the liver increases, thereby stimulating the secretion into plasma of triglycerides from this organ. Ultimately, plasma triglyceride levels rise, as do the levels of other lipoprotein constituents, e.g. cholesterol.

5.2 Choice of methodology

One way of testing this hypothesis would be to expose subjects to psychosocial stimuli of relatively short duration and moderate intensity (Levi, 1961), to make sure that this exposure does, indeed, evoke distress reactions, and to study the effect, if any, on catecholamine excretion [as an index of sympathoadrenomedullary activity, cf. Euler (1964)] and on the concentration in arterial plasma of FFA, triglycerides, and cholesterol. In order to assess the role of FFA mobilization in this context, the effect of an antilipolytic agent (nicotinic acid) on psychosocially induced responses of the plasma lipids might be studied, as nicotinic acid is known to inhibit the stimulated FFA mobilization produced by exogenous catecholamines in vivo (Carlson and Orö, 1962; Carlson et al., 1963) and in vitro (Carlson, 1963 a; Carlson, 1965).

To accomplish this, we needed a set of psychosocial stimuli that could be assumed to be meaningful and potent enough to evoke moderate distress in most of the subjects but not so potent that their application would be unethical and/or would make it difficult to recruit subjects for the study.

Physiology and clinical medicine both make extensive use of various tests of stimulation, function and tolerance. Usually, various physical and chemical agents are utilized as stimuli—e.g. physical work, ACTH, insulin, cold, allergens, etc. In spite of the well-known fact that psychosocial stimuli, too, can strongly influence a variety of physiological variables, such stimuli have been used to only rather a limited extent in medical research and for diagnostic purposes (Levi, 1963).

There is growing awareness that working-life subjects many people to a wide variety of distress- and stress-provoking psychosocial stimuli (cf. Bronner and Levi, 1967; Carlestam and Levi, 1971). This would speak in favour of the application of such stimuli for our purposes, among other reasons because they are presumably experienced as meaningful, constituting part of most people's every-day experience. On the other hand, the need to obtain serial, fasting, arterial blood samples for the study of plasma lipids made it less practicable to conduct an investigation in a real-life work setting in a factory, workshop or office. We therefore preferred a laboratory setting that *simulates* some of the psychosocial elements of working-life.

Accordingly, the stimulus situation was designed to comprise simple, monotonous but attention-demanding routine work, that is affected to only a minor degree by learning and intelligence and requires no special training or skill, i.e. a common type of work in factories and workshops. The task involved two hours' sorting of 2000 steel balls of four different sizes, 14, 15, 16 and 17 thirtysecondths of an inch, making a difference of about 0.8 mm between any two consecutive sizes, which is possible but difficult to observe, makes the subject feel that he might be doing the work incorrectly, and confronts him with the necessity of making a great number of consecutive decisions. Imitating what seem to be pertinent environmental stimuli in industrial and craft work, the task would be performed in the presence of a realistic and presumably disagreeable industrial noise (97-104dB-C), variations in intensity of a dazzling light, rush due to a considerable shortage of time, and continuous critical observation (cf. Levi, 1961). The study was conducted in 1962 and 1963. Preliminary notes on some of the results have been published (Carlson, 1964; Carlson et al., 1965 a; Carlson et al., 1967). This chapter is based on relatively comprehensive accounts published more recently (Carlson et. al., 1968; Levi, 1970).

5.3 Material and methods

The subjects were selected from patients consulting a medical out-patient clinic for minor complaints. With the exception of 10 subjects, who were hypertensive (during the first 2-hour period of our study they had a diastolic blood pressure ranging between 100 and 130 mm Hg), the 33 middle-aged males finally selected were free from cardiovascular, endocrine, metabolic, or any other serious disease as judged from history, physical examination, and routine laboratory investigations of blood and urine. No subject was on any regular drug. The ECG at rest was normal in all subjects.

These subjects were chosen instead of so-called normal, healthy volunteers partly because they were already familiar with being subjected to medical procedures, so that an additional procedure would not be an entirely novel experience. In addition, the present study was envisaged as part of an extended research program to which two of the authors planned to re-invite these subjects. Before consenting to participate in the present study, the subjects had received detailed written and oral information and instructions about its nature and purpose.

The subjects were divided into three equal-sized groups, so that means and variations with respect to age, blood pressure, and levels of plasma triglycerides and cholesterol were similar in all groups (tables 5:1 and 5:2).

The 11 control subjects sat comfortably for the three 2-hour periods of the experiment; no stressors or treatments were introduced (*control group*).

Eleven subjects spent the first and the third 2-hour period relaxing and resting but underwent the experimental work procedure as described below during the second of the three 2-hour periods, without, however, receiving nicotinic acid (*untreated stress group*).

The remaining 11 subjects (*treated stress group*) also underwent the control and experimental procedures indicated above. In addition, this group was given during the week prior to the experiment proper, nicotinic acid in increasing dosage, up to a maximum of 1 g three times daily, reached after 4—5 days. The last pre-experimental nicotinic acid dose was taken approximately 16 hours before the beginning of the 6-hour experiment proper. During this experiment, starting 30 minutes after its beginning, these subjects were further given six doses of 0.5 g of nicotinic acid by mouth at intervals of 30 minutes, as indicated in Figure 5:1. The pretreatment mentioned above was given in order to minimize and accustom the subjects to the flush produced by the drug. Otherwise the unpleasantness of the flush, if experienced during the actual experiment, might have interacted with the psychosocial stimuli in their effects on the variables under study.

The subjects reported at the laboratory at 7 a.m. after fasting overnight and refraining from food, tobacco, coffee, and tea in the morning. An arterial catheter was placed in the left brachial

Table 5:1. Age, blood pressure, heart rate, and FFA in the three groups at the start of the first control period (0 hours). Mean values (MV), standard errors of the mean (SEM), and ranges.

Group	Age	Blood pressure: Systolic	Blood pressure: Diastolic	Heart rate	FFA
	years	mm Hg		beats/min	meq/liter
Control					
MV ±SEM	49± 2	153± 8	91± 4	66± 2	0.64±0.08
Range	43−62	125−200	70−115	60−78	0.39−1.11
Untreated stress					
MV ±SEM	52± 2	164± 9	98± 5	61± 3	0.69±0.09
Range	32−57	110−205	70−125	50−80	0.48−1.50
Treated stress					
MV ±SEM	48± 3	146± 6	95± 5	68± 4	0.62±0.05
Range	32−59	120−190	70−120	54−96	0.47−0.94

Table 5:2. Plasma lipid levels in the three groups determined 3−8 weeks before and at the start of the experiment (0 hours). Mean values (MV) ± SEM.

	3−8 weeks before the experiment		0 hours: start of experiment		Change during the pre-experimental period	
Group	Triglycerides	Cholesterol	Triglycerides	Cholesterol	Triglycerides	Cholesterol
	mmoles/liter	mg/100 ml	mmoles/liter	mg/100 ml	mmoles/liter	mg/100 ml
Control						
MV ±SEM	1.89±0.17	293± 17	1.41±0.18	307± 14	−0.49±0.19*	14±22
Range	1.04−2.28	239−385	0.71−2.49	263−378	−1.28−0.30	−122−72
Untreated stress[1]						
MV ±SEM	2.09±0.14	288± 14	1.85±0.15	264± 14	−0.24±0.17	− 24±12
Range	1.49−2.80	252−386	1.31−2.65	208−342	−0.75−0.02	− 70−49
Treated stress[1]						
MV ±SEM	1.92±0.18	300± 17	1.18±0.15	198± 9	−0.73±0.13***	−102±22**
Range	1.07−2.66	231−388	0.68−2.08	171−240	−1.52−0.19	−217−17

[1] N = 9 since no pretreatment values were available in two subjects in each group.

Table 5:3. Self-rated distress during the second 2-hour period, involving rest for the control group but "work" conditions for the other two groups.

	Control group	Untreated stress gr.	Treated stress gr.
The most unpleasant experience I ever had (det obehagligaste jag varit med om)	0	0	0
Very pressing and unpleasant (mycket pressande och obehagligt)	0	2	0
Rather pressing and unpleasant (ganska pressande och obehagligt)	2	3	1
Rather trying but not actually unpleasant (ganska besvärligt men inte direkt obehagligt)	0	6	7
It did not bother me on the whole (jag var på det hela taget oberörd)	9	0	3
Total	11	11	11

artery; heparin was not used. The subjects were then allowed to rest for at least 1 hour, i.e. until 9 a.m., when the experiment proper started. The experimental procedure involved three consecutive 2-hour periods, the second being the *"work"* period for two of the groups, as indicated above. As indicated above, the task involved sorting small shiny steel balls of four very similar sizes in the presence of a loud industrial noise, variations in the intensity of a dazzling light, rush due to lack of time, and standardized criticism. The criticism was presented in writing 13 and 28 minutes after the beginning of the "work" period, the subjects being blamed for slowness and carelessness, respectively, at these times. During the *control* periods before and after this period (i.e. during the first and third 2-hour period) the subjects relaxed by reading a weekly magazine and listening to soft music. No food was served. At the beginning of each period, the subjects ingested 300 ml of tap water. Urine samples were collected at the end of each 2-hour period.

Serial blood samples were drawn into heparinized syringes every 15th or 30th min (figure 5:1

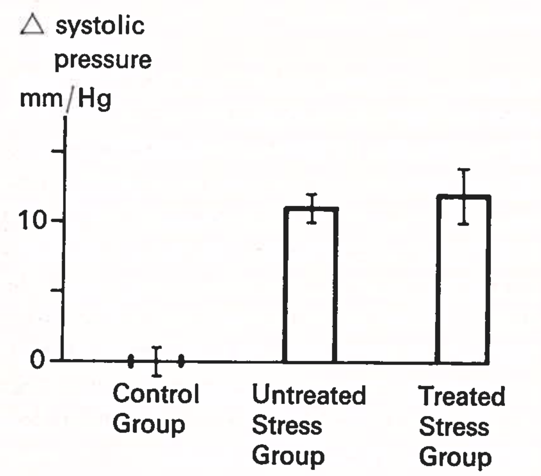

Figure 5:1. Mean ± standard error of the mean for the changes in systolic blood pressure during the first 15 minutes of the second 2-hour period in the control group (left), the untreated stressor-exposed group (centre) and the treated stressor-exposed group (right).

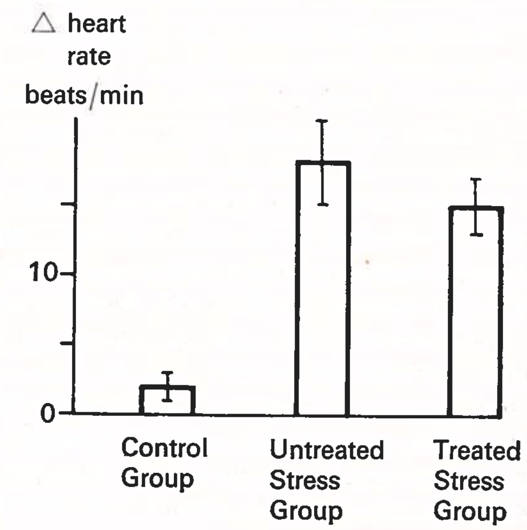

Figure 5:2. Mean ± standard error of the mean for the changes in heart rate during the first 15 minutes of the second 2-hour period in the control group (left), the untreated stressor-exposed group (centre) and the treated stressor-exposed group (right).

Table 5:4. Statistical comparison of means ± SEM and changes in urine volume, specific gravity, urinary creatinine, systolic and diastolic blood pressure, and heart rate in the three groups.

Group	Period[1]	Urine volume ml/min	Spec. gravity (N-1)×1000	Creatinine mg/min	Syst. blood pressure mm Hg	Diast. blood pressure mm Hg	Heart rate beats/min
Controls	A	3.10±0.57	8.0±1.3	1.14±0.10	147.6± 2.0	90.3± 4.4	65.8± 2.0
	B	2.24±0.26	7.8±1.1	1.02±0.05	138.4± 7.4	86.4± 4.5	65.1± 1.8
	C	1.79±0.18	8.8±1.4	1.08±0.06	138.0± 8.2	84.3± 6.2	65.1± 2.8
	B−A	−0.86	−0.2	−0.13	− 9.2**	− 3.9**	− 0.7
	B−C	+0.45	−1.0	−0.07	+ 0.4	+ 2.1	± 0.0
	A−C	+1.32*	−0.8	+0.06	+ 9.6*	+ 6.0	+ 0.7
Untreated Stress	A	3.10±0.41	8.6±2.0	0.90±0.06	158.8± 8.7	98.7± 5.2	62.7± 3.2
	B	1.53±0.27	11.6±1.8	0.86±0.05	153.8± 8.3	99.1± 5.6	76.6± 5.1
	C	2.18±0.29	8.4±2.2	1.03±0.15	156.3± 7.4	98.9± 4.7	64.9± 3.8
	B−A	−1.56***	+3.0	−0.04	− 5.0	+ 0.4	+13.8***
	B−C	−0.65*	+3.2	−0.17	− 2.4	+ 0.2	+11.6***
	A−C	+0.91*	+0.2	−0.13	+ 2.6	− 0.2	− 2.2
Treated Stress	A	3.75±0.40	7.9±1.9	1.19±0.06	143.4± 4.8	93.6± 2.9	69.4± 3.3
	B	2.61±0.45	9.8±2.0	1.04±0.06	144.4± 4.4	95.9± 2.3	79.3± 3.1
	C	1.64±0.30	12.4±2.5	0.99±0.06	141.6± 4.0	95.9± 2.9	69.2± 2.8
	B−A	−1.15	+1.9	−0.14	+ 1.0	+ 2.3	+ 9.8***
	B−C	+0.97*	−2.6	+0.05	+ 2.7	± 0.0	+10.1***
	A−C	+2.11***	−4.5	+0.20*	+ 1.7	− 2.3	+ 0.3
Group differences							
Untreated Stress minus Controls	A	±0.00	+0.6	−0.24	+11.2	+ 8.4	− 3.1
	B	−0.71	+3.8	−0.15	+15.4	+12.7	+11.4*
	C	+0.40	−0.4	−0.05	+18.3	+14.6	− 0.2
	B−A	−0.71	+3.2	+0.09	+ 4.2	+ 4.3	+14.6***
	B−C	−1.10**	+4.2*	−0.11	− 2.9	− 1.9	+11.6***
	A−C	−0.40	+1.0	−0.19	− 7.1	− 6.2	− 2.9
Treated Stress minus Controls	A	+0.65	−0.1	+0.04	− 4.3	+ 3.3	+ 3.6
	B	+0.37	+2.0	+0.03	+ 5.9	+ 9.6	+14.2***
	C	−0.14	+3.6	−0.09	+ 3.6	+11.6	+ 4.1
	B−A	−0.29	+2.1	−0.02	+10.2**	+ 6.2	+10.6***
	B−C	+0.51	−1.6	+0.12	+12.3	− 2.1	+10.1***
	A−C	+0.80	−3.6	+0.14	− 7.9	− 8.3*	− 0.4
Untreated Stress minus Treated Stress	A	−0.66	+0.7	−0.29**	+15.4	+ 5.1	− 6.7
	B	−1.08	+1.8	−0.18	+ 9.4	+ 3.2	− 2.7
	C	+0.54	−4.0	+0.05	+14.6	+ 3.0	− 4.3
	B−A	−0.42	+1.1	+0.10	− 6.0	− 1.9	+ 4.0
	B−C	−1.62**	+5.7*	−0.23	− 5.2	+ 0.2	+ 1.6
	A−C	−1.20*	+4.6	−0.33*	+ 0.8	+ 2.1	− 2.4

[1] *A* stands for the period from 0−2 hours, *B* for 2−4 hours, and *C* for 4−6 hours.

and table 5:4), immediately centrifuged, and the plasma lipids were extracted. FFA were determined by the method of Dole (1956) as modified by Trout et al. (1960), total cholesterol according to Sperry and Webb (1950) and Carlson (1960), and triglycerides by the method of Carlson (1960 and 1963 b).

During the first 2-hour period, the subjects were asked how they felt "now, immediately before the start of the test". After the second 2-hour period, the subjects were asked how they felt "during the test". During this period observations were made every 10 minutes by one of the authors concerning the "level of general emotional arousal" manifested by the subjects.

5.4 Results

5.4.1 The pre-experimental period: changes in plasma triglycerides and cholesterol

As indicated earlier, the subjects were assigned to the three groups so that means and variations with respect to blood lipid levels, i.e. the levels found during the screening procedure 3—8 weeks

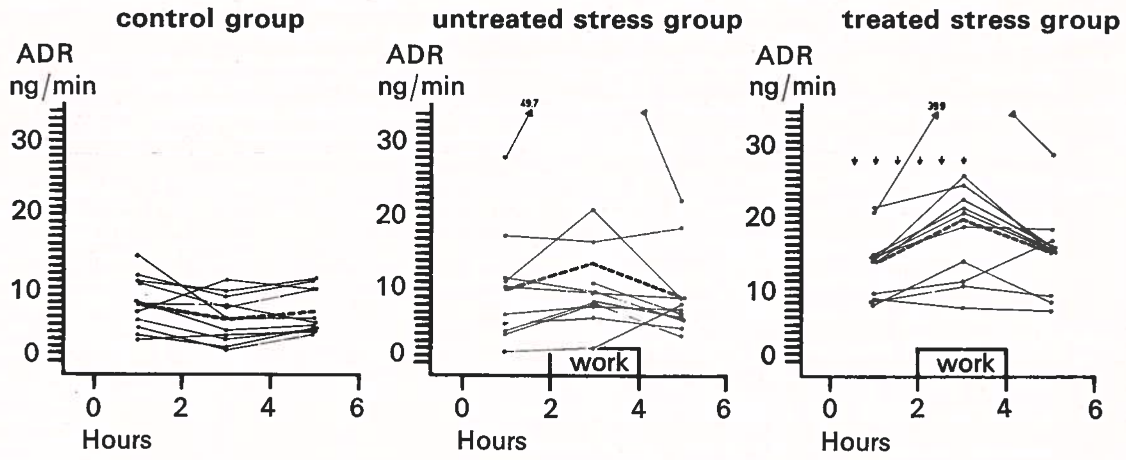

Figure 5:3. Individual values for the excretion of adrenaline during the three 2-hour periods in the control group (left), the untreated stressor-exposed group (centre) and the treated stressor-exposed group (right). Dashed line indicates means. Arrows indicate nicotinic acid administration (0.5 g 6 times, i.e. every 30 minutes in the treated stressor-exposed group).

before the actual experiment were similar in all groups (table 5:2). In the interval between this measurement and the actual experiment i.e. during the pre-experimental period, the triglyceride levels of the *control group* fell moderately but significantly. In the *untreated stress group,* there was no significant change. The reason for this difference in reaction pattern is not known but may have been due, at least in part, to a hypothetical, relative decrease in apprehension in the control group, in contrast to some similarly hypothetical, moderate but continuous apprehension in the untreated stress group, as both groups knew in advance the experimental procedure they were to undergo. The influence on the triglyceride levels may have been similar to that found in the experiment proper, as indicated below. Finally, the *treated stress group* showed a significant and pronounced fall in plasma triglycerides during the pre-experimental period, probably attributable to the remaining lipid-lowering effect of the *pretreatment* with nicotinic acid (Altschul et al., 1955).

5.4.2 The experiment proper

5.4.2.1 Some indices of distress reactions

During the first 2-hour (control) period, eight, eight and ten of the subjects in the control group, the untreated and the treated stress groups, respectively, reported that they felt "calm and unconcerned", generally in support of our assumption that this period would be characterized by feelings of calmness and equanimity. In contrast, the corresponding self-ratings with regard to the second 2-hour period demonstrate moderate distress reactions in most of the subjects belonging to the untreated and treated stress groups but in only a few in the control group, see table 5:3. While performing the observations mentioned in paragraph 5.3 we found it most difficult to quantify the distress reactions, if any, of our subjects on the basis of their gross behaviour. Suffice it to say that these observations, crude as they were, are generally in agreement with the data from the self-ratings, indicating that both stressor-exposed groups probably experienced moderate distress during the work period whereas the control subjects during the corresponding period were relatively unconcerned.

5.4.2.2 Some indices of cardiovascular reactions

The *blood pressure* (figure 5:1) of the *untreated stress group* increased significantly when measured 15 minutes after the start of exposure to "work" conditions. Systolic blood pressure increased by 12±2 mm Hg and diastolic blood pressure by 9±2 mm Hg ($p < 0.001$ and $p < 0.01$, respectively) from the values found just before

Table 5:5. Statistical comparisons of means $\bar{x}$± SEM and changes in plasma FFA, triglycerides and cholesterol, and urinary adrenaline, and noradrenaline in the three groups.

Group	Period[1]	Free fatty acids[2] meq/liter × 100	Triglycerides[3] mmole/liter	Cholesterol[3] mg/100 ml	Adrenaline ng/min	Noradrenaline ng/min
Controls	A	78.6± 6.2	1.24±0.19	308± 10	7.62± 1.10	23.4± 4.1
	B	79.6± 6.2	1.21±0.17	296± 11	5.59± 0.96	23.6± 2.9
	C	82.2± 6.4	1.22±0.17	292± 12	6.57± 0.90	24.3± 2.9
	B−A	+ 1.0	−0.02	− 12	− 2.04	+ 0.2
	B−C	− 2.6	−0.01	+ 5	− 0.98	− 0.7
	A−C	− 3.6	+0.02	+ 16*	+ 1.05	− 0.9
Untreated Stress	A	71.0± 6.5	1.78±0.15	271± 13	9.53± 2.37	23.8± 2.8
	B	82.9± 6.2	1.88±0.15	278± 12	13.31± 3.94	33.1± 3.6
	C	93.2± 3.9	2.00±0.18	268± 14	8.85± 1.72	28.2± 3.8
	B−A	+11.9**	+0.10	+ 7	+ 3.78	+ 9.3***
	B−C	−10.3*	−0.12	+ 10	+ 4.46	+ 4.9
	A−C	−22.2***	−0.22*	+ 3	+ 0.68	− 4.4
Treated Stress	A	45.2± 2.8	1.24±0.15	199± 7	13.39± 1.39	29.0± 2.4
	B	27.6± 2.3	1.07±0.13	201± 9	19.52± 2.70	42.0± 3.9
	C	27.4± 2.1	0.99±0.12	200± 11	14.96± 1.73	32.0± 2.6
	B−A	−17.6***	−0.17	+ 2	+ 6.13**	+13.1***
	B−C	+ 0.2	+0.08	+ 1	+ 4.57*	+10.0**
	A−C	+17.7***	+0.25*	− 2	− 1.57	− 3.1
Group differences	A	− 7.6	+0.55*	− 37*	+ 1.91	+ 0.3
	B	+ 3.4	+0.66**	− 18	+ 7.73	+ 9.5
Untreated Stress minus Controls	C	+11.0	+0.78**	− 23	+ 2.28	+ 3.9
	B−A	+10.9*	+0.12	+ 19*	+ 5.82*	+ 9.2
	B−C	− 7.6	−0.12	+ 5	+ 5.45	+ 5.6*
	A−C	−18.6**	−0.23**	− 13	− 0.37	− 3.6
Treated Stress minus Controls	A	−33.4***	±0.00	−109***	+ 5.77**	+ 5.5
	B	−51.9***	−0.15	− 95***	+13.94***	+18.4**
	C	−54.7***	−0.23	− 91***	+ 8.39***	+ 7.7
	B−A	−18.6***	−0.15	+ 14	+ 8.17***	+12.9*
	B−C	+ 2.8	+0.09	− 4	+ 5.55**	+10.7***
	A−C	+21.4***	+0.23*	− 18	− 2.62	− 2.2
Untreated Stress minus Treated Stress	A	+25.8**	+0.54*	+ 72***	− 3.86	− 5.2
	B	+55.3***	+0.81***	+ 77***	− 6.21	− 8.9
	C	+65.7***	+1.01*	+ 68**	− 6.11*	− 3.8
	B−A	+29.4***	+0.27*	+ 5	− 2.35	− 3.7
	B−C	−10.4*	−0.20*	+ 10	− 0.10	− 5.1
	A−C	−39.9***	−0.47***	+ 5	+ 2.25	− 1.4

[1] *A* stand for the period from 0—2 hours, *B* for 2—4 hours, and *C* for 4—6 hours.
[2] Mean values calculated on the basis of six measurements (period A), eight measurements (period B), or five measurements (period C) in each subject.
[3] Mean values calculated on the basis of three measurements (period A) or two measurements (periods B and C) in each subject.

exposure started. In the *treated stress group* the corresponding increases were 14±4 mm Hg and 9±2 mm Hg ($p < 0.01$ and $p < 0.001$, respectively). The *control group* exhibited no corresponding change.

The experimentally induced blood pressure reactions were of short duration. Comparing the *mean* blood pressure during each of the three 2-hour periods (table 5:4), the changes between periods were not significant in either of the two work-exposed groups. The control group showed significant decreases of the mean systolic and diastolic blood pressures. The differences in levels and reactions between the two work-exposed groups were not statistically significant; neither were the corresponding differences between the untreated stress group and the control group.

Exposure to the experimental work conditions

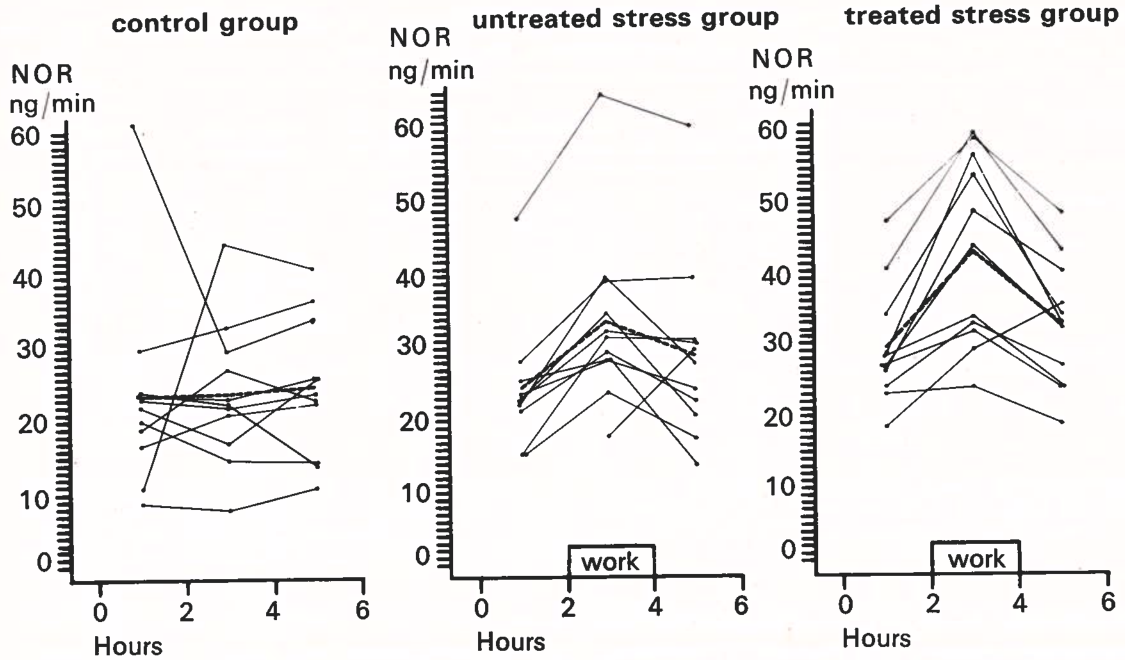

Figure 5:4. Individual values for the excretion of noradrenaline during the three 2-hour periods in the control group (left), the untreated stressor-exposed group (centre) and the treated stressor-exposed group (right). Dashed line indicates means.

was accompanied by significant accelerations in *heart rate*, the levels and responses being of the same magnitude in both exposed groups (figure 5:2 and table 5:4). The heart rate of the control group remained on a constant level throughout the experiment, significantly below that during the work period for the two exposed groups.

5.4.2.3 Some indices of sympathoadrenomedullary and renal reactions

In the *control group,* urinary *adrenaline excretion* decreased during the second 2-hour period, although the change was not significant (table 5:5). In the *untreated stress group* there was a non-significant increase during the same period, while the increase in the *treated stress group* was significant, cf. figure 5:3.

During the first control period, the adrenaline excretion was significantly higher in the *treated stress group* than in the *control group* (table 5:5). Otherwise, there were no significant differences between the adrenaline levels of different groups during this period.

Comparing the changes in adrenaline excretion in the three groups, no significant differences were found between the two work-exposed groups, while the reactions of both groups during the second 2-hour period differed significantly from those displayed by the control group (table 5:5).

The *noradrenaline excretion* of the control group remained largely unchanged throughout the experiment (table 5:5), whereas in the other two groups it increased significantly and similarly during work exposure (figure 5:4). During the first 2-hour period the level of noradrenaline excretion was much the same in all three groups.

The *urine volume* in all three groups decreased significantly between the first and the third of the three 2-hour periods. Table 5:4 lends some support to the hypothesis that both work exposure and nicotinic acid treatment affect urine flow. As to urinary *specific gravity,* no significant changes occurred in any group, though the general trend corresponded to that for urine flow, cf. table 5:4.

Creatinine excretion decreased significantly in the treated stress group from the first to the third 2-hour period of the experiment (table 5:4). Apart

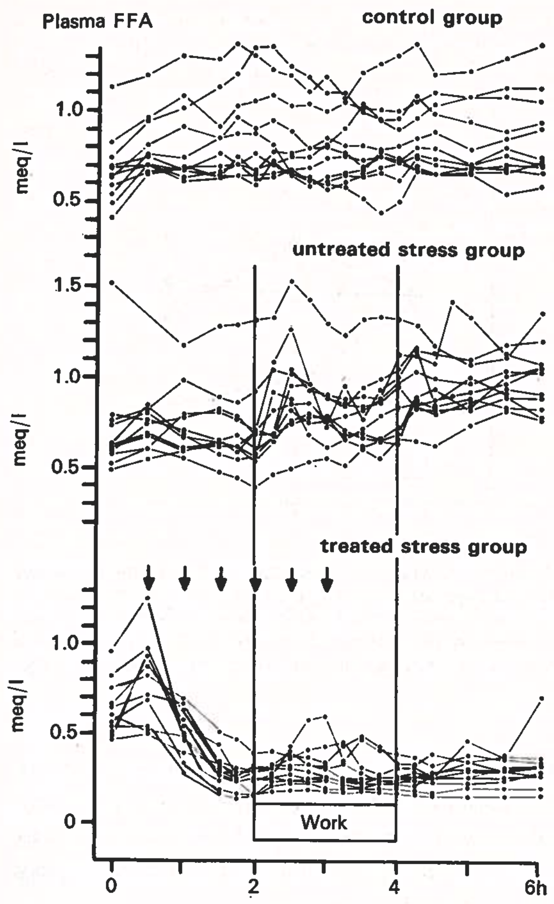

Figure 5:5. Individual values for arterial plasma levels of free fatty acids in the control group (top), the untreated stressor-exposed group (centre) and the treated stressor-exposed group (bottom). Arrows indicate nicotinic acid administration (0.5 g 6 times, i.e. every 30 minutes in the treated stressor-exposed group).

from this, there were no significant changes in any of the groups. During the first 2-hour period, when the administration of nicotinic acid started, the group receiving this exhibited a significantly higher creatinine excretion than the untreated stress group, but during the last two 2-hour periods there were no differences between the groups.

5.4.2.4 Free fatty acids, triglycerides and cholesterol in arterial plasma

In the *control group* the concentration of *free fatty acids* remained largely unchanged throughout the experiment. In the *untreated stress group,* FFA remained constant during the first 2-hour

Table 5:6. Changes in arterial concentration of FFA (in meq/l × 100) from 2 hours (just prior to start of the work period for two of the groups) and onwards.

FFA concentration at 2 hours	Controls	Untreated Stress	Treated Stress
2 hours	83±8	68±7	24±7
2^{15}	2±2	12±3**	2±1*
2^{30}	—3±3	24±5***	5±2*
2^{45}	—6±4	17±4**	6±3
3^{00}	—5±4	11±3**	5±3
3^{15}	—5±5	9±3*	4±2
3^{30}	—5±6	10±3**	1±2
3^{45}	—5±6	13±4**	1±1
4^{00}	—5±5	20±4**	1±2
4^{15}	3±5	26±5***	1±1
4^{30}	9±6	21±5***	1±2
5^{00}	4±7	21±5***	4±2
5^{30}	0±8	27±5***	3±2
6^{00}	1±7	28±5***	7±2**

The changes are calculated on the individual changes and are expressed as means ±S.E.M. *, **, and *** indicate that $p < 0.05$, 0.01 and 0.001, respectively, for the statistical significance of the changes *from 2 hours.*

period and increased significantly during and after work exposure (figure 5:5, table 5:6). In the *treated stress group,* the concentration of FFA fell during the first 2-hour period, when nicotinic acid treatment started (figure 5:5), reaching a mean level of 0.24±0.07 meq/liter immediately before the start of work exposure; there was no significant rise in 2-hour means during or after the work period (table 5:6). The absolute levels of FFA were significantly lower in the treated stress group than in the other two groups during the last two 2-hour periods.

Throughout the experiment, the *triglyceride* levels of the *control group* remained unchanged, whereas those of the *untreated stress group* increased significantly towards the end, the levels being significantly higher in the latter group throughout the experiment. In the *treated stress group,* on the other hand, the triglyceride level decreased progressively and significantly. The contrasting behaviour of the triglycerides in the *untreated stress group* and the *treated stress group* is summarized in figure 5:6; the group differences in respect of both the levels and the changes are highly significant throughout the study (table 5:5).

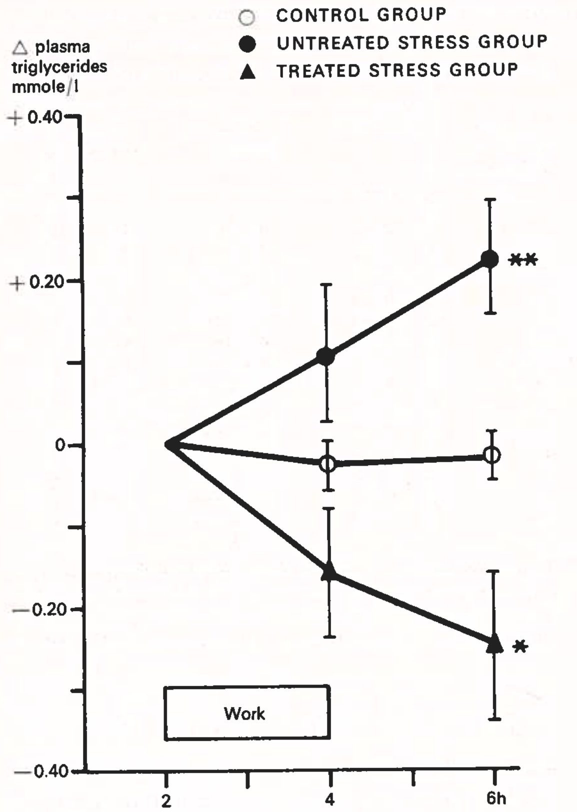

Figure 5:6. Mean ± standard error of the mean for the changes in plasma triglycerides during and after the second 2-hour period, which was designed to induce distress in the untreated and treated stressor-exposed groups but not in the control group. * and ** indicate that $p < 0.05$ and 0.01, respectively.

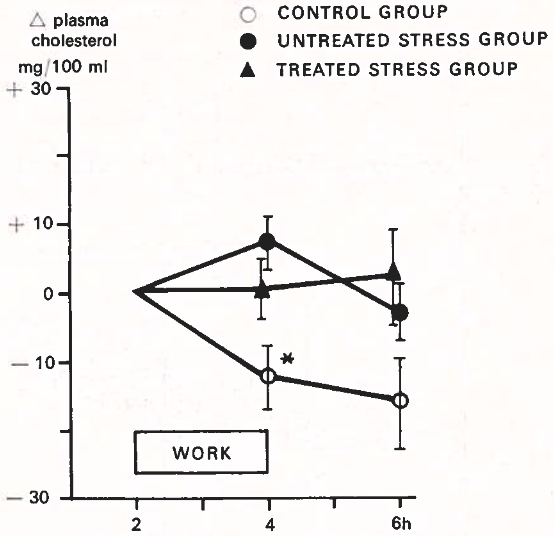

Figure 5:7. Mean ± standard error of the mean for the changes in plasma cholesterol during and after the second 2-hour period, which was designed to induce distress in the untreated and treated stressor-exposed groups but not in the control group. * indicates that $p < 0.05$.

The plasma *cholesterol* levels fell slightly towards the end of the experiment in the *control group* (table 5:5 and figure 5:7), but there were no significant changes in either the *untreated stress group* or the *treated stress group*. The cholesterol levels of the treated stress group were significantly lower than those of the other groups throughout the experiment. The difference between the decrease from the first to the second 2-hour in the control group and the corresponding increase in the untreated stress group is statistically significant ($p < 0.05$), cf. table 5:5.

5.5 Discussion

5.5.1 Some general considerations

As demonstrated above, the simulated work conditions provoked, in most of the subjects exposed to these conditions, (a) distress reactions, (b) cardiovascular reactions, and (c) sympathoadrenomedullary reactions. These reactions were not modified by nicotinic acid treatment, at least not to a marked degree.

Concomitantly with the reactions mentioned above, FFA and triglycerides in arterial plasma rose significantly. This rise was significantly and markedly modified by nicotinic acid treatment.

5.5.2 Distress, sympathoadrenomedullary activity, lipid metabolism, and nicotinic acid

The exposure to experimental psychosocial stimuli caused a significant increase in the concentration of *free fatty acids* both during and after the work period in the *untreated stress group* but not in the *treated stress group* (means for 2-hour periods). The FFA increase was probably caused by an increased mobilization from adipose tissue.

According to our hypothesis (p. 91), increased activity of the sympathetic nervous system plays a significant role in the increase of FFA concentration seen after exposure to psychosocial stimuli (cf. Bogdonoff et al., 1960 b). Thus, ganglionic blockade with Arfonad® inhibits the rise

in FFA during anxiety (Bogdonoff et al., 1960 b). In the untreated stress group there was a significant, positive correlation between the changes in adrenaline excretion and the changes in FFA levels between the first and the second 2-hour period ($r = 0.61$, $p < 0.05$). The corresponding correlations in the control group and in the treated stress group were, as expected, not significant ($r = 0.23$ and $r = 0.11$, respectively). The low correlation between these two variables in the treated stress group may have been caused by a selective nicotinic acid induced blockade of FFA without a corresponding influence on adrenal medullary function.

No significant correlation was found in any group between the corresponding changes in noradrenaline excretion and FFA levels. However, nothing is known about the relationship, if any, between increased sympathetic activity *locally* in adipose tissue and the urinary excretion of catecholamines. Furthermore, the urinary catecholamines provide an index of the *mean* sympathoadrenomedullary activity during the period of urine collection, whereas the blood samples inform about the *momentary* situation as regards lipid metabolism. Finally, other FFA mobilizing hormones may also have been released during and particularly after the work period and contributed to the changes in FFA level, cf. Robison et al. (1971).

The lowering effect of nicotinic acid on the concentration of FFA during the first 2-hour (resting) period is in accordance with previous results in man (Carlson and Orö, 1962; Carlson et al., 1963). The decreased (but possibly not entirely blocked, cf. figure 5:5) response of FFA to psychosocial stimuli during nicotinic acid treatment suggests an inhibition of the stressor-induced enhancement of lipid mobilization (Carlson et al., 1963) due to inhibition of lipolysis in adipose tissue (Carlson, 1963 a; Carlson, 1965).

The exposure to psychosocial stimuli was accompanied by an acute rise in the plasma *triglyceride* concentration of the *untreated stress group*, without inducing concomitant changes in the *cholesterol* level, indicating an increase in the amount of triglyceride-rich but cholesterol-poor very low density lipoproteins. An increase in these lipoproteins that raises the plasma triglyceride content by 0.20 mmole/liter would increase the cholesterol concentration by only about 5 mg/100 ml. Such small changes in cholesterol concentration would not be detected with the technique used. Measurements of the concentration of plasma lipoproteins in medical students during stressful examination periods have shown (Grundy and Griffin, 1959 b) that the concentration of the cholesterol-rich low density lipoproteins (S_f0-12) was unaffected, while that of the triglyceride-rich very low density lipoproteins (S_f12-400) increased by 50 per cent. This is an accordance with our findings during short-term distress, and with those recently reported by Taggart and Carruthers (1971) from a study of racing-car drivers.

According to our hypothesis, there is an increased mobilization of FFA from adipose tissue during distress [and probably during "stress (Selye)"], eventually resulting in an elevated concentration of triglycerides in plasma. Our data support this hypothesis since the plasma triglycerides increased in the *untreated stress group*, in which the concentration of FFA increased, and decreased in the *treated stress group*, in which the concentration of FFA decreased. This decrease occurred before the stressor exposure and the FFA then remained at a low level throughout the study. The following rough calculations represent an attempt to evaluate the *quantitative* aspects of our hypothesis.

5.5.3 Plasma triglycerides and the mobilization of free fatty acids: some quantitative aspects

The increase in plasma triglycerides in the untreated stress group was approximately 0.20 mmole/liter from the start of the work period (at 2 hours) to the end of the experiment (at 6 hours). Assuming that the plasma volume was 3 liters, the mean *increase* of triglycerides in plasma works out as $3 \times 0.2 = 0.6$ mmole, which corresponds to $3 \times 0.6 = 1.8$ meq of fatty acids. Similarly, the plasma pool of triglyceride fatty acids is calculated to have *decreased* by 2.2 meq in the treated stress group. If our hypothesis is correct, the amount of FFA taken up by the liver must thus have changed by at least 2 meq in both the untreated stress group and in the treated stress group. To calculate the changes in the influx of FFA to the liver, let us assume (a) that 25 per cent of the FFA turnover is taken up by the liver (Carlson and Ekelund, 1963), and (b) that the fractional turnover rate of FFA at rest and during the work period in the untreated stress group was 0.30/minute (Fredrickson and Gordon, 1958), rising to 0.40/minute during administration of nicotinic acid when the FFA level was around 0.30 meq/liter (Carlson et al., 1963). The amount of FFA taken up by the liver at rest was thus $0.25\times0.30\times0.7\times3\times60 \approx 10$ meq/hour.

In the untreated stress group the FFA level increased to about 0.9 meq/liter for 4 hours. The increase above the resting state of the influx of FFA to the liver was thus: $(0.25\times0.30\times0.9\times3\times60\times4)—(10\times4) \approx 10$ meq/liter. In the treated stress group, the FFA level was reduced to 0.3 meq/liter for approximately 4.5 hours. As above, it can be estimated that the hepatic uptake of FFA during this time was reduced from the basal uptake by $(4.5\times10)—(0.25\times0.40\times0.3\times3.0\times60\times4.5)\approx20$ meq. The calculated changes in the amount of triglycerides in plasma, 1.8 and 2.2 meq, respectively, are thus much smaller than the figures for the changes in the hepatic uptake of FFA, 10 and 20 meq, respectively. The changes in the hepatic uptake of FFA are thus great enough to cause changes 5—10 times greater than those seen in the plasma triglyceride pools.

Our results thus support the hypothesis but cannot establish it, as other mechanisms than those involved in our hypothesis may also have contributed to the changes observed in plasma triglyceride levels. Hepatic triglyceride output could have been stimulated in other ways than by increased flux of FFA, while during nicotinic acid treatment its output could have been reduced by other mechanisms, e.g. by direct interference of nicotinic acid on lipoprotein secretion in the liver. Furthermore, both distress-provoking psychosocial stimuli and nicotinic acid may have influenced the fractional turnover rate of very low density lipoproteins.

5.5.4. Distress, urinary catecholamines, and nicotinic acid

According to the self-ratings of our subjects, moderate distress reactions occurred during the second 2-hour period, primarily in the two groups exposed to the simulated work. Concomitantly, increases in catecholamine excretion were noted, in agreement with previous findings (cf. paragraph 1.5.2).

One subject in the untreated stress group excreted 27.6, 49.7, and 21.6 ng of adrenaline per minute and 47.5, 64.0, and 59.5 ng of noradrenaline per minute during the three consecutive 2-hour periods, respectively, i.e. very considerable amounts, even during the two control periods. During the first 2-hour period this subject reported that he felt "calm and unconcerned". At the end of the work period, he reported that during this period it had been "rather trying but not actually unpleasant". His observed behaviour, however, indicated relatively pronounced distress, although primarily during the work period. *If,* for some reason, it is considered justifiable to question the "normality" of this case from the catecholamine point of view—to suppose that these high values are attributable to some intrinsic cause not relevant in this context and to exclude this subject—the two work-exposed groups differ significantly from each other in catecholamine excretion during all three periods, the excretion of the treated stress group being higher, possibly due to the nicotinic acid treatment. The addition of nicotinic acid, nicotinamide, nicotinuric acid, and N-methyl-nicotinic acid in a concentration of 2 g/liter to separate urine samples did not influence the determinations of catecholamine levels performed in this study. Consequently the elevated values of the nicotinic acid group cannot be ascribed to any interference from nicotinic acid or its main metabolites with the procedure for estimating catecholamines. The *treated stress group* exhibited a significantly higher creatinine excretion than did the *untreated stress group* but only during the first 2-hour period. This might have been accompanied by an increased renal clearance of catecholamines. While it is true that the effects of nicotinic acid on the sympathoadrenomedullary system require further study (cf. the hypotheses put forward by Hoffer and Osmond, 1960), it is of major importance in our context that nicotinic acid certainly *did not inhibit* the stressor-induced rise in catecholamine excretion.

5.5.5 Cardiovascular reactions

Stressor exposure was accompanied by a brief rise in systolic and diastolic blood pressure (cf. Holmberg et al. 1967), whereas rest under control conditions was accompanied by a fall. Nicotinic acid treatment did not modify the blood pressure responses. This is in accordance with previous findings that nicotinic acid does not inhibit the blood pressure response to injected noradrenaline (Carlson and Orö, 1962). Similarly, our results indicate that exposure to psychosocial stimuli is accompanied by an acceleration in heart rate, which is not modified by nicotinic acid treatment. This lends some further support to our assumption that the nicotinic acid blockade of the rise in plasma lipoproteins that accompanied distress reactions is explained by an inhibition of the sympathoadrenomedullary-mediated *mobilization* of FFA from adipose tissue, and not by an inhibition of the sympathoadrenomedullary activity per se.

5.5.6 Clinical aspects

This study has clearly shown that increased plasma-triglyceride levels, and probably an increased sympathoadrenomedullary activity, are readily induced even by a work situation which is not real but simulated, of short duration and moderate intensity. It is tempting to speculate about the effects of the socioeconomic or other real-life stressors, which may be repeated over months and years and surely may represent a threat to the individual far exceeding that implied in our laboratory situation (Friedman et al., 1958; Levi, 1967 b and c, 1971; Raab, 1966; Cleghorn et al., 1969). The frequent finding of elevated levels of triglycerides in plasma from patients with coronary heart disease are worth considering in this context (cf. Carlson et al., 1965 a; Selye, 1971; Wolf, 1971; Raab, 1971). For further discussion of these and related aspects, see Chapter 8.

5.6 Summary

Thirtythree male volunteers were studied in the morning after fasting overnight; 11 (the control group) were allowed to sit comfortably for three consecutive 2-hour periods, no stressors or treatments being introduced; the remaining 22 were divided into two groups, each being exposed to psychosocial stimuli (simulated work) during the second of the three 2-hour periods. Following one week of premedication with nicotinic acid and after a drug-free interval of at least 16 hours, the subjects in one of these groups were each given a total dose of 3 g of nicotinic acid during the first 3 hours of the experiment, whereas the other group received no treatment.

The simulated work situation comprised monotonous but attention-demanding psychomotor performance (sorting small ball-bearings) under unfavourable environmental conditions (noise, flickering light), shortage of time and criticism. Exposure to this situation evoked moderate distress, accompanied and/or followed by increases in heart rate, blood pressure, urinary excretion of adrenaline and noradrenaline, and levels of free fatty acids and triglycerides in arterial plasma. No such increases were seen in the control group.

The experimentally induced rise in free fatty acids was markedly modified by nicotinic acid treatment and triglycerides fell instead of rising, whereas the increase in catecholamine excretion was not significantly affected, neither were the increases in heart rate and blood pressure.

The hypothesis is discussed, from a qualitative as well as a quantitative viewpoint, that there is a direct relationship between the increased concentration of free fatty acids accompanying distress reactions in man (and possibly evoked by an increase in sympathoadrenomedullary activity) and the eventual development of "stress hyperlipoproteinemia".

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6 CONDITIONS OF WORK AND SYMPATHOADRENO-MEDULLARY ACTIVITY: EXPERIMENTAL MANIPULATIONS IN A REAL LIFE SETTING

By Lennart Levi

6.1 The problem: payment by results as an example of psychosocial stimuli in every-day life

6.1.1 Some general considerations on payment by results

One of the factors inherent in modern working life that is most often claimed to induce stress and distress in employees is payment by results, i.e. piece-wages of one type or another. For this reason, *and* in order to study whether or not moderate changes in psychosocial conditions of work would be effective in eliciting psychological and physiological responses, we conducted the study to be presented in this chapter.

Piece-work systems have in common the payment of a price or rate per piece or unit of work. This price may be uniform at all levels of output or may vary as production rises (cf. Marriott, 1957). Thus, when discussing piece-wages one must define the type referred to: pure or mixed piece-wages, individual or group piece-wages, linear or non-linear piece-wages.

Systems by which workers' earnings increase more than output are based on the philosophy that the workers should benefit from the reduction of overhead costs that is achieved as output rises. Under the *high* piece-rate system workers' earnings are linearly related to output, as they are under *straight* piece-work, but a greater increment is paid for each increase in output. For example, an increment of 1.33 per cent may be awarded to the workers' time-rate for each 1 per cent increase in output.

Accelerating premium systems are based on the principle that earning increments are small for low and average levels of output, but become increasingly larger as output exceeds the average. The increments thus differ for each 1 per cent increase in output. At low output the differences are small and scarcely apparent to the worker, but at high output they provide a powerful stimulus to the worker to increase his output more and more (ILO 1951).

Apart from these schemes there are bonus systems where a *major* part of the income is paid in salary form, to which is added a small bonus for each piece of work accomplished. This bonus may be linear, accelerating or diminishing. The resultant incentive to work harder is comparatively slight and may even disappear at the higher performance levels.

6.1.2 Incidence of payment by results

According to statistics for the year 1969 prepared by the Swedish Employers' Confederation, 63.2 per cent of the total hours worked in Swedish industry were paid by result in one form or another. Similar findings have been made for workers employed by the Swedish State and local authorities (Bolinder, personal communication).

In a recent nation-wide survey of wage systems in Sweden conducted by the Swedish Employers' Confederation it was found that 95 per cent of the responding firms employed piece-rates to a greater or lesser extent. Moreover, all the large firms paid at least part of their blue-collar workers on a piece-rate basis. Of the total number of hours worked, some 45 per cent were paid for by straight piece-rates, while about 20 per cent were paid for by bonuses of one kind or another.

The use of payment-by-results or bonus systems has increased somewhat in Swedish industry during the postwar period (cf. table 6:1), mostly in industries where hourly rates formerly prevailed.

Table 6:1. Average volume of piece-work in Swedish industry (Source: Swedish Employers' Association).

Year	Piece-work volume in per cent of total
1950	61
1955	62
1960	64
1965	65

In Great Britain, all types of payment by results taken together cover 43 per cent of all workers in industry (33 per cent of all workers in the British economy). In the Scandinavian and East European countries and in the USSR the proportion of workers on piece-wages is higher, about 50—70 per cent of those employed by industry proper. In the USA the proportion is lower and has been estimated to some 30 per cent (McKersie, 1970).

Paying civil servants and other so-called salaried employees by unit of output is much less common. The Swedish industry with the largest proportion of salaried employees—engineering—pays less than 5 per cent of their work on this basis. The piece rate in these cases amounts to only a small bonus, the remainder of the payment being regular monthly salaries. In this sector, payment by results is applied primarily in card punching routines, and, to a lesser extent, in typewriting, photoprinting, drawing and invoicing.

However, great interest has been displayed in a wider application of piece rates in white-collar employment, and—unless strong arguments are found against payment by results—we may presumably expect a fairly rapid spread during the next few years. This trend, however, is presently a matter of much controversy.

The introduction of some type of piece-wage for civil servants has been proposed by the employer in many sectors of Swedish public administration. Some of the organizations belonging to the Swedish Central Organization of Salaried Employees (TCO) have agreed to tentative experiments in this direction but have also expressed their hesitation due to occasional spontaneous negative reactions, especially from the higher age groups.

6.1.3 Payment by results: influence on productivity

Reviewing a series of laboratory experiments and field studies, Vroom (1964) concludes that a positive correlation generally exists between piece-wages and productivity. The introduction of piece-wages in industry and office life has generally been found to increase productivity (Viteles, 1953; ILO, 1967; Hoffman, 1964; Richman, 1964; Edgren and Rhenman, 1970, p. 44). According to Hoffman's and Richman's descriptions, this likewise applies in the People's Republic of China and the USSR, respectively, where payment by results is said to be extensively and increasingly used.

But the co-occurrence of payment by results and high productivity does not warrant the assumption—often made by management—that the latter is necessarily a result of the former. Both may be due to other factors: for example, more efficient and alert management, better labour-management relations, or better organization of the work (ILO, 1967).

With reference to Swedish conditions it has been emphasized (Lindholm, 1966) that the favourable effect of piece rates on production may be explained to some degree in terms of "indirect" factors rather than the financial stimulus as such, e.g. (a) favourable attitudes of the Swedish trade unions and workers towards production advances and cost-cutting programs in general, (b) concomitant favourable effects of the introduction of piece-wages on work planning, (c) favourable effects because piece-wages have constituted a vital impelling force for the introduction of work studies, and (d) the general belief that piece-work should always entail a higher work tempo.

A search for published evidence on the effects of incentive payment systems in the form of *controlled experiments* is not very rewarding numerically, as a glance at any textbook which includes this subject will reveal. However, Marriott (1957) reviews two experimental studies worth mentioning in the present context.

Burnett (1925) conducted a laboratory experiment in order to compare the effects of time-rate and piece-rate remuneration. Four girls, aged 17, were given a highly repetitive task, two months on time-rate and five weeks on piece-rate, separated by an interval of six months. On time-rate they worked six hours a day for four consecutive days a week at a rate of 30 shillings a week. Attempts were made to simulate actual factory conditions. Unfortunately, the author gives no details concerning the piece-rate payment. The report states that during the five consecutive weeks of piece-work, output increased over the average for the time-rate period by 7.2, 18.0, 20.2, 10.8 and 7.9 per cent, respectively.

Wyatt (1934) studied 10 girls in a factory, under reasonably well controlled conditions. The girls, aged 15—16, worked in pairs on five operations of unwrapping, wrapping, packing, weighing and combined weighing and wrapping of chocolate and toffee. For nine weeks, each worker received a fixed time-rate irrespective of output; after this, a competitive bonus system was applied for the next 15 weeks and a flat piece-rate for the following 12 weeks. It was found that both piece-wage models were accompanied by substantial increases in work output. These increases came rapidly and remained relatively steady till the end of the period. A return to the original time-rate for the unwrapping operation was accompanied by a substantial decrease in output. During the next nine weeks the subjects were given bonus-rates for an operation very similar to the packing process mentioned above. A considerable and progressive increase in work output occurred as compared with time-rate conditions.

These two studies and similar ones are difficult to evaluate for many reasons. The usual managerial and supervisory controls were absent. The experimental conditions introduced by the experimenters involved changes not only to the remuneration system but to many other factors as well. The groups were small and the age range was restricted to adolescents, whose financial circumstances presumably induced them to earn all the money they could.

The over-all evidence, part of which is reviewed by Locke, Bryan and Kendall (1968), nevertheless suggests that monetary incentives enhance work output. These authors also present five studies of their own supporting their hypothesis that these incentives affect task performance only through or by means of their effects on the individual's goals or intentions.

Reviewing some of the beneficial results usually expected by management, Shimmin (1959) mentions not only (a) increased output, (b) higher earnings and (c) better production control and planning, but also (d) greater cooperative efforts by workers and (e) more satisfied employees.

Briefly, then, it is generally agreed that piece-wages constitute one of the most important incentives to boost productivity. It is often claimed that piece wages are a necessary prerequisite of good performance, yielding higher earnings for workers and lower costs for management.

6.1.4 Payment by results: psychological and physiological effects

In spite of this nationwide or even worldwide acceptance, little is known about the *psychological* and *physiological effects* of this remuneration system. The evidence mentioned above suggests that money strengthens motivation at work, thereby probably increasing the intensity and endurance of employees' performance, but at the same time it is conceivable that excessively strong motivation, if prolonged, could lead to undue strain on psychological and physiological mechanisms. The urge for or need of money may temporarily or permanently seduce the individual to ignore psychological and physiological warning signals such as physical and mental fatigue, nervous tension, dysfunction of organs and organ systems etc.

Yoder (1947) has pointed out that piece-wages may encourage a disregard for essential health considerations, because "workmen, when they are liberally paid by the piece, are very apt to overwork themselves, and to ruin their health and constitution in a few years".

Discussing possible disadvantages inherent in piece-work, Marriott (1957), too, mentions among other things

(a) a tendency for quality to deteriorate

(b) a danger of disregarding safety regulations and thereby increasing accidents
(c) a tendency by some workers to overwork and to undermine their health
(d) jealousy among workers because some are able to earn more than others.

Guttormsson and Smith (1971) report a study of attitudes among 2,705 subjects in Swedish civil administration (National Postal Bank). A majority of the subjects were women. All were working at departments where piece-wages had already been introduced or would be within the next year or two. Out of those who were on salary, 45 per cent expressed positive attitudes toward a mixed piece-wage system, compared with 39 per cent of those already on piece-wages. The corresponding negative attitudes were expressed by 37 per cent and 42 per cent, respectively. Attitudes were generally more negative among the over 40s. Subjects working under *individual* piece-wage plans were more positive towards piece-wages in general than those working on group piece-wages: 51 per cent of those on individual and 25 per cent of those on group piece-wages described a decreased propensity to help fellow workers since the introduction of piece-wages; 47 and 57 per cent respectively reported no change in this respect. Out of those on salary, 73 per cent believed that piece-wages would lead to a loss of comfort and well-being. Out of those working on individual and group piece-wages, 60 per cent and 70 per cent, respectively, reported a decrease in comfort and well-being since the introduction of piece-wages. A great majority of all subjects reported that they envisaged, or had experienced, an increased feeling of distress in response to piece-wages.

This aspect—the relationship between piece wages and reported experience of distress—has been studied in more detail in two sociological investigations. Gardell (1971) found that industrial workers who were paid by the piece (in combination with low income and unskilled tasks) rated lower on a number of "mental health" variables. Similarly, Ohlström (1970) and Bolinder and Ohlström (1971) identified piece-wages as a factor contributing to subjective feelings of dissatisfaction and distress, respectively. However, none of these investigations aimed at quantifying psychological and physiological *reactions* to the piece-work situation, only measuring attitudes to piece-wages.

6.2 Choice of methodology

The above constituted the background for the study to be reported in this chapter. If reliable data could be produced on the stress and distress evoked by different work routines and modes of management in various professions, this would have obvious implications for activities such as the engagement of new employees, transfers within a given company, vocational guidance, safety precautions, and industrial hygiene, and also with regard to the fair assessment of remuneration, mental hygienic evaluation of proposals for new processes, streamlining and automation.

It is also important clinically to know how the human organism adapts or fails to adapt to certain minor, but often repeated, psychosocial stimuli of an *every-day* character.

In order to furnish at least part of the basis necessary for such developments, we have exposed groups of subjects to conditions of work that are often assumed to constitute significant stressors in modern working-life.

These conditions included those facing telephone operators, invoicing clerks working on a salary and piece-wage basis, office clerks subjected to changes in work environment (conventional offices, office landscapes, different noise levels), supermarket cash desk girls (during rush hours and ordinary conditions), supervisors in engineering, and paper mill workers and engine-drivers working in various shifts.

The responses to these exposures were assessed with respect to psychological self-ratings by the subjects; performance was evaluated, subjectively and—wherever possible—objectively, and sympathoadrenomedullary activity was measured as the urinary excretion of adrenaline and noradrenaline.

The great majority of experiments in the field of psychophysiological research have utilized laboratory situations as stimuli. Although laboratory situations like those mentioned in the previous chapter have obvious advantages, they are clearly liable to lack realism to the subjects tested. Therefore, as mentioned above, we also made use of real life situations which have been manipulated to suit necessary design requirements. As an *example* of studies of this kind, an investigation conducted in 1962 and reported in preliminary form elsewhere (Levi, 1964) will now be described in detail.

The primary aim of the present study was to find out (a) if a change in remuneration system from salary to piece-wages is accompanied by changes in urinary catecholamine excretion, and (b) how these two payment systems affect psychological reactions and levels of performance.

6.3 Material and methods

All 12 subjects were young, healthy, female invoicing clerks (age range 18—31, mean age 20.4). They constituted the entire subordinate staff of one of the invoicing departments at the Swedish National Telecommunications Administration. After being carefully informed about the aim and procedure of this study, all agreed to participate. They were told that the study aimed at a comparison between the effects of salary and piece-wages. They were further informed about some of the supposed pros and cons of these remuneration systems but also about our general ignorance in this field. This was done in order to equalize, as far as possible, the attitudes towards piece-wages, and to neutralize any possible bias for or against either of these modes of remuneration. It turned out that none of the girls had any experience of piece-work. All had worked at the present invoicing department for a year or more under the same supervisor and for a modest monthly salary.

The study proper was conducted on four consecutive days, beginning on a Tuesday and ending on a Friday. However, in order to accustom the subjects to all details of the experimental procedure per se and to minimize any possible apprehension that it might entail, the subjects fol-

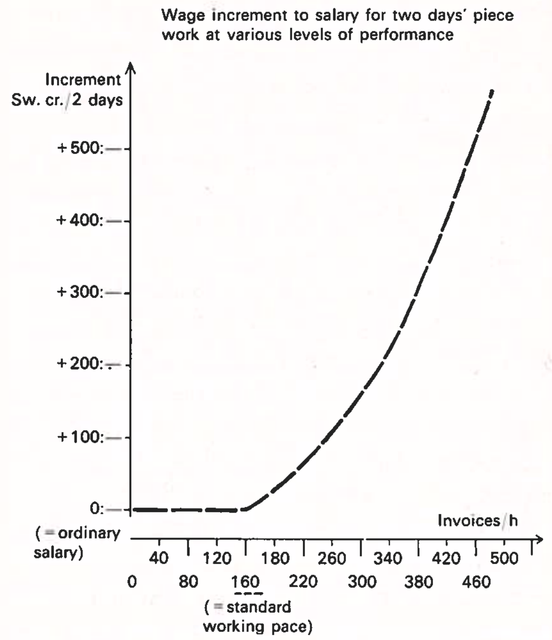

Figure 6:1. Graphic presentation of the accelerating premium system applied during days 1 and 3. One Swedish krona is at present (March 1972) US $0.21, and English £0.08.

lowed all details of the procedure on the Monday too, this day thus serving as a pre-experimental "dress rehearsal". So from Monday on, the subjects were instructed to go to bed before midnight, abstain from alcoholic beverages and drugs, and from tobacco from awakening to the end of the working day. They were further asked to drink two glasses of tap water at bed-time, on awakening to drink two additional glasses and empty their bladders, to omit breakfast and morning coffee, and to report at the office not later than 8.00 a.m. Having arrived they were allowed to relax for some 15 minutes.

At 8.15 a.m. they emptied their bladders and were asked to eat two ham sandwiches, to drink two glasses (300 ml) of tap water and to complete a short questionnaire. This routine was repeated every 2 1/2 hours, i.e. at 10.45 a.m. and 1.15 p.m. At 8.30 a.m. they started to work. At 3.45 p.m., the subjects again emptied their bladders, completed the questionnaire and went home.

In accordance with this schedule, they *worked* a total of 6.75 hours during their eight-hour day. All this time they worked at their usual invoicing

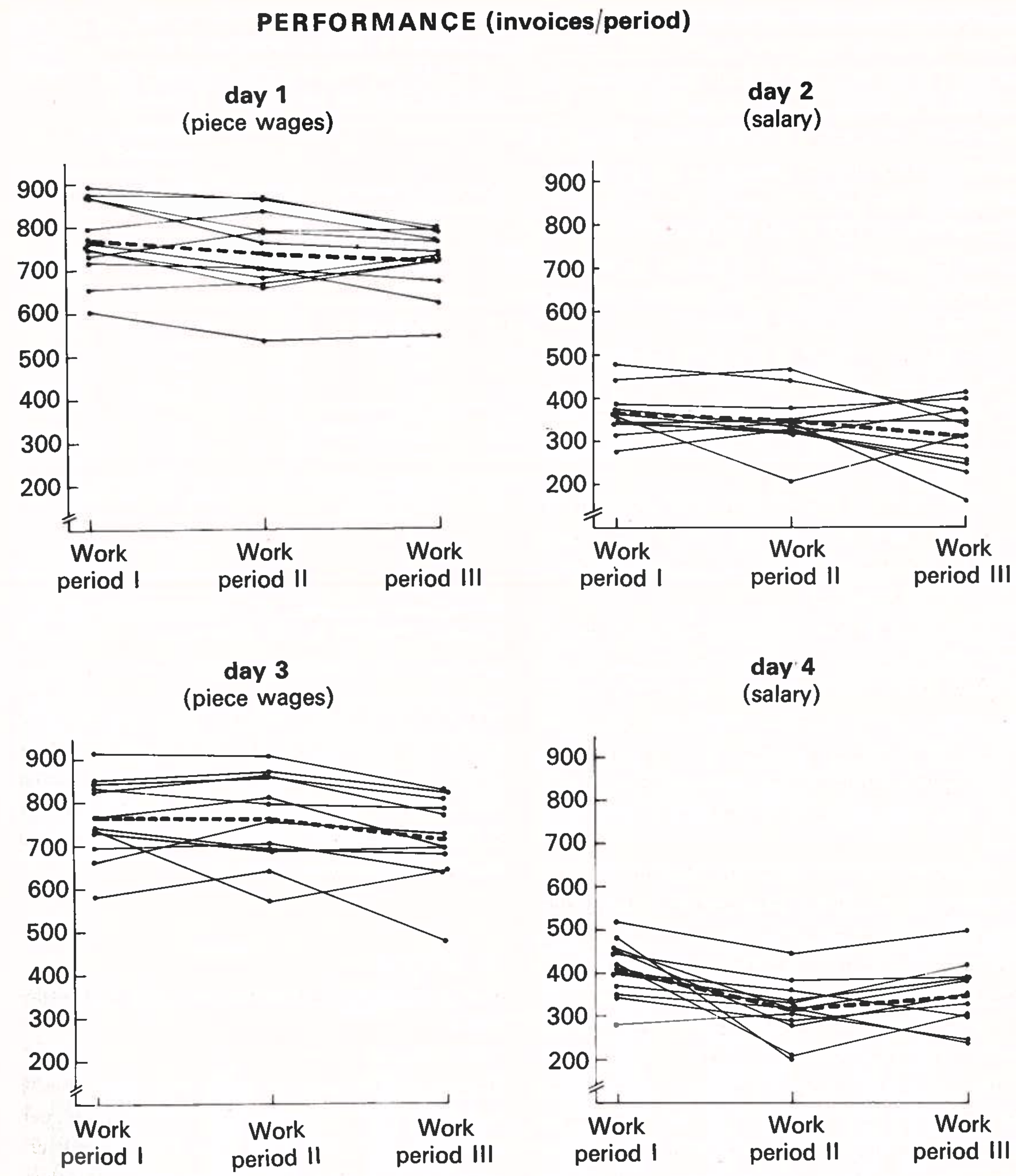

Figure 6:2. Individual performance during each of the three periods of work under piece-wages (days 1 and 3, left) and salaried conditions (days 2 and 4, right). Dashed line indicates means.

task, in their usual environment and under their usual supervisor, who knew them well. The task involved performing on an invoicing machine a few simple mathematical operations, the result of which was then typed on a postal paying-in form and on a check slip.

On the *second* and *fourth* of the four experimental days, remuneration was on the customary basis, namely the modest monthly salary. On the *first* and *third* days, on the other hand, a system of piece-wages was introduced. As the most extreme form of piece-wages was considered to be the non-linear, progressive, individual model, a piece-wage of this type was added to the ordinary salary if and when the subjects' performance exceeded 160 invoices per hour (figure 6:1). This level was chosen as a suitable base-line because previous work studies, performed by the Administration a few months earlier without the employees' knowledge, had demonstrated in this group of invoicing-clerks a habitual mean work output of approximately 160 invoices per head and hour of work (range 122—195).

The system included a moderate deduction for each subject's miscalculations and typing errors, by eight invoices per hour for each per mille of errors (habitual mean 2.5 per mille, range 0.0—6.8 per mille).

The number of invoices per time unit, and the mean per mille of invoicing errors were established by a cross-check made by the experimenter's clerical assistants.

Except for the change in remuneration, the experimental setting was held constant. The individual work output and the number of errors were kept secret from the employer as well as from fellow-workers in order, as far as possible, to eliminate pressures from these sources, be they real or imagined, on the individual invoicing-clerk.

Subjective reactions (rushed, tired, physical discomfort—in Swedish: jäktad, trött, kroppsliga obehag) were assessed on simple 4-point rating scales ranging from "very" (rushed etc.) = 4 points, over "fairly" = 3 points, and "slightly" = 2 points, to "not at all" = 1 point (in Swedish: mycket, ganska, något, inte alls).

Briefly, then, a strong monetary incentive was introduced on days 1 and 3, but only for a work output exceeding the habitual level. This system was chosen in order to mimic qualitatively (although not quantitatively) what industrial management actually might do to eliminate a bottleneck in a production process. Thus, the study was designed as a factorial experiment with the factors (a) salary versus piece-wages, (b) first versus second day of presentation of each mode of remuneration, and (c) morning versus afternoon. Five differences of special interest were calculated

Table 6:2. Means and S.E.M. for output of work [invoices per 2 1/2 hour period, each comprising 2 1/4 effective working-hours, during days 1 and 3 (piece-wages) and days 2 and 4 (salary)].

			Work output (invoices)	
Day No.	Condition	Period[1]	Mean ±	S.E.M.
1	Piece-wages	A	771.8	26.4
		B	736.9	28.2
		C	719.8	21.7
2	Monthly salary	A	364.4	15.4
		B	343.7	18.6
		C	308.6	21.8
3	Piece-wages	A	765.2	27.0
		B	762.1	30.4
		C	711.0	29.0
4	Monthly salary	A	409.3	19.3
		B	314.5	19.6
		C	347.4	21.3

[1] *A* stands for the period 0—2 1/2 hours, *B* for 2 1/2—5 hours, and *C* for 5—7 1/2 hours.

and will be reported below, namely between (a) piece-wages and salary, (b) afternoon and morning hours, (c) afternoon and morning hours during piece-wages and salary, (d) second and first pair of days, and (e) piece-wages and salary on second and first presentation, table 6:6.

6.4 Results

6.4.1 Differences in reactions to salary and piece-wages

6.4.1.1 Output

During the two days on salary only, the subjects performed at a mean rate of 155 invoices per hour and head, i.e. very close to the predetermined habitual level of 160. During the two days with piece wages, output more than doubled, to 331 invoices per hour and head ($p < 0.001$), cf. figure 6:2 and table 6:2.

In spite of this very considerable increase in output, the number of errors remained very low (mean 3.0 per mille, range 0.6—8.1 per mille), not significantly different from the habitual level reported above.

Table 6:3. Means and S.E.M. for self-ratings (rush, fatigue, physical discomfort) for each period during days 1 and 3 (piece-wages) and days 2 and 4 (salary).

			Rush		Fatigue		Physical discomfort	
Day No.	Condition	Period[1]	Mean ±	S.E.M.	Mean ±	S.E.M.	Mean ±	S.E.M.
1	Piece-wages	A	1.75	0.25	1.50	0.20	1.33	0.19
		B	1.50	0.20	2.17	0.27	1.92	0.26
		C	1.83	0.27	2.58	0.34	2.17	0.35
2	Monthly salary	A	1.00	0.00	1.25	0.25	1.00	0.00
		B	1.00	0.00	1.25	0.13	1.00	0.00
		C	1.08	0.08	1.33	0.14	1.00	0.00
3	Piece-wages	A	1.08	0.08	1.33	0.14	1.33	0.19
		B	1.42	0.19	2.33	0.31	1.75	0.31
		C	1.83	0.30	2.92	0.23	2.25	0.41
4	Monthly salary	A	1.00	0.00	1.33	0.14	1.25	0.25
		B	1.00	0.00	1.67	0.26	1.25	0.25
		C	1.00	0.00	1.75	0.22	1.42	0.26

The ratings were made on 4-point scales ranging between "much" (4 points) and "not at all" (1 point).
[1] *A* stands for the period 0—2 1/2 hours, *B* for 2 1/2—5 hours, and *C* for 5—7 1/2 hours.

6.4.1.2 Subjective reactions

During salaried days, the "rush" and "physical discomfort" scores were all on a very low level, only a few individual girls occasionally reporting sensations of this type. Under piece-wage conditions these rating scores rose significantly ($p < 0.01$), but the *mean* levels were still below or around 2 points (i.e. "slight" feelings of rush and physical discomfort), cf. table 6:3.

"Fatigue" ratings also increased significantly ($p < 0.01$) from salaried to piece-wage conditions, reaching "moderate" (= 3 points) mean levels towards the end of the piece-work days, cf. table 6:3.

On the morning of the forth day (salaried work), one of our subjects started to complain about pronounced menstrual pain. After having completed the first two work periods of that day,

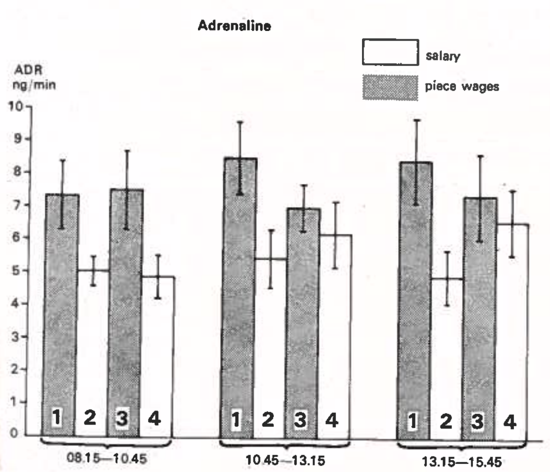

Figure 6:3. Means and S.E.M. for adrenaline excretion during each period of work during piece-work conditions (days 1 and 3, filled bars) and on salaried days (days 2 and 4, white bars).

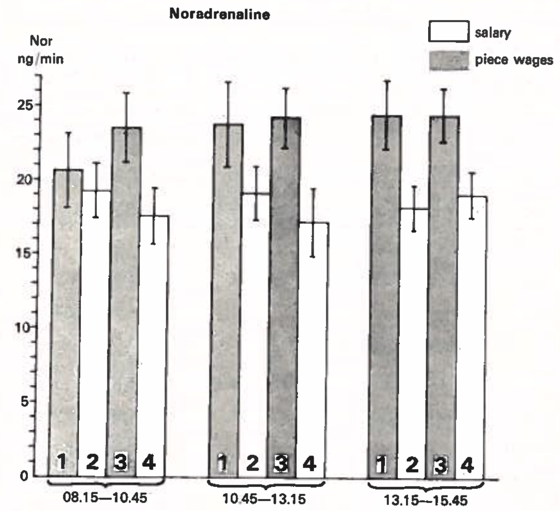

Figure 6:4. Means and S.E.M. for noradrenaline excretion during each period of work during piece-work conditions (days 1 and 3, filled bars) and on salaried days (days 2 and 4, white bars).

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Table 6:4. Means and S.E.M. for urinary excretion of adrenaline and noradrenaline for each period during days 1 and 3 (piece-wages) and days 2 and 4 (salary).

Day No.	Condition	Period[1]	Adrenaline ng/min Mean ±	S.E.M.	Noradrenaline ng/min Mean ±	S.E.M.
1	Piece-wages	A	7.33	1.03	20.62	2.50
		B	8.52	1.13	23.81	2.89
		C	8.44	1.28	24.46	2.33
2	Monthly salary	A	5.02	0.46	19.20	1.86
		B	5.46	0.88	19.16	1.77
		C	4.97	0.82	18.22	1.47
3	Piece-wages	A	7.49	1.21	23.49	2.36
		B	7.00	0.72	24.33	1.98
		C	7.38	1.27	24.49	1.80
4	Monthly salary	A	4.87	0.66	17.55	1.91
		B	6.20	1.01	17.16	2.31
		C	6.98	1.00	19.11	1.55

[1] *A* stands for the period 0—2 1/2 hours, *B* for 2 1/2—5 hours, and *C* for 5—7 1/2 hours.

she left for home. Her adrenaline excretion levels during these two periods were about twice as high as those from the corresponding periods of day 2.

6.4.1.3 Physiological reactions

There was a highly significant increase in adrenaline as well as noradrenaline excretion ($p < 0.001$) under piece-wage conditions, cf. figures 6:3 and 6:4, and table 6:4. Significant changes ($p < 0.001$) were also found for the increase in urine flow and decrease in specific gravity (figures 6:5 and 6:6, and table 6:5). Creatinine excretion, too, increased ($p < 0.05$) during the days on piece-wages, cf. table 6:5.

6.4.2 Differences in reactions during morning and afternoon hours

6.4.2.1 Output

Throughout the study, output decreased significantly ($p < 0.001$) from the first working period (8.30—10.45 a.m.) to the third (1.30—3.45 p.m.), cf. table 6:6.

Table 6:5. Means and S.E.M. for urinary creatinine, urine flow and specific gravity for each period during days 1 and 3 (piece-wages) and days 2 and 4 (salary).

Day No.	Condition	Period[1]	Urinary creatinine mg/min Mean ±	S.E.M.	Urine flow ml/min Mean ±	S.E.M.	Specific gravity (N−1)×1000 Mean ±	S.E.M.
1	Piece-wages	A	1.11	0.18	2.24	0.17	8.03	0.69
		B	0.80	0.04	1.60	0.16	9.42	1.10
		C	0.68	0.04	1.46	0.12	9.25	0.99
2	Monthly salary	A	0.83	0.03	1.28	0.12	11.83	1.25
		B	0.75	0.10	1.06	0.11	13.00	0.97
		C	0.65	0.05	1.21	0.10	13.08	0.89
3	Piece-wages	A	0.83	0.04	1.73	0.21	11.33	1.65
		B	0.73	0.03	1.76	0.14	9.33	1.03
		C	0.65	0.04	1.62	0.10	9.17	0.55
4	Monthly salary	A	0.75	0.05	1.57	0.17	12.50	1.39
		B	0.77	0.05	1.31	0.13	12.00	1.76
		C	0.75	0.03	1.61	0.12	9.33	0.89

[1] *A* stands for the period 0—2 1/2 hours, *B* for 2 1/2—5 hours, and *C* for 5—7 1/2 hours.

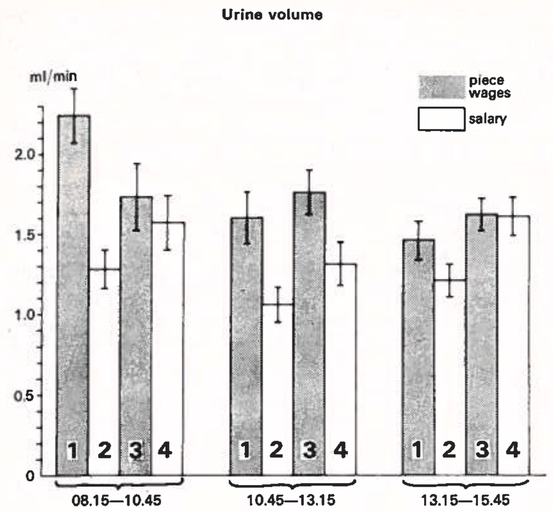

Figure 6:5. Means and S.E.M. for urine volume during each period of work during piece-work conditions (days 1 and 3, filled bars) and on salaried days (days 2 and 4, white bars).

6.4.2.2 Subjective reactions

"Fatigue" scores increased significantly ($p < 0.001$), as did those for "physical discomfort" ($p < 0.05$), whereas the changes in "rush" scores did not reach significance, cf. table 6:6.

6.4.2.3 Physiological reactions

Neither adrenaline nor noradrenaline excretion rates exhibited any significant changes from morning to afternoon hours, whereas urine volume decreased ($p < 0.05$), as did creatinine excretion ($p < 0.01$). No significant changes were found in specific gravity, cf. table 6:6.

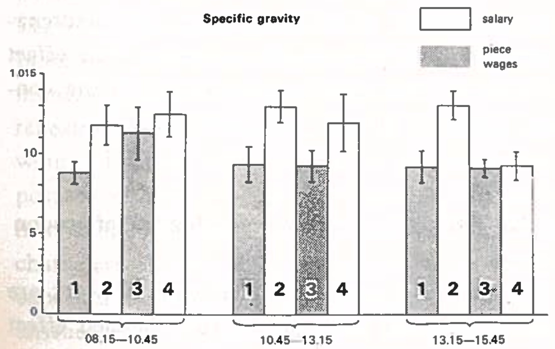

Figure 6:6. Means and S.E.M. for urinary specific gravity during each period of work during piece-work conditions (days 1 and 3, filled bars) and on salaried days (days 2 and 4, white bars).

6.4.3 Differences between morning and afternoon hours under salaried and piece-work conditions

The increases in "fatigue" and "physical discomfort" ratings were significantly higher during piece-work than during salaried work, ($p < 0.01$, and $p < 0.05$, respectively), as was the decrease in urine volume ($p < 0.01$). For the other variables studied, no significant differences were found, cf. table 6:6.

6.4.4 Differences in reactions during first and second pair of days

No significant changes occurred from the first two days to the last two in any of the variables under study, cf. table 6:6.

6.4.5 Differences between the two remuneration models on first and second presentation

The difference between the two remuneration conditions turned out to to be significantly greater on the first than on the second presentation day for urine volume ($p < 0.05$), specific gravity ($p < 0.05$) and creatinine ($p < 0.01$) but not for any of the other variables, cf. table 6:6.

6.5 Discussion

6.5.1 Differences between salary and piece wages

Every psychological and physiological variable covered by this study turned out to be influenced by the change in remuneration system. As our subjects were free to choose their performance rate under both conditions of work, it must be concluded that the piece-wage incentive reinforced the motivation to work at a higher rate. It is, however, extremely unlikely that the subjects would have been able to maintain their output at the very high level found during the piece-work days for any length of time.

It is often claimed (Shimmin, 1959) that such an increase in productivity is accompanied by a corresponding decrease in the quality of work. This was, however, not the case to any marked degree under the conditions of our study. Again, it is conceivable that a long-term experiment would have given different results.

Table 6:6. Means, S.E.M. and tests of significance for work output, subjective reactions, and physiological reactions with respect to differences between (a) piece-wages and salary, (b) afternoon and morning hours, (c) afternoon and morning hours during piece-wages and salary, (d) second and first pair of days, and (e) piece-wages and salary on first and second presentation.

	DIFFERENCES BETWEEN									
	piece-wages and salary		afternoon and morning hours		afternoon and morning hours during piece-work and salaried conditions		second and first pair of days		the two remuneration models on second and first presentation	
Variable	Mean ±	S.E.M.	Mean ±	S.E.M.	Mean ±	S.E.M.	Mean ±	S.E.M.	Mean ±	S.E.M.
Work output (invoices)	396.35***	25.62	−56.15***	9.90	5.38	16.62	10.85	8.53	−14.64	14.95
Rush	0.56**	0.15	0.23	0.14	0.38	0.31	−0.14	0.09	−0.22	0.16
Fatigue	0.71**	0.16	0.79***	0.14	1.08**	0.25	0.21	0.12	−0.19	0.22
Physical discomfort	0.64**	0.19	0.48*	0.17	0.79*	0.29	0.14	0.18	−0.33	0.19
Adrenaline ng/min	2.11***	0.45	0.77	0.72	−0.53	0.87	0.03	0.45	−1.68	0.80
Noradrenaline ng/min	5.13***	0.86	1.35	0.68	2.13	1.81	0.11	1.22	2.06	1.70
Urine volume ml/min	0.40***	0.08	−0.23*	0.08	−0.43**	0.12	0.13	0.08	−0.38*	0.17
Specific gravity $(N-1)\times 1000$	−2.53***	0.49	−0.73	0.79	0.46	1.20	−0.17	0.59	2.39*	0.95
Urinary creatinine mg/min	0.05*	0.02	−0.20**	0.05	−0.22	0.12	−0.06	0.04	−0.15**	0.05

This may also apply to "rush", "physical discomfort" and "fatigue" ratings, all of which increased significantly during piece-work days. Nothing definite can be concluded about whether or not the increase in these ratings was due to the piece-wages per se, or to the increase in output. Although the *means* for these ratings never reached more than "slight" or "moderate" intensity, the questionnaire returns as well as clinical observations support the assumption that individual girls worked at a supraoptimal rate and experienced relatively pronounced discomfort.

Catecholamine and creatinine excretion, urine flow and specific gravity were all significantly affected by the remuneration system. Mean adrenaline excretion was about 40 per cent higher during piece-work compared with salaried work.

It might be argued that this increase in adrenaline excretion reflects a corresponding increase in muscular work. But although muscular work has been demonstrated to affect adrenaline excretion, this is only true of rather high levels of exertion (Frankenhaeuser et al., 1969). Therefore, it seems more justified to assume that this increase primarily reflects a corresponding increase in distress. This also applies to the other physiological reactions, these being of the same direction and order of magnitude as those described during short-term exposure to other types of psychosocial stimuli. In the case of noradrenaline and creatinine excretion, however, the effect may have been mixed, comprising also the consequences of increased muscular activity.

6.5.2 Differences between morning and afternoon hours

The changes in variables over hours of work are relatively small and represent a combined effect of circadian variation and the duration of work. The increases in "fatigue" and "physical discomfort" ratings and the decrease in output are in

accordance with every-day experience. The changes in urine volume and creatinine excretion are probably due to the circadian variation demonstrated to occur during these hours of the day, cf. paragraph 2.7.

6.5.3 Differences between morning and afternoon hours during salaried versus piece-work conditions

Our findings support the assumption that the remuneration system, and not just circadian variation, is responsible for some of the reactions occurring from morning to afternoon hours.

6.5.4 Differences between first and second pair of days

Several other investigators have found that an increased familiarity with the experimental situation results in decreases in psychological and physiological reactions to it. Thanks to the pre-experimental "dress-rehearsal day" included in our study, all subjects were to some degree accustomed to their routine and the experimental procedure. One might hypothesize this to be the reason for no significant effects occurring from a repetition of the exposure, though of course it is conceivable that the absence of any significant changes was due to a combined effect of habituation (decreasing the levels) and prolonged exposure (increasing the levels), resulting in no net change.

6.5.5 Differences between the two remuneration models, first and second presentation

The results speak in favour of a diminishing difference between the reactions to the two remuneration models when exposure to them is repeated. We do not know whether this difference would diminish still more after prolonged exposure or even disappear altogether. Probably this would depend on the interplay between the characteristics of the piece-wage system and the expectations, needs, attitudes and other characteristics of the individuals.

Clearly, the object of the present study was not to describe the psychosomatic health hazards, if any, or the relative efficiency of the remuneration systems. The aim was simply to compare the effects of two every-day settings with respect to their effects on psychological, behavioural and physiological variables. The results support the assumption that psychosocial factors of an every-day type have, indeed, significant effects on the functions under study. It was further found that a real-life setting can be used in the study of psychosocial influences on psychophysiological reactions.

6.6 Summary

Following a dress rehearsal day, 12 healthy female invoicing clerks were studied under conditions very similar to those involved in their every-day work, a number of extraneous physical and psychosocial stimuli, however, being kept under control. Highly progressive piece-wages were introduced on the first and third day of the experiment, and were found to result in significant increases in output but also in rush, fatigue and physical discomfort ratings, in adrenaline, noradrenaline and creatinine excretion and in urine flow, with a concomitant decrease in specific gravity. The implications, clinical and methodological, of these results are discussed.

6.7 Acknowledgements

This investigation was made possible by the kind cooperation of Mr. Harry Westerberg, Director and his colleagues of the Swedish Telecommunications Administration, which is gratefully acknowledged. The Swedish Central Organization of Salaried Employees, the Swedish Confederation of Trade Unions (Dr. Erik Bolinder), the Swedish Employers' Confederation (Dr. Nils Masreliez), and Drs. Åke Swensson and Bertil Gardell have all furnished valuable advice and background information for this study, for which the author expresses his gratitude. The original study was supported by a grant from the Swedish Union of Clerical and Technical Employees in Industry. The final compilation of the data was supported by a grant from the Bank of Sweden Tercentenary Fund.

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7 PSYCHOLOGICAL AND PHYSIOLOGICAL REACTIONS TO AND PSYCHOMOTOR PERFORMANCE DURING PROLONGED AND COMPLEX STRESSOR EXPOSURE

By Lennart Levi

7.1 The problem

All studies reported in the previous chapters have been of relatively short duration, partly because such studies are easier to conduct and partly because they were focused intentionally on rather acute reactions to short-term stimuli. Whereas we know that catecholamine excretion in man changes rather rapidly when the organism is exposed to psychosocial influences, other clinically relevant physiological and biochemical variables may necessitate stimulation—or at least a time lag—of considerably longer duration before reactions materialize. Here, then, was the main reason for making repeated measurements over a rather long period, comprising at least several days. An additional reason was that it is usually assumed that the psychosocial stimuli of real life which really are of pathogenic significance, are relatively long-lasting. At least they certainly usually do act on the organism for considerably longer than just an hour or two or even a day. It therefore seemed to be of considerable interest to study the psychological and physiological reactions of the human organism to relatively *prolonged* exposure.

True, a number of studies have been published which involved stimuli that lasted several days, but many studies of this type have either been conducted under poorly controlled conditions, the subjects often being allowed to smoke, drink coffe and choose the work/rest cycles they preferred, or the measurements have comprised either psychological or physiological or performance variables, but usually not a combination of these.

In view of the above, the present study was designed to include the following objectives.

First, we intended to study changes over time in self-ratings of "distress" and "fatigue" under strictly controlled environmental conditions.

Second we intended to collect data on changes in *catecholamine excretion* in response to prolonged exposure to presumably distress-provoking stimuli under controlled conditions. Would the increased excretion elicited by short-term exposure persist at the enhanced level, continue to increase, or be brought back to—or even below—the control level by some homeostatic mechanism?

Third, although it was known that catecholamine excretion was higher during waking than during sleeping hours, available data did not clearly indicate whether this difference was due to rather acute effects of Zeitgebers such as (a) participation in physical and mental activities, (b) bodily posture, (c) eating and drinking, (d) smoking and (e) a generally higher sensory input, as opposed to some intrinsic (circadian) rhythms.

Fourth, as mentioned in paragraph 1.5.4, existing information was rather inconclusive as to the influences of psychosocial stimuli on the release of *thyroid* hormones in man. In view of our ignorance concerning the etiology and pathogenesis of Graves' disease, and the pronounced influence of these hormones on a great number of physiological and biochemical variables in health and disease, inter alia interacting with the catecholamines, it seemed important to study protein-bound iodine (PBI) as an index of thyroid function under the influence of a rather prolonged stressor exposure.

Fifth, as emphasized by Malmström (1970) and many others, *iron* plays a central role in the energy metabolism of all living cells. There exists a labile iron exchange compartment which is in equilibrium with the plasma stores (for a review, see Najean et al., 1970), and changes in plasma iron levels are accordingly bound to reflect some of the changes in iron kinetics. Plasma iron is known to exhibit a circadian rhythm (Vahlquist, 1941; Hemmeler, 1944; Høyer, 1944; Waldenström, 1946; Hamilton et al., 1950; Laurell, 1953; Perkoff et al., 1959; Speck, 1968). It is further reported that serum iron levels decrease in response to infections (for a review, see Bothwell and Finch, 1962) and 2—3 days before the onset of menstruation (cf. Zilva and Patston, 1966), to gross cerebral stimuli such as short-wave irradiation of the brain-stem, lumbar puncture, pneumoencephalography and intraventricular bleeding (Laurell, 1952; Schäfer, 1964), and to injections of histamine, adrenaline, adrenal cortical extracts and ACTH (for a review, see Laurell, 1952). Moreover, Liljedahl et al. (1969) have demonstrated an accelerated elimination of plasma iron following meniscus or hernia operations with minimal blood loss. Phlebotomy of comparable volume to the loss by bleeding and haemolysis (100—150 ml) did *not* accelerate iron elimination.

Low serum iron levels have been reported in schizophrenic patients (Frohman et al., 1958), and in psychiatric patients shortly after admission to a mental hospital (Skaug, 1970; Amdisen, personal communication), and iron deficiency is often accompanied by mental fatigue, lack of drive, lack of concentration, loss of energy, and rapid mental exhaustion (Heilmeyer and Harwerth, 1970).

Briefly, then, serum iron levels seem to be influenced in a rather stereotyped way by a considerable number of diverse stimuli that possibly act through a common neuroendocrine pathway, conceivably activating the reticuloendothelial system (Schäfer and Boenecke, 1949; Laurell, 1952; Lederer, 1962; Zilva and Patston, 1966), and iron metabolism, in turn, exercises a profound influence on a great number of organs and organ systems. Accordingly, one of the aims of the present study was to investigate whether changes in serum iron could be induced by experimental stressor exposure of young, healthy male subjects receiving an adequate supply of alimentary iron.

The study also comprised several other physiological and biochemical variables that will not be reported in detail in the present context. As some of these data may help to elucidate the problems under discussion, they will be mentioned, but only in the discussion.

7.2 Choice of methodology

In order to achieve the objectives indicated above, we needed an experimental situation that could be expected to induce distress (and stress) reactions of a prolonged nature but not so pronounced as to be harmful to the population in question. The situation should further be rather homogeneous with respect to the stimuli applied (to allow systematic studies of changes in reactions over time as well as the detection of circadian rhythms) and should allow simultaneous assessments of performance (as to quality and quantity), subjective reactions, and the physiological and chemical variables mentioned above.

To accomplish this, we designed an electronic shooting range and created a situation in it that our subjects, who were officers and soldiers, would presumably recognize as involving some of the elements of prolonged ground combat. This "pseudorealistic" setting was rather convenient for the assessment of psychomotor performance (quantity and quality) and it also kept the subjects uniformly occupied. Furthermore, the task, which was of a vigilance type, was considered rather meaningful for military subjects.

Briefly, then, the procedure was assumed to be meaningful to the subjects, kept them uniformly occupied throughout the study, did not allow self-chosen periods of rest, allowed studies focussed on stress, distress and circadian rhythms, made possible the collection of urine and blood samples at predetermined intervals and generally made it possible to study psychomotor performance, subjective reactions and physiological and biochemical reactions under strictly controlled environmental conditions.

7.3 Material, methods and procedures

7.3.1 The subjects

The 31 subjects of the study were Army officers and corporals attending platoon-leader training school, with an age range of 20 to 44 years, the mean being 29.

They were in excellent health and either non-smokers or able to give up smoking for the days of the experiment. All the subjects volunteered for this study after they had received precise written information about its aim and the procedure involved (informed consent).

The Army officers were selected from a large sample of regular and reserve officers who had responded to a memorandum inviting them to participate. To qualify, every subject had to pass a thorough medical examination, including ECG at work. Only those who were found to be in perfect health were allowed to participate. The corporals were recruited in a similar way, some probably being motivated by professional interest, others by a desire for a new thrill or the medical check-up offered as part of the investigation, or by the monetary reward (Swedish Kronor 200: —, i.e. approximately US $40.—).

Clearly, this procedure resulted in an experimental group that did not form a random sample of the populations from which it was drawn; on the contrary, the group constituted a highly selected pick. Many of the subjects were active sportsmen. As judged by their superior officers they constituted a positive selection, physically and intellectually as well as according to military criteria. However, in view of the assumption that the strain on the subjects would be considerable, this selection was considered necessary on ethical grounds.

7.3.2 The procedures

7.3.2.1 Pre-experimental procedures

During the week prior to the experiment, each subject was allowed to adapt to the test situation, adjust the telescopic sight and support of his rifle, choose the most convenient height for his adjustable office-chair, and do some trial shooting. He was also carefully instructed in and informed about all the details of the experimental procedure in order to secure maximal co-operation. During this week, the subjects also underwent a comprehensive check-up including (a) a medical investigation, (b) a psychiatric investigation, (c) two personality inventories, (d) a bicycle ergometer maximal work capacity test, including ECG, and (e) biochemical parameters.

A "pre-stress" blood sample was obtained on either Wednesday or Thursday of the pre-experimental week, between 12.00 noon and 3.00 p.m. The venous puncture was always preceded by restriction on physical activity for at least four hours; this time was used to inform and instruct the group about the experimental routine, to demonstrate the premises, and to complete the questionnaires. Food and fluid (two standard sandwiches with ham, 300 ml tap water) were administered every three hours from awakening until three hours before the blood sample was collected, all tobacco, coffee and alcoholic beverages as well as all unscheduled activities being strictly prohibited during the same period. None of the subjects was or had recently been on any drug regimen whatsoever.

The experiment, run in 1965, was conducted in two shifts, four weeks apart, the first with 15 subjects, the second with 16. As the procedures and results were practically the same for both shifts, they will be reported together. Preliminary accounts have been published (Levi, 1966, 1967).

7.3.2.2 The experiment proper

The experiment started on a Tuesday morning. On awakening, the subjects, having fasted over night, emptied their bladders, drank 300 ml of tap water and reported at the laboratory as indicated below. At the beginning of the control period they again emptied their bladders, drank 300 ml of tap water and were served two standard sandwiches (with ham and beef). This procedure was repeated at 3-hourly intervals throughout the experiment, which ended on Friday, a good 75 hours later. In this way, each subject produced 25 urine samples from the same number of 3-hour periods.

During the 3-hour control period (for half the group 8.00 a.m.—11.00 a.m.; for the other half

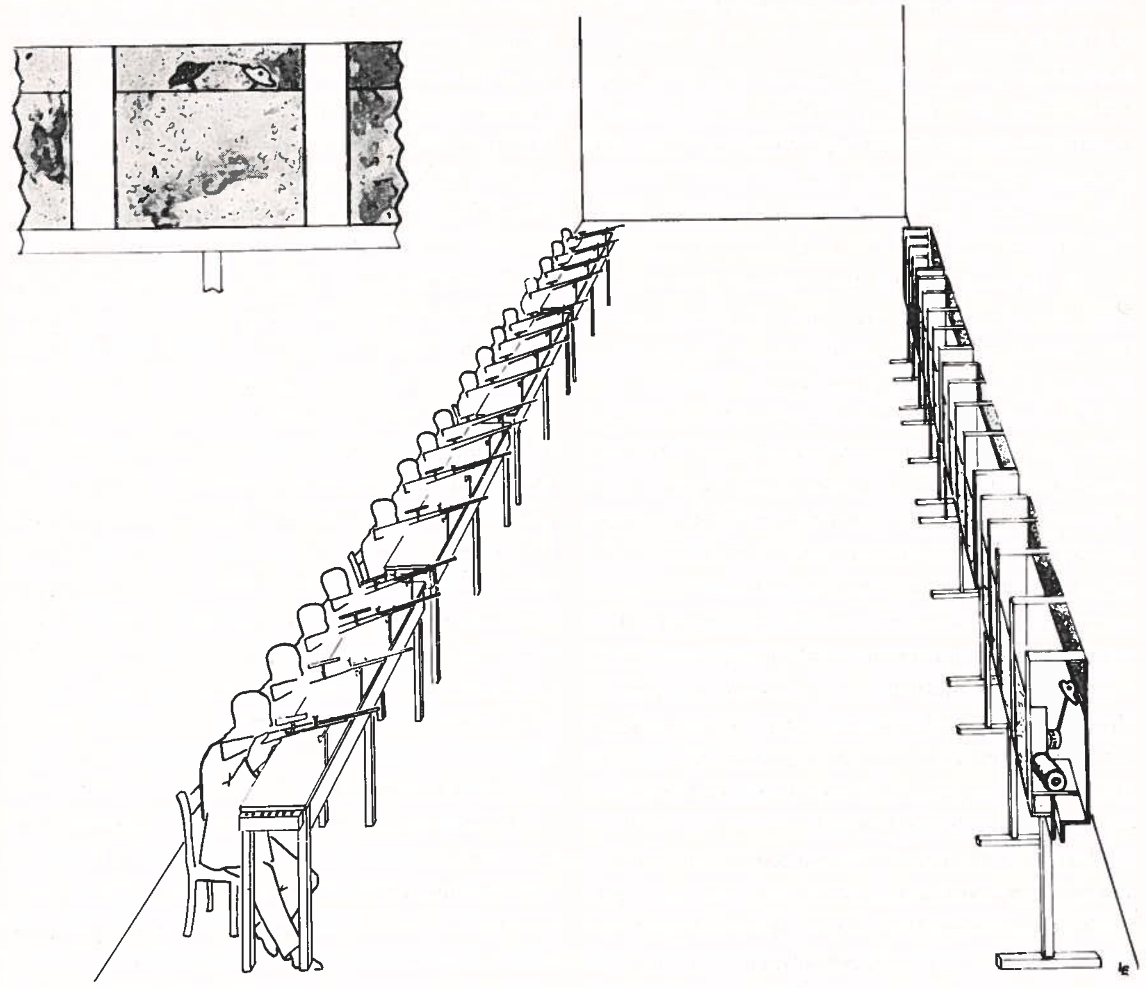

Figure 7:1. Schematic drawing of the shooting range. The target area is shown in the left upper corner.

11.00 a.m.—02.00 p.m.) the subjects relaxed, listening to soft music, reading weekly magazines, or just dozing. During the subsequent 72 hours, divided into 24 3-hour periods, they were exposed to the experimental conditions, which simulated some of the elements of war.

The situation involved shooting on a specially designed shooting-range (figure 7:1) with electronic rifles (producing light-beams) at small targets (tanks) containing photo-diodes. The tanks moved across the field of vision at unpredictably varying speeds, disappeared behind the horizon of the shooting-range and reappeared again after a perpetually changing interval. Each shot and each hit was registered electronically and individual results were noted at the end of each 3-hour period. Shortly after the end of each period, the individual number of shots and hits obtained during the period was reported to each subject in order to increase his motivation. The optimal shooting rate was one shot per second during the time the target was visible over the horizon. This rate was indicated by small flashing lights in the neighbourhood of the target area. The entire target area was operated automatically.

In alternate periods the pendant lamps were turned on, which made the shooting task relatively easy. In the intervening periods, however, the lights were off, the only source of illumination now being weak footlights near the target area.

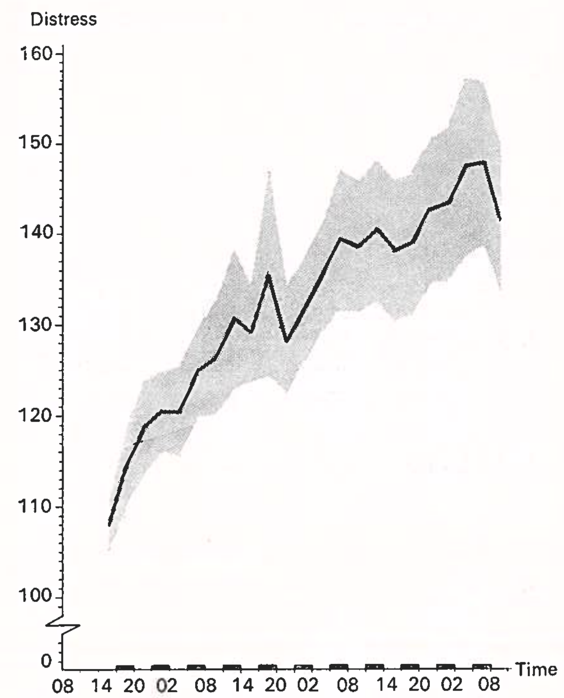

Figure 7:2. Means ± S.E.M. of self-rated "distress" (magnitude estimations). Control level by definition = 100 for control period 08—11 and 11—14 hours, respectively. Black markings on time scale indicate periods with bad illumination and high levels of battle noise.

In addition, in these periods an authentic battle noise from a tape-recorder was played, amplified to a level of approximately 95 dB-C.

An unabated 2 3/4 hours of such activity was followed by a concentrated 15-minute period for answering questionnaires, ingestion of the standard meal described above, voiding urine for analysis, and attendance to other toilet functions. After this pause, the shooting range was switched on again, and in this manner the experiment was continued for three days and nights.

Throughout the experiment, members of the research staff prevented the subjects from falling asleep or turning away from their task. If someone fell asleep, he was roused immediately and told to go on shooting. The subjects were continuously supervised by the experimenters and their assistants, one being in the shooting-range, the other watching via closed-circuit television in an adjoining room, communicating with the subjects through the amplifiers.

The physical setting was such that the activity was performed in a large room, isolated from the rest of the hospital. There were no windows nor any other means of communicating with the outer world, and the subjects were deprived of their watches in order to minimize any cues as to time of day. No activity but the experimental one was allowed. The subjects had to sit on their chairs all the time except when voiding.

A "post-stress" blood sample was obtained after at least 72 hours of stimulus exposure, in each subject at the same time of day as the "pre-stress" sample ±30 minutes, being preceded by the same food and fluid at the same interval as mentioned above.

7.3.3 Methods of measurement

Self-ratings of "distress" and "fatigue" were made every 3 hours by the magnitude estimation method (cf. paragraph 2.18) and on 11-point rating scales (cf. paragraph 2.20.7.2). By definition, the amount of "distress" and "fatigue" at the beginning of the vigil was given the value of 100 in the magnitude estimations. During each of the subsequent 3-hour periods, the subjects were asked to report their average 3-hour "distress" and "fatigue" in per cent of this initial level.

Performance in the psychomotor task on the shooting range was evaluated as to speed and accuracy simply by reading off the individual counters for shots and hits.

Serum iron was analyzed according to Agner (1955) and protein-bound iodine by the method of Riley and Gochman (1964). The samples from the different days for each subject were always analyzed in a single sequence and by the same laboratory technician. The standard deviation in blind analyses of duplicate samples within the range of values found by us has been investigated previously and amounted to 4.9 μg/100 ml plasma for serum iron (Strandberg, 1966) and 0.3 μg/100 ml plasma for protein-bound iodine (Crowley and Jensen, 1965).

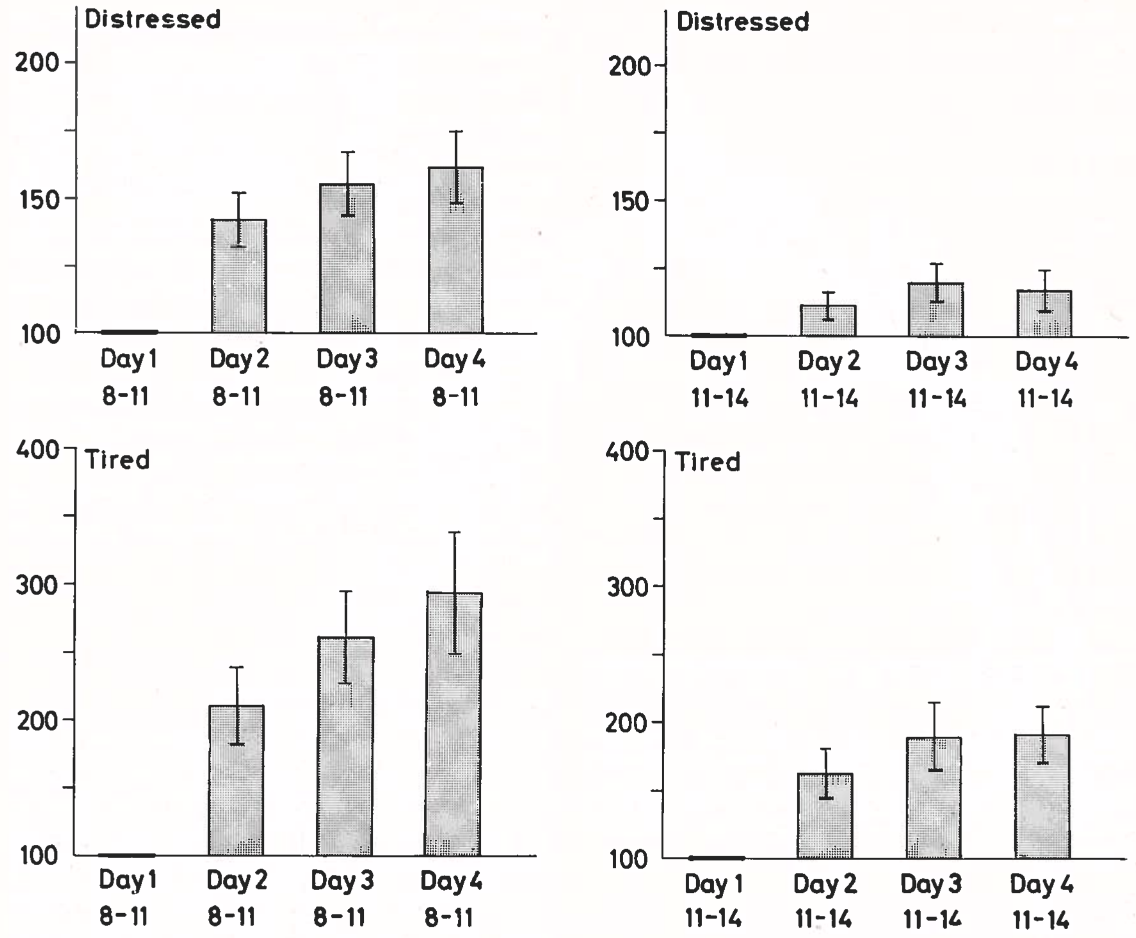

Figure 7:3. Self-rated "distress" and "fatigue" (magnitude estimations) during the control period (day 1, 08—11 hours for half the group, 11—14 hours for the other half) as compared with the corresponding periods of days 2, 3 and 4. Means ± S.E.M.

7.4 Results

7.4.1 Behaviour and performance

7.4.1.1 Self-ratings

As shown in figure 7:2, magnitude estimations of *"distress"* increased significantly throughout the study. A comparison of initial control levels (i.e. 8.00—11.00 a.m., or 11.00 a.m.—2.00 p.m., on day 1) and levels during the corresponding periods of days 2, 3 and 4 shows a significant and progressive increase, see figure 7:3. Self-ratings on the 11-point scale (figure 7:4) show the same trend, though the highest means never reach more than moderate levels.

Magnitude estimations of *"fatigue"* increased step-wise from day to day throughout the study (figure 7:5), besides exhibiting a significant circadian rhythm, cf. also figures 7:3 and 7:4.

7.4.1.2 Observed behaviour

Pronounced fatigue was the main *observable* behavioural reaction in our group, cf. figure 7:6. In spite of the highly uniform environmental stimulation, and the subjects' relative lack of cues as to the hour of day, sleepiness was observed to be far more pronounced during the hours immediately following midnight. It is noteworthy that three out of the four subjects who vomited did so during the early morning hours.

In general, the behaviour of our group was not

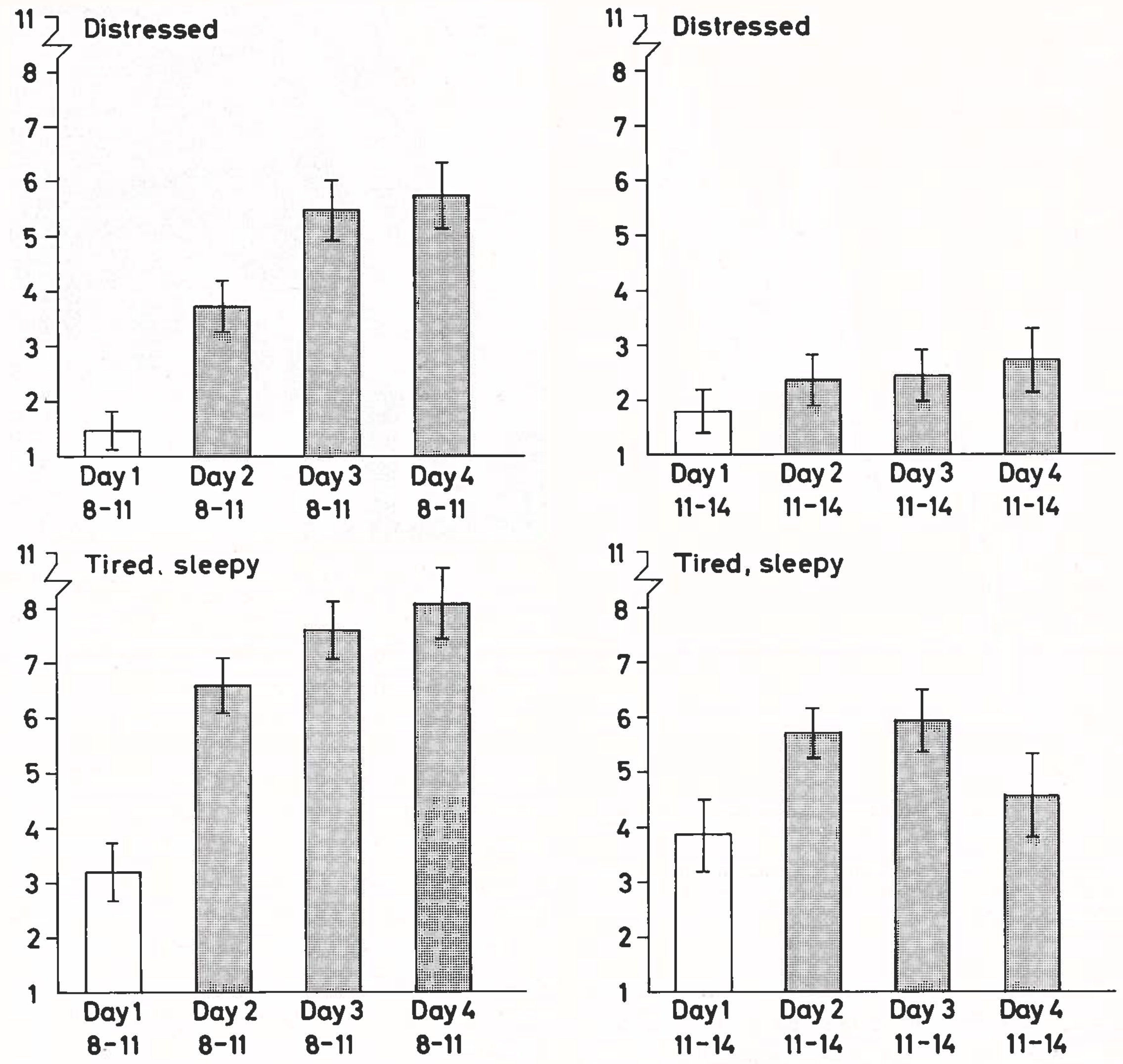

Figure 7:4. Self-rated "distress" and "fatigue" (11-point rating scales) during the control period (day 1, 08—11 hours for half the group, 11—14 hours for the other half) as compared with the corresponding periods of days 2, 3 and 4. Means ± S.E.M. For description of rating scale, see p. 44.

very conspicuous. However, rather pronounced confusional reactions did occur in two subjects:

Subject "*A* " was in his early twenties. On the third day, in his short conversation during the food breaks, he reported some confusion about what his fellow subjects said and also about some of his own viewpoints. He said, for example, that his thoughts "spun clockwise" and that he "ought not to forget the instruments for the dentist". At noon, the experimenter observed that the subject was fiddling about with his rifle, scrutinizing it thoroughly but not shooting. He related that he did not know how to use it but was trying to find out. On being asked to leave the shooting range, the subject went to the wall, which he inspected and fingered in a search for non-existing seams. He was escorted to a bed and put to sleep. Initially he exhibited some uneasiness about being cranky and therefore not being allowed to go home after the end of the vigil. Being reassured that such feelings might be normal in sleep-deprived people, he fell asleep and slept for 9 hours,

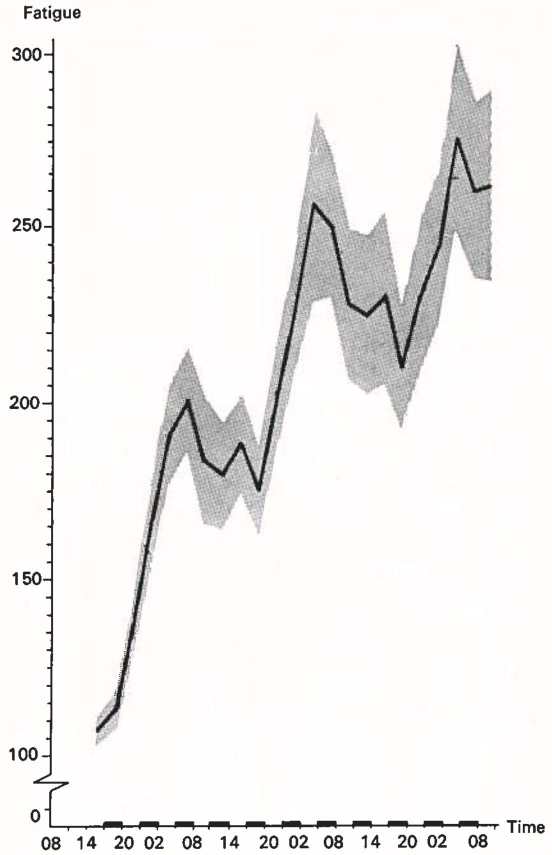

Figure 7:5. Self-rated "fatigue" (magnitude estimations) under conditions described in figure 7:2. Means ± S.E.M.

being woken up, however, every third hour for eating, drinking and producing a urine sample. Afterwards he reported no recollection of this sleeping period and also indicated that he had a complete blackout for the period just prior to his removal from the shooting range. Having slept, the subject recovered completely and finished the study as originally planned without behavioural or subjective disturbances.

The other subject, "*B*", was in his late twenties. During the afternoon of the second day, he reported increasing anxiety, malaise and emotional tension. Indicating a wish to leave the study, he was kindly asked to give it another try for a few more hours, which he agreed to do. After an hour or so he vomited and then reported that he felt better. After a few more hours he suddenly rose, complaining of intense anxiety and claustrophobia,

Figure 7:6. View of the shooting range during early morning hours of the second night, illustrating behaviour characterized by pronounced fatigue and sleepiness. Picture taken with ultra-red (invisible) light and special film. The visible faces have been retouched to make them unrecognizable.

and indicated that he "could not stand it any more". He was immediately removed from the shooting range and put to bed, being dealt with in much the same way as subject "A". After 9 hours of sleep (with breaks every three hours for food, drink and urine samples) he felt completely recovered and finished the rest of the study without any subjective or observable disturbances.

7.4.1.3 *Performance*

Performance as reflected in *number of shots* and *number of hits* decreased significantly throughout the study, cf. figures 7:7 and 7:8. Although the quality of performance (number of hits) varied considerably between any two consecutive 3-hour periods (probably mainly because of the difference in illumination between alternate periods), there is a tendency towards a circadian rhythm.

Briefly, then, the exposure was accompanied by moderate increases in "distress" and "fatigue" save in a few subjects, who exhibited more pronounced reactions including confusional states, and by rather marked drops in performance.

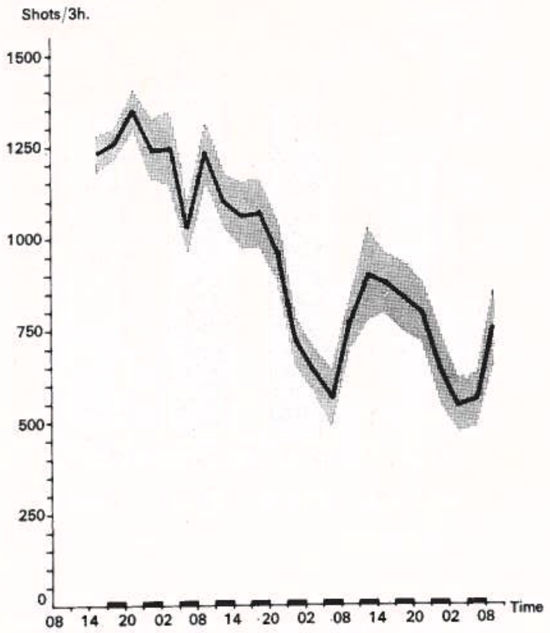

Figure 7:7. Number of shots per 3-hour period under conditions described in figure 7:2. Means ± S.E.M.

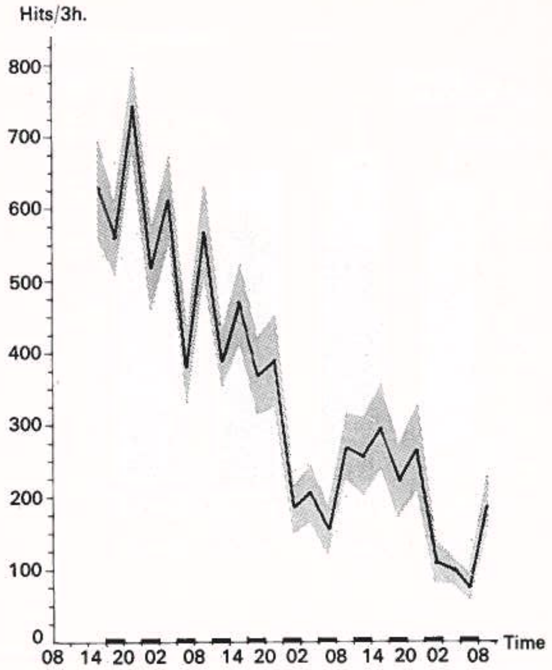

Figure 7:8. Number of hits per 3-hour period under conditions described in figure 7:2. Means ± S.E.M.

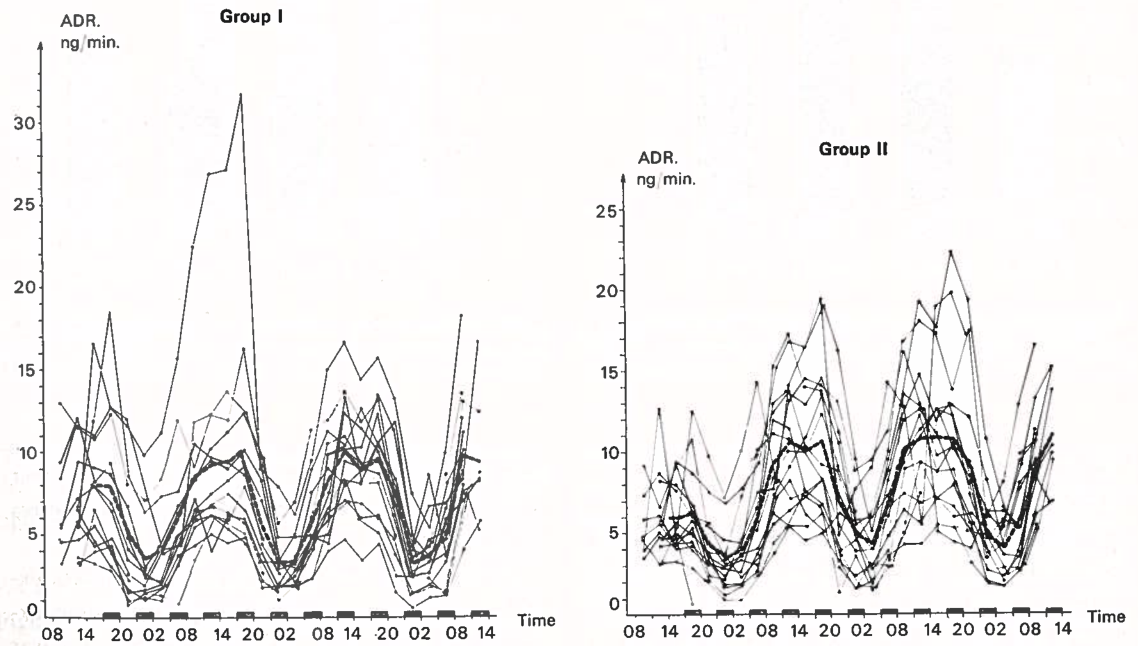

Figure 7:9. Adrenaline excretion under conditions described in figure 7:2. Adrenaline excretion peak in left diagram parallels the development and exacerbation of episode of claustrophobia and panic in one subject.

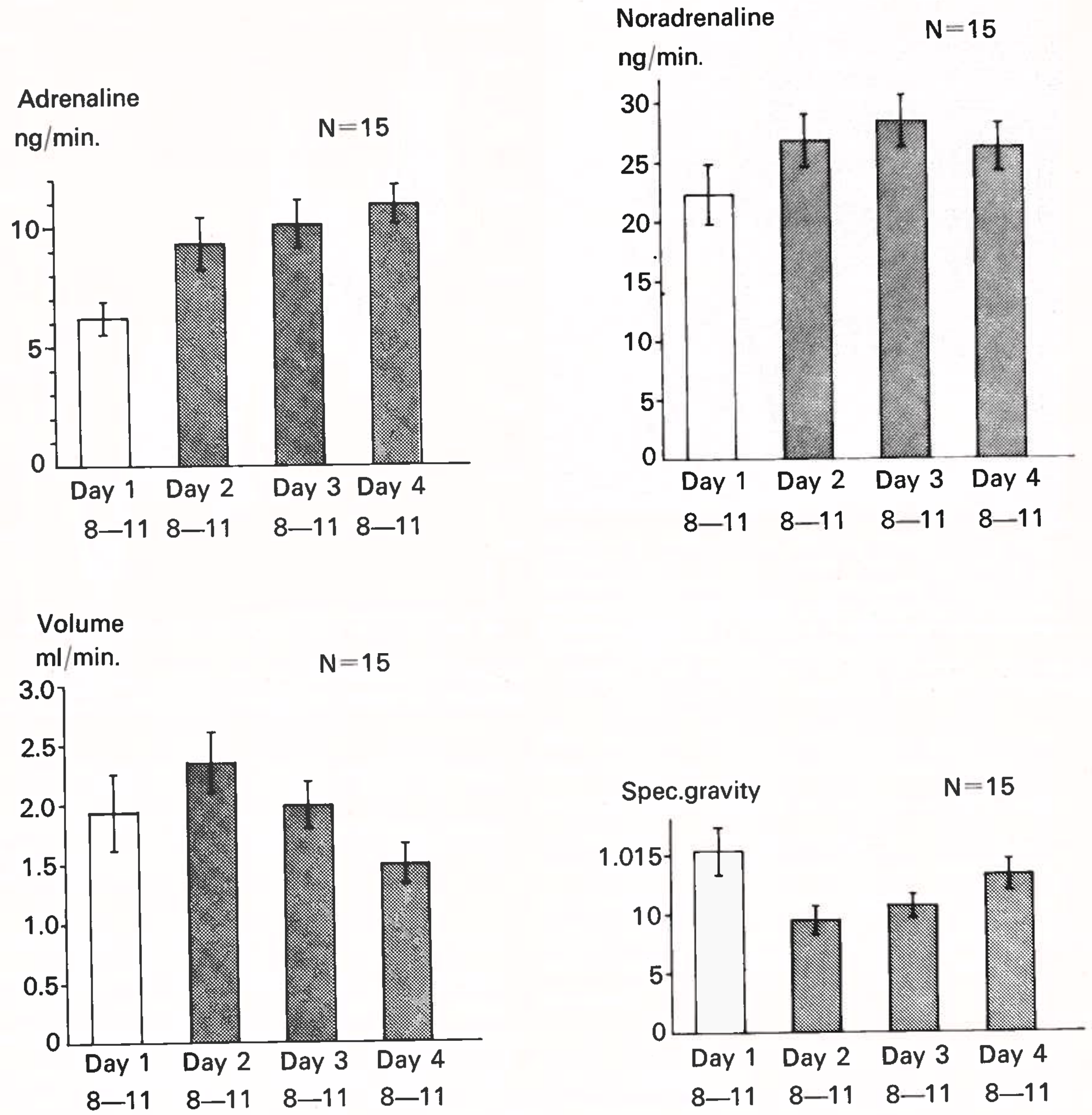

Figure 7:10. Urinary adrenaline and noradrenaline excretion, urine flow and specific gravity during control conditions (empty bars) and corresponding periods of days 2, 3 and 4, at 8—11 hours. Means ± S.E.M.

7.4.2 Physiological reactions

7.4.2.1 Adrenaline excretion

The urinary excretion of *adrenaline* followed a sine-shaped curve, exhibiting significant circadian rhythm (Fröberg et al., 1970), with a maximum during the hours following 12.00 noon and a minimum about 12 hours later, cf. figure 7:9. Adrenaline excretion exhibited a successive rise from the first day to the next, the increase over the control level being highly significant, figures 7:10 and 7:11.

As shown in figure 7:9, one of the subjects exhibited a pronounced increase in adrenaline excretion on the second day of exposure. This was subject "B", who reported intense anxiety and claustrophobia (see above), and the increase in

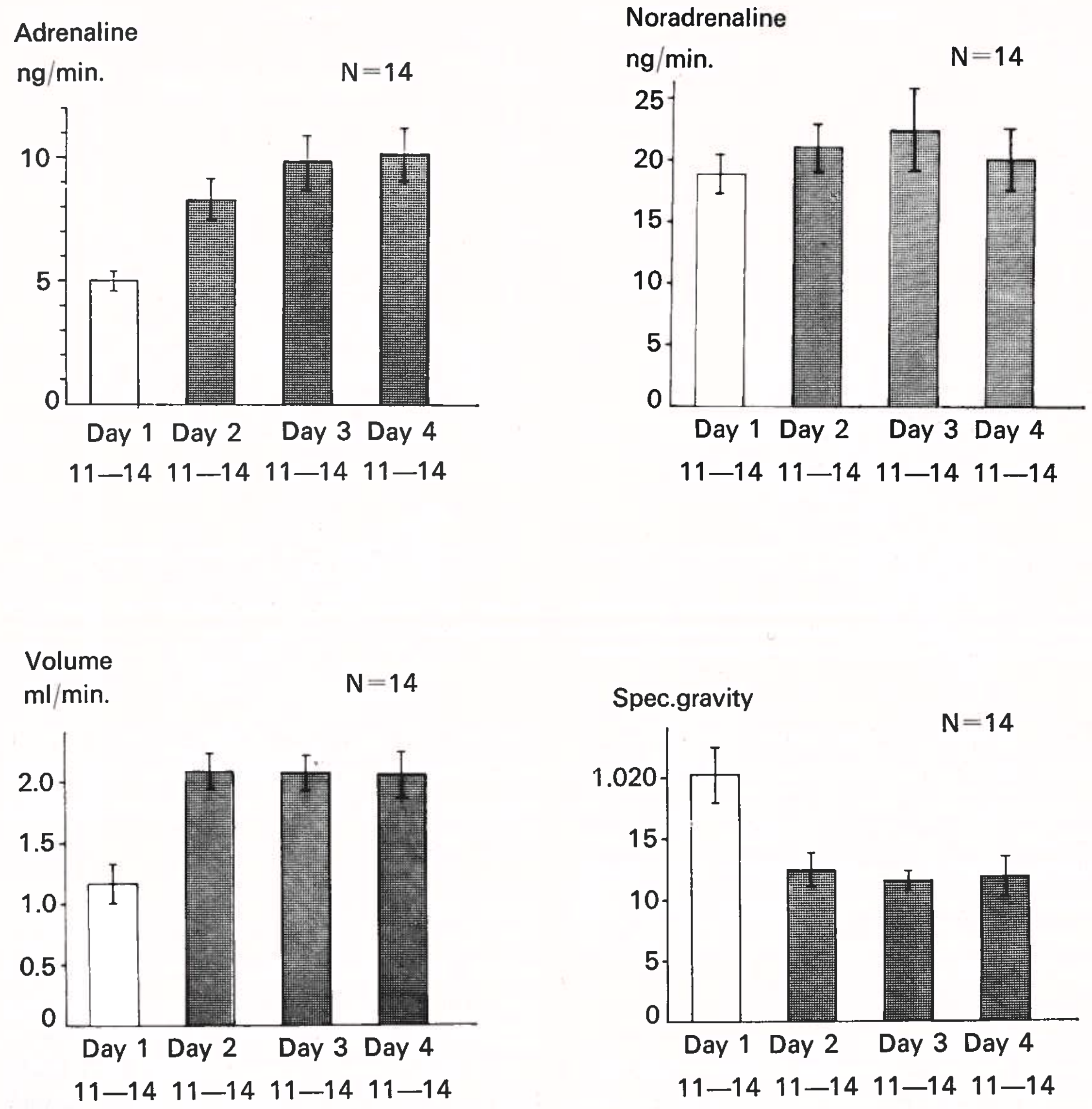

Figure 7:11. Urinary adrenaline and noradrenaline excretion, urine flow and specific gravity during control conditions (empty bars) and corresponding periods of days 2, 3 and 4, at 11—14 hours. Means ± S.E.M.

reported emotional tension largely coincided with the increase in catecholamine excretion, cf. also figure 7:12.

7.4.2.2 Noradrenaline excretion

Figure 7:12 demonstrates the individual levels of *noradrenaline* excretion throughout the study. The noradrenaline curve is more irregular than the one for adrenaline, exhibits a significant but less pronounced circadian rhythm (Fröberg et al., 1970) and shows peak values at about 8.00 a.m. Figures 7:10 and 7:11 demonstrate a significant rise from day 1 to day 2, but only for the period 8.00—11.00 a.m.

7.4.2.3 Urine flow

In spite of the 3-hourly standard intake of fluid throughout the experiment, *urine flow* exhibited

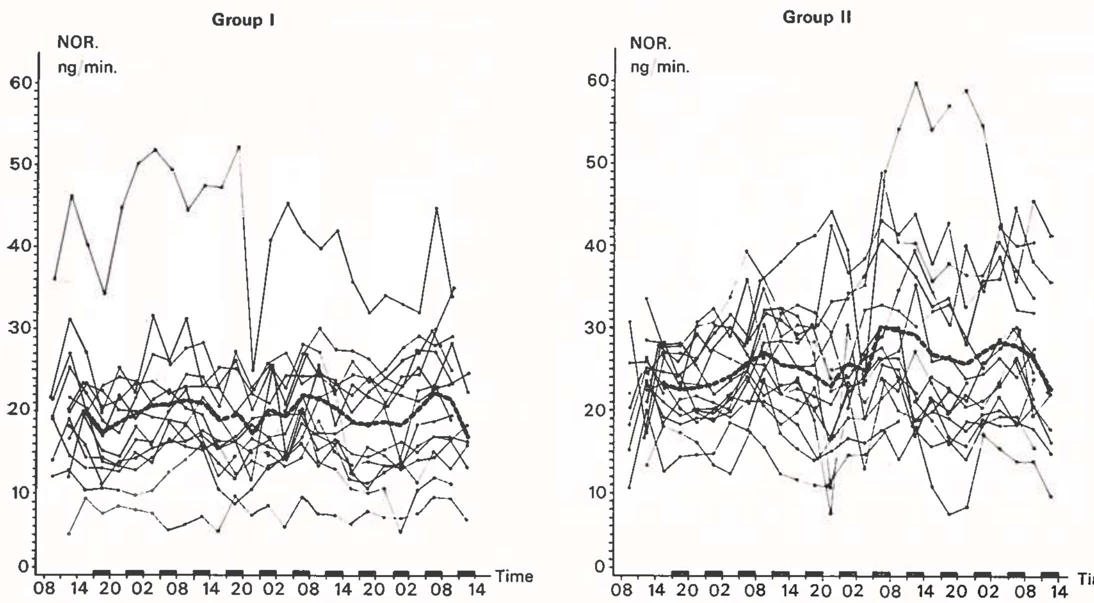

Figure 7:12 Noradrenaline excretion under conditions described in figure 7:2. Noradrenaline excretion peak in left diagram parallels the development and exacerbation of episode of claustrophobia and panic in one subject.

a very marked circadian rhythm (Fröberg et al., 1970), reaching peak values at about 9.00 a.m.

As to changes over time, the effects on this variable, as on several of the others, differ somewhat, depending upon which set of 3-hour periods the comparison concerned, namely 8.00 a.m.—11.00 a.m. or 11.00 a.m.—2.00 p.m., cf. figures 7:9 and 7:10.

7.4.2.4 Specific gravity

Specific gravity of the urine samples exhibited a decrease, cf. figures 7:10 and 7:11. Specific gravity displayed much the same cycle as urine flow but varied in the opposite direction.

7.4.2.5 Protein-bound iodine

The mean level of *protein-bound iodine* and the S.E.M. the week before the vigil started was 6.1 ± 0.2 μg/100 ml plasma. At the end of the vigil, the level had risen by 30 per cent to 7.9 ± 0.2 μg/100 ml plasma (figure 7:13), the rise being statistically highly significant ($p < 0.001$), cf. Johansson et al. (1970).

In the "pre-stress" samples, PBI levels above 8μg/100 ml plasma (i.e. above the upper normal limit with the assay method used in this context) were found in three subjects. At the end of the exposure, eight of the 31 subjects exhibited levels of this magnitude.

7.4.2.6 Serum iron

The "pre-stress" *serum iron* level was 111 ± 6.1 μg/100 ml plasma. At the end of the vigil the level had decreased by 52 per cent to 53.0 ± 3.7 μg/100 ml plasma ($p < 0.001$), see figure 7:14.

In the "pre-stress" samples, serum iron levels below 75 μg/100 ml plasma (= lower normal limit) were found in three of our subjects. At the end of the exposure, levels below this point were found in 28 subjects.

7.5 Discussion

7.5.1 Self-ratings, observed behaviour and performance

7.5.1.1 Self-ratings

As shown above, self-ratings of "distress" and "fatigue" increased significantly throughout the exposure. It is noteworthy that the enhancement of "distress" and "fatigue" ratings over time is

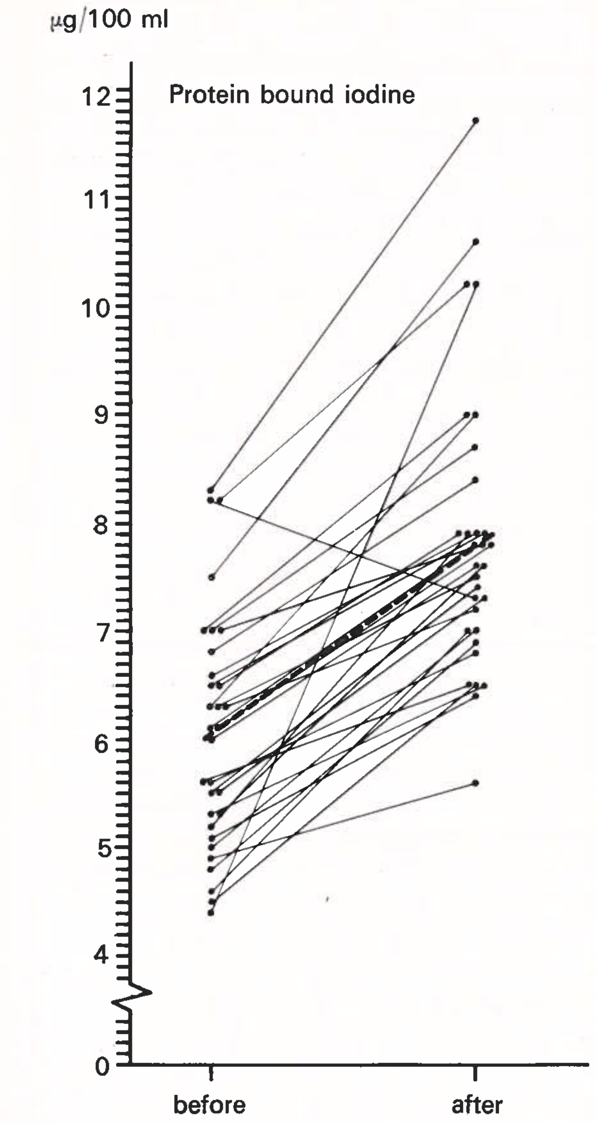

Figure 7:13. Protein-bound iodine before and after the stressor exposure.

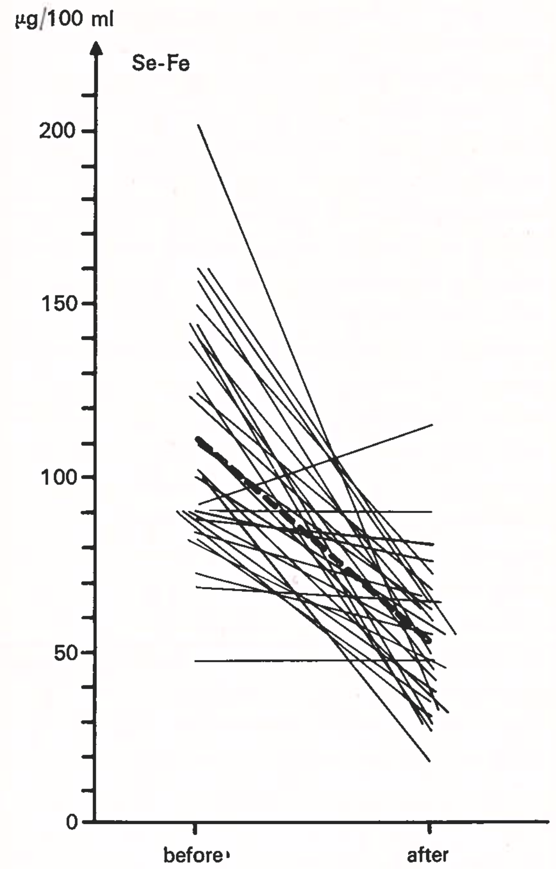

Figure 7:14. Serum iron before and after the stressor exposure.

more pronounced when the comparisons between days are made with respect to the period 8.00—11.00 a.m. than to the next period, 11.00 a.m.—2.00 p.m., cf. figures 7:3 and 7:4. This finding supports the assumption of an interaction between duration of exposure and time of day, as influenced by a circadian rhythm. The 24-hour means for each of the three days likewise show significant increases in "distress" and "fatigue" ratings (Fröberg et al., 1970).

7.5.1.2 Observed behaviour

Dramatic delusional and confusional states have been described repeatedly in sleep-deprived subjects (for review see Naitoh, 1969; Rechtschaffen and Eakin, 1969). It has been claimed that sleep-deprived subjects who develop florid psychotic behaviour appear to have atypical personalities and personal histories. However, the two subjects in the present study who exhibited a confusional and a claustrophobic reaction, respectively, were not and had never been psychiatrically conspicuous as judged from pre-experimental psychiatric interviews. Their reactions were rather benign and transient, disappearing after the equivalent of a good night's sleep.

7.5.1.3 Performance

Performance decrements following sleep deprivation combined with continuous work have been described repeatedly (for review see Naitoh, 1969; Morgan et al., 1970; Drucker et al., 1969). Our results, indicating quality and quantity decrements, are in general agreement with those reported by other authors. Feeding back information to the subject on how well he had performed each task shortly after its execution (Wilkinson, 1961) and the intermittent exposure to noise (Wilkinson, 1963) probably tended to counteract the performance decrements. The reasons for the decrements are no doubt manifold, one of them probably being the occurrence of brief intermittent lapses in performance as described e.g. by Bjerner (1949), who demonstrated that such lapses were accompanied by a transient fall in pulse rate and a change in the EEG pattern, indicative of brief periods of sleep.

The quality and quantity of performance are no doubt influenced by many other factors as well, such as changes in motivation (cf. Ax et al., 1957) and the occurrence of minor neurological disturbances, e.g. ptosis and tremor (Sassin, 1970). It is unlikely that learning contributed to counteract the performance decrements substantially, because all the subjects were qualified marksmen and the shooting task was not very different from ordinary rifle shooting.

7.5.2 Physiological reactions

7.5.2.1 Adrenaline excretion

As shown in the review in paragraph 1.5.2 and in Chapters 3—6, psychosocial stimuli of short duration can evoke enhanced sympathoadrenomedullary activity as reflected in plasma levels and urinary excretion of adrenaline. The present study demonstrates that a similar reaction occurs in response to a stressor exposure lasting several days. The prolonged exposure is accompanied by a significant and sustained increase in adrenaline excretion over control values (cf. figures 7:10 and 7:11), as well as by a significant increase in 24-hour adrenaline excretion over days (Fröberg et al., 1970).

Rubin et al. (1969) reported a 205-hour sleep deprivation study on 4 subjects, 2 of whom exhibited increased excretion levels of urinary vanillylmandelic acid (VMA) during the latter half of the deprivation period. However, these subjects had access to television, radio, a phonograph, table tennis, and a snack kitchen, and in the slack periods between various psychological testing procedures they amused themselves with games, physical activities, and other diversions. In addition, according to the authors, the subjects used a "basin of ice cubes-face immersion technique" to combat increasing waves of drowsiness, creating their own version of the cold pressor test, which has been shown to increase the urinary excretion of VMA (Sapira and Shapiro, 1966), making the results difficult to evaluate. Exposing subjects to physical work in combination with ambient temperatures and one night's sleep deprivation, Hasselman et al. (1960) reported that the last-named factor contributed to the increase in sympathoadrenomedullary activity thus provoked (cf. also Hernández-Peón et al. 1969). Fiorica et al. (1970), on the other hand, found no increases in "total catecholamine" excretion.

7.5.2.2 Noradrenaline excretion

Noradrenaline excretion generally remained on the control level and did not exhibit pronounced fluctuations attributable to the duration of exposure. It may be noted, however, that in subject "B", who developed an episode of claustrophobia and panic, noradrenaline excretion rose to and remained on rather high levels before and during this episode.

7.5.2.3 Urine flow and specific gravity

As to urine flow and specific gravity, an increase in diuresis was found during the stressor exposure as compared to the initial control periods. This is consistent with our findings in most of our previous experiments. On the other hand, at least part of this response probably reflects rather high hydration, 300 ml of water being ingested every third hour. Although this fluid dosage began prior to the study proper, it is conceivable that water balance was not reached until well after the start.

The 24-hour means for urine flow showed a significant increase from day 1 to day 2 (Fröberg et al., 1970).

7.5.2.4 Protein-bound iodine

As demonstrated in figure 7:13, our subjects exhibited a highly significant increase in PBI, sometimes even exceeding the upper normal limit.

For a more comprehensive discussion of these findings the reader is referred to Johansson et al. (1970). In the present context we shall simply consider some of the main issues.

The first question is whether the PBI rise was caused by the combination of continuous shooting and sleep deprivation, as opposed to stimuli like the 3-hourly food servings. This hypothesis might have been tested by letting a control group just sit and be exposed to the experimental procedures described above, excluding, however, the sleep deprivation and the psychomotor activities. Such a prolonged "non-stress" study was, however, considered unsatisfactory as the sheer monotony would presumably represent a stressor.

PBI levels have been shown not to change appreciably over relatively short periods of time (Danowski et al., 1949), even in the *absence* of any standardization of diet, physical and mental activities etc. Similarly, Gaffney et al. (1960) report that an increase in the interval between PBI measurements from 1—13 days to 13 days—7 months did not increase the variability in level.

Other reasons, too, make it unlikely that the present diet contributed to the rise in PBI. With an adequate dietary supply of iodine, an additional daily ingestion of up to 125 mg of iodine is reported not to alter PBI levels appreciably (Friend, 1960). Such an amount corresponds to no less than 3 kg of iodized salt, i.e. much more than any one could possibly ingest over a period of a few days. Neither did the subjects in fact receive appreciable amounts of iodine from non-dietary sources. Had the subjects started with an iodine deficiency, however, it is conceivable that even more or less "normal" doses of iodized table salt would have increased the levels of PBI (cf. Kelsey et al., 1957). But in our case, iodine deficiency (cf. Lundwall et al., 1965) at the start of the study is improbable, because the diet used in the Swedish Army (not comprising iodized salt) has been calculated (Karlsson and Levi, 1969) to include approximately 120 μg of iodine daily. This amount compares favourably with the recommended daily iodine allowance for adult males, which is 110—140 μg (U.S. National Research Council's Food and Nutrition Board 1968). Furthermore, the sandwiches served in our experiments cannot have constituted even a modest "iodine load" as mentioned above, because *none* of their ingredients is prepared with iodized salt or contains iodine in appreciable amounts (cf. Karlsson and Levi, 1969). Accordingly, the PBI rises in our studies could not be attributed to dietary factors of the type described above.

On the other hand, it is of course impossible to separate the psychosocial from the physical stimuli included in the experimental situation, the latter being the prolonged sitting, the monotonous and oft-repeated ingestion of food etc. (cf. Bergner et al., 1968). Suffice it to say that exposure to the total experimental situation, including as it did several conspicuous psychosocial elements, resulted in significant increases in PBI levels.

Our second key question relates to whether or not the rise in PBI is accompanied by a corresponding increase in thyroid activity and in free thyroxine in plasma.

Protein-bound iodine normally consists mainly of thyroxine, small amounts of triiodothyronine and perhaps traces of other iodinated substances as well (for a review and discussion see Wayne et al., 1964). As a rule, PBI is considered to be an approximate measure of the concentration of thyroid homones in the blood (Scazziga and Lemarchand-Béraud 1967, Mason 1968, Farran et al., 1971). As often pointed out, this measure is not a simple function of the rate of hormonogenesis but merely a steady state concentration (Gregerman, 1967).

This "steady state" may be disrupted in several ways, as demonstrated by LaRoche and Johnson (1967) in rats exposed to a simulated altitude of 17,000 feet. The authors suggest "than in the early stages of treatment there is a profound dichotomy between rates of thyroidal uptake and secretion". Similarly, Söderberg (1958) concludes that rate of secretion and rate of uptake are not parallel in the acute experiment. If this is true in man, the rise in plasma PBI found in our studies may theoretically have been determined not only by an increased thyroxine release (cf. Dewhurst et al., 1968 b) or by a (catecholamine-induced?) shift in the compartmental distribution of hormonal iodine (Hays and Solomon, 1969), but also by a decreased elimination rate, including decreases in some or all of the following processes: (a) peripheral utilization, (b) tissue binding, and (c) excretion (Brockis 1962).

However, the demonstration by Blomstedt (1965) of an increase in thyroxine breakdown following surgical trauma as well as cortisone administration argues against such a decrease in thyroxine elimination rate. Surgical trauma has further been reported to result in "an increased production of thyroxine as measured by changes in the protein-bound iodine", as well as in a reduced uptake of iodine by the thyroid immediately after the operation (Johnston, 1965). The levels of protein-bound iodine rose quickly and were maintained for 3 days after operation. The author interprets his results as pointing to a redistribution of iodine in the body after injury (with less iodine available to enter the thyroid gland) and to a rapid release of preformed stored thyroid hormone after trauma, along with an increased rate of hormone utilization by the tissues. Studying the same phenomenon, Brockis (1962) reports findings which suggest that active changes take place in the thyroid gland following a surgical operation, and as it is known that the content of iodine in urine is not diminished under these circumstances, this could not account for the rapid rise in hormone level. In an analogous way, the thyroid of normal man is said to respond rapidly to acute febrile illness with a marked increase in the rate of release of thyroxine (Gregerman, 1967). However, as the bacterial illness often results in a marked and perhaps proportional acceleration of thyroxine elimination ($t_{1/2}$ for injected thyroxine-I^{131} decreasing from 10.8 to 2.3 days), the plasma thyroxine concentration may remain unaffected (Gregerman and Solomon, 1964).

As judged from these studies there is no a priori reason to expect that thyroxine *elimination* from blood should *decrease* during the stressor exposures of our study. If anything, it could be expected to increase because (a) the urinary excretion of iodine has been shown to increase following catecholamine injection in the rat, rabbit and dog (cf. Pitt-Rivers, 1960) and (b) as indicated above, an increase in tissue utilization has been proposed to occur in response to various stressor exposures, possibly as a result of the increased release of catecholamines (cf. Pitt-Rivers, 1960). As all these processes tend to lower the PBI level, and yet the PBI levels rose in our studies, our results speak in favour of a thyroxine release big enough to make up for a presumably increased elimination and, in addition, to raise the plasma pool of circulating hormone.

Determinations of the level of untagged PBI in contrast to PBI^{131} and radioactivity counted over the thyroid gland did *not* change significantly according to Flagg et al. (1965) in subjects exposed to a stressor film, suggesting that untagged PBI is not a particularly sensitive indicator of thyroid response. On the other hand, we considered it inexpedient to use radioiodine methods in large-scale studies with healthy volunteers. Furthermore, as pointed out by Brockis (1962), the tracer protein-bound iodine represents only a small proportion of the overall protein-bound iodine. The increases and decreases reflect the fate of the most recently produced thyroid hormone. Whether this protein-bound iodine fraction behaves similarly to the overall PBI is not yet known.

High PBI levels are occasionally found in patients with clinically normal thyroid function (cf. Rosenbaum et al. 1968). What remains normal is the small non-protein-bound or *free* thyroxine fraction, which represents the physiologically active form of this thyroid hormone. The high PBI levels in such a case may be due to increased levels of thyroxine that has been *bound by serum proteins,* particularly thyroxine-binding globuline (TBG) but also thyroxine-binding albumin and prealbumin (TBPA) (Sisson, 1965; Scazziga and Lemarchand-Béraud, 1967). If the number of available binding sites of TBG and (to a lesser extent) TBPA and albumin increases, more thyroxine becomes bound to these sites and the PBI level rises. This is said to occur during pregnancy, estrogen administration (including the common oral contraceptives), prolonged perphenazine administration, and acute liver disease and cirrhosis (Sisson, 1965). However, none of these influences is very likely in our officers and soldiers, all of whom were in perfect health as judged by clinical criteria and not on any drug regimen whatsoever.

Furthermore, surgery has been reported to induce not an increase but a significant decrease in the binding capacity of TBPA, a fall in prealbumin-1 (Surks et al., 1967) and in TBPA (Surks and Oppenheimer, 1964) and an increase in the peripheral breakdown of thyroxine (Blomstedt, 1965). Further, the release of corticosteroids is known to rise during stress (Mason, 1968), and cortisone derivatives have been reported to reduce the binding capacity of TBG (Scazziga and Lemarchand-Béraud 1967). Against this background it is considered improbable, although definitely not impossible (cf. Taylor and Fisher, 1968; Hays and Solomon 1969), that the PBI increases found in our study were due predominantly to changed levels of carrier proteins.

This position finds further support in the recent demonstration by Crystal et al. (1970) of a rise in free thyroxine and a fall in TBPA occurring 1—4 days after myocardial infarction in five euthyroid subjects.

As already noted, three of our subjects exhibited "pre-stress" PBI levels above 8 μg/100 ml plasma. It is not known whether these subjects experienced specially pronounced anticipatory anxiety or whether their rather high PBI levels were due to other factors. Anyhow, none of them was clinically hyperthyroid. The *mean* "pre-stress" PBI level of our group was, however, quite normal (6.1 ± 0.2 μg/100 ml) and rather close to the normal levels obtained with the same method (5.8 ± 0.4 μg/100 ml) and reported by Lemarchand-Béraud and Vanotti (1969).

To sum up, we managed to induce relatively pronounced and highly significant increments in PBI levels in our group of 31 young and middle-aged military subjects. It is not entirely clear whether these increments were due to rises in biologically inactive thyroxine, indicating a rise in carrier proteins, or whether they reflect either an increase in thyroid activity accompanied by increased levels of free thyroxine, or an adrenaline-induced shift of thyroxine from tissue stores into the vascular compartment.

In a subsequent study of similar design, significant PBI increments were induced in 32 senior officers (Levi, 1969; Johansson et al., 1970), confirming the present results. In a third study to be carried out this year, the mechanisms of the PBI rises will be investigated in more detail.

7.5.2.5 Serum iron

As indicated above, the stressor exposure was accompanied by a pronounced and highly significant fall in serum iron, in fact down to levels usually considered clearly subnormal, in spite of a rather liberal supply of iron-containing food throughout the study. This dramatic drop in serum iron could not be due to the venous punctures per se, as the blood loss amounted to no more than 50 ml per puncture. Liljedahl et al. (1969), in their studies of plasma iron elimination rate, found that phlebotomy of 100—150 ml did not accelerate this elimination.

The "pre-stress" serum iron levels of our group were very close to those found for healthy Swedish adult males as reported in numerous papers (for a review, see Strandberg, 1966). In contrast, as indicated above, the "post-stress" serum iron levels of all but 3 subjects were below the lower limit of the normal range (cf. Fairbanks, 1970). As mentioned in paragraph 7.1, serum iron levels have been shown to decrease in response to a variety of physical stressors and in the course of diseases as diverse as rheumatoid arthritis, cancer, infections, and mental illness. This brings to mind the Selye hypothesis of stress as the *non-specificity* of physiological response. The present finding speaks in favour of this hypothesis, demonstrating that the stressor exposure of the present study, too, evokes a serum iron decrease.

Our results have been confirmed in a similarly designed study on 32 senior officers (Levi, 1969) and in studies reported by Kuhn et al. (1967 a and b). These authors found the same type of serum iron decrements in 4 males exposed to a 120 hour vigil and confirmed their findings in a second study on another group of 6 males. During sleep deprivation they found a gradual decline in serum iron, the maximum drop being to half the original levels, in much the same way as in our study. The decline was most marked during the first 48 hours of sleep deprivation. The return to normal values took roughly one week. Total iron binding capacity also decreased, but much less, the maximum drop occurring during the 72nd hour of the vigil. Urinary iron excretion and gastrointestinal iron absorption did not change significantly.

In agreement with the last named authors we are inclined to interpret these results along the lines proposed for the serum iron decrements found in response to physical stressors, namely with reference to a stimulation of the reticulo-endothelial system, probably induced through neuroendocrine pathways. However, future studies should also consider other theoretically possible explanations, such as an increase in hemoglobin synthesis and a decrease in hemolysis and/or in iron release from tissue stores. No doubt, the problem deserves further study.

7.5.2.6 Hematocrit

Before drawing any conclusions as to changes in various plasma and serum constituents, one must consider the possibility that the stimuli evoked changes in the extracellular fluid volume, which, in turn, would automatically change the concentration of all compounds normally present in this fluid. Distress reactions are known to be accompanied by changes in water and electrolyte metabolism (Schottstaedt et al., 1956). The resulting shifts of water between intra- and extracellular fluid compartments may conceivably influence the serum level of various compounds, e.g. serum iron and PBI (Reichlin and O'Neal, 1962; Wilson, 1966). If the extracellular fluid volume decreases, the concentrations of these compounds may be expected to rise, and vice versa. Such a hemoconcentration or hemodilution, if pronounced, would be reflected by the hematocrit. However, no significant changes in hematocrit were found in our study, the "pre-" and "post-stress" levels being 43.9 ± 0.5 and 43.0 ± 0.5, respectively ($p > 0.05$).

It is an everyday experience that prolonged sitting leads to swelling of the feet. This phenomenon was noted in several of our subjects towards the end of the exposure. As shown by Johnson et al. (1972), 24 hours of sitting, although leading to swelling of the lower extremities, does not evoke any change in interstitial and intracellular fluid volumes as calculated from measured plasma volume, extracellular volume and total body water of 6 subjects before and after a 24-hour commercial overseas flight. Neither did peripheral hematocrit or total serum protein concentration change significantly. It seems unlikely that the shift in body fluids to the dependent parts of the body explains the changes in serum levels of various compounds, as there is no water retention and the intravascular water volume remains unchanged.

7.5.3 Circadian rhythms

Briefly, all our indices of sympathoadrenomedullary and renal function as well as our fatigue and distress ratings exhibited circadian rhythms during most of the 24-hour spans, in spite of the uniform nature of the routine and the extensive equalization of extrinsic Zeitgebers (task, ingestion of food and fluid, bodily posture etc.) between all 3-hour periods of the day (Fröberg et al., 1970). The quantity and quality of performance decreased, and distress and fatigue increased during the early morning hours (3.00—5.00 a.m.). It may be noted that these reactions did not coincide with, but were *preceded* by, a pronounced drop in adrenaline excretion. This sequence of events may be a cue to a possible causal relationship between the two sets of variables.

Several of the psychophysiological circadian rhythms may have obvious implications in situations where subjects are expected to perform continuously for 24 hours or more, or to alternate their periods of work and sleep, as in shift work (cf. Luce, 1970).

It has further been shown that births (Jenny, 1933; Málek et al., 1962; Kaiser and Halberg, 1962) and deaths (Frey, 1929; Jusatz and Eckardt, 1934) reach their peak frequencies and several somatic diseases make their début or exacerbate (cf. e.g. Menzel, 1942; Halberg, 1953; Zülch and Hossman, 1967; Ask-Upmark, 1969) at the very hours when, according to Shakespeare (1605), "churchyards yawn, and hell itself breathes out/ Contagion to this world: now could I drink hot blood/ And do such bitter business as the day/ Would quake to look on", i.e. during the hours round about midnight, whereas e.g. endogenous depressions usually are reported to be most intense not until the early morning hours, when "depression comes down like a cloud" (Slater and Roth, 1969; Middelhoff, 1967). It would be tempting to speculate here about this time lag between physiological and psychological phenomena which obviously occurs in clinical practice as well as in our experimental situation, but the *circadian aspects* of the present study and others conducted at our laboratory will be dealt with in detail in a future report (Fröberg, in preparation).

7.5.4 Psychophysiological relationships

Considerable numbers of parallel psychological and physiological data were obtained concurrently in the present study, which therefore constitutes a better basis for the assessment of psychophysiological relationships than do the studies reported in Chapters 3—6.

Correlations were computed over the entire sequence of the last 16 3-hour periods, based on group and period means for each pair of variables. In this analysis the observations from the first 24 hours were excluded in order to diminish possible effects of learning the task and getting acquainted with the situation, which would presumably complicate the relationship. It was found that both performance measures correlated positively and significantly to adrenaline excretion but negatively and significantly to noradrenaline excretion, cf. table 7:1.

Table 7:1. Correlations between paired means of variables calculated for the last 48 hours of the experiment.

Variable A	Variable B	r_{AB}	d.f.	p<
Adrenaline	Noradrenaline	.05	14	
	Urine flow	.31	14	
	Shots	.66	14	.01
	Hits	.55	14	.05
	Fatigue	−.54	14	.05
	Distress	−.24	14	
Noradrenaline	Urine flow	.75	14	.001
	Shots	−.52	14	.05
	Hits	−.54	14	.05
	Fatigue	.53	14	.05
	Distress	.55	14	.05
Shots	Fatigue	−.92	14	.001
	Distress	−.78	14	.001
Hits	Fatigue	−.87	14	.001
	Distress	−.86	14	.001

The reverse was true regarding the correlations between self-ratings of fatigue and urinary catecholamines. Thus, fatigue ratings correlated significantly but negatively with adrenaline excretion, and significantly and positively with noradrenaline excretion.

There was also a significant positive correlation between "distress" ratings and levels of noradrenaline, whereas the correlations with performance measures (shots and hits) were significant but negative, cf. table 7:1.

Similarly, performance showed high negative correlations with "fatigue" ratings.

When computing correlations between variables, it must be kept in mind that the reactions, although simultaneously *measured,* did not necessarily *occur* simultaneously, but can still be significantly related to each other. As shown by Fröberg et al. (1970), minimum adrenaline excretion levels *precede* by several hours the subsequent low in performance and high in fatigue ratings. Therefore part of our analysis has been based not only on a correlation of data obtained in our subjects from the same periods of measurement but also on correlations obtained after *lagging* one set of the data 1—2 measurement periods. The choice as to which variable to lag was based on inspection of the curves and calculations con-

Table 7:2. Correlations with 3- and 6-hour lags between paired means of variables. A lag of e. g. 3 hours for a variable implies that the values for that variable have been "shifted" one measurement period in relation to another variable.
Calculations refer to the last 48 hours of the study.

Variable A	Variable B	Lag in hours	Lagged variable	r_{AB}	d.f.	p<
Adrenaline	Noradrenaline	3	B	.55	13	.05
		6	B	.76	12	.01
	Urine flow	3	B	.82	13	.001
		6	B	.70	12	.01
	Shots	3	A	.78	13	.001
		6	A	.40	12	
	Hits	3	A	.65	13	.01
		6	A	.28	12	
	Fatigue	3	A	−.75	13	.01
		6	A	−.50	12	.05
	Distress	3	A	−.44	13	
		6	A	−.32	12	
Noradrenaline	Urine flow	3	B	.49	13	.05
		6	B	.19	12	
	Shots	3	B	−.80	13	.001
		6	B	−.81	12	.001
	Hits	3	B	−.63	13	.05
		6	B	−.81	12	.001
	Fatigue	3	B	.83	13	.001
		6	B	.69	12	.01
	Distress	3	B	.53	13	.05
		6	B	.52	12	.05

cerning their phases (Fröberg et al., 1970). Some of the results of these analyses are shown in table 7:2.

It will be seen from this table that several correlation coefficients become considerably higher if one of the variables is lagged one or two 3-hour periods (cf. Fröberg et al., 1970).

In describing the relationships between different sets of variables, one may further wish to separate two important factors, both of which may influence the correlations under study:

(a) progressive changes due to sleep deprivation etc. per se, and (b) circadian variations.

Making the assumption that the former effects are approximately linear with time, partial correlations were computed (Fröberg et al., 1970). The results of this analysis indicate that when the effect of hours of sleep deprivation is "partialled out", the correlations between *adrenaline* excretion on the one hand and performance and fatigue measures on the other are clearly significant and of the same magnitude as those reported in table 7:1 ($r = .80$ for number of shots, and $-.70$ for fatigue ratings). The corresponding correlations between adrenaline excretion and distress ratings was $-.19$. Partial correlations between *noradrenaline* and performance, distress and fatigue, however, were not significant. These results support the assumption that there is a relationship between the *rhythms* of adrenaline on the one hand and performance and fatigue on the other, while the relationship between the two latter variables and noradrenaline excretion is due primarily to "stressor-induced", progressive changes. In evaluating the non-significant, negative correlations between adrenaline excretion and distress ratings (table 7:1) it should be kept in mind that distress and fatigue ratings were highly positively intercorrelated in the present experiment ($r = .78$, $p < 0.01$). Probably most of the distress, which never reached more than rather modest levels, was due to the fatigue simultaneously experienced. There is probably a considerable qualitative difference between the distress reported in several of the previous chapters and e.g. in studies conducted by Frankenhaeuser (1971) on the one hand and the present distress ratings on the other. The situation was neither open-ended nor obviously threatening. With the exception mentioned above, no manifest anxiety was observed or reported. Probably, a high "fatigue loading" in the distress ratings accounts for the negative correlations found between adrenaline and distress.

7.5.5 Miscellaneous physiological variables

As indicated by the data presented above, the stressor exposure was accompanied by a number of significant physiological reactions, some of which are significantly related to performance and/or self-ratings of "distress" and "fatigue". The assumption that the stressor exposure did, indeed, significantly influence physiological function is further supported by the finding of significant increases in erythrocyte sedimentation rate (from 2.8 ± 0.4 to 7.5 ± 0.9 mm per hour, $p < 0.001$). A more recent study on senior officers demonstrated the same trend, accompanied by ST and T level depressions in the ECG, decreases in fibrinolysis, and increases in plasma free fatty acids and cholesterol (cf. Levi, 1972). Some clinical implications of these findings will be discussed briefly in the next chapter.

7.6 Summary

A study is presented, in which a total of 31 Army officers and corporals were exposed to a 75-hour vigil that started with a 3-hour control period and continued with 72 hours of performance on an electronic shooting range under strictly standardized environmental conditions. It was found that the exposure was accompanied by significant and pronounced increases in fatigue ratings, moderate increases in distress ratings, pronounced but transient confusional reactions in two of the subjects and decreased psychomotor performance. Simultaneously, our subjects exhibited marked and significant increases in adrenaline excretion and in protein-bound iodine, and a marked and significant decrease in serum iron.

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8 GENERAL DISCUSSION

By Lennart Levi

8.1 Objectives of this chapter

The data presented so far have been discussed in some detail, but only chapter by chapter. In the present chapter, the theoretical model and some of the main hypotheses presented in Chapter 1 will be discussed, drawing on data from several studies, including those by other authors. Hypotheses and data discussed in eariler chapters will either not be repeated at all, or only in summary form.

Some of our findings seem to have implications for clinical and occupational medicine, and for social planning and engineering. A few of these implications will be presented and discussed.

Some of our findings also make possible the formulation of new hypotheses and proposed routes for further research. Based on these considerations, some general outlines for a future research program will be presented.

8.2 Psychophysiological reactions to psychosocial stimuli

8.2.1 Psychological response to psychosocial stimuli

As mentioned in paragraph 2.17, coping behaviour and differences in attitudes can profoundly modify human responses to psychosocial stimuli. Accordingly, it can never be taken for granted that an experimental or "real-life" situation will evoke distress and stress merely because the experimenter assumes this to be the case. Therefore, before stating anything about psychophysiological relationships, the experimenter is obliged to check, by questionnaires, interviews or behavioural observations, whether the subjects did in fact react as predicted. For example, the present author assumed, for obvious reasons, that the sex films (Chapter 4) would induce at least some degree of sexual arousal; yet one out of five of the female subjects denied even the slightest arousal of this type. Although we do not know for certain whether these self-ratings reflected the actual degree of sexual arousal, the ratings do have some face value, and the finding illustrates the necessity of not using situational criteria alone but of also always checking with the subjects concerning their subjective reactions to the stimuli applied.

As repeatedly emphasized, the simple ordinal rating-scales, although offering the advantage of simplicity and intelligibility, are no doubt rather crude yardsticks for measuring subjective reactions. They may be adequate when used for qualitative purposes only, as was the case e.g. in the studies reported in Chapters 3 and 5, but if we want to use them for quantitative purposes, e.g. primarily for the study of psychophysiological correlations, it is probably preferable to use methods like magnitude estimation, cf. Chapter 7. Using this method we were able to demonstrate distinct and reproducible maxima and minima as well as in-between sections of the fatigue self-rating curve (figure 7:5). The mere shape of this curve, and the rather high correlation between the fatigue ratings on the one hand, and performance and physiological variables on the other, speak strongly in favour of the application of this method of measurement in psychophysiological studies.

8.2.2 Psychosocial stimuli, physiological mechanisms, and disease

Paragraph 1.3 outlined some hypotheses within the general frame of reference presented in our theoretical model (figure 1:1). It was hypothesized that a variety of environmental psychosocial stimuli (e.g. "life change", cf. Rahe, 1972) would elicit an increase in "stress (Selyle)", characterized inter alia by enhanced sympathoadrenomedullary activity and, concomitantly, by increased lipolysis, under certain circumstances contributing to a hyperlipoproteinemia. These and other, phylogenetically old adaptational reactions, usually rather obsolete in today's psychosocial environment, prepare the organism for a physical activity that is rather seldom manifested. Simultaneously with this prolonged state of physical "preparedness," the "rate of wear and tear" in the organism increases, as do eventually morbidity and mortality.

Against the background of what has been reported in the previous chapters we will now reappraise some of the hypotheses on which our model is based.

According to our first hypothesis, psychosocial stimuli lasting *hours* or *days* evoke physiological reactions, comprising "stress (Selye)".

The results presented in this volume, comprising own studies as well as those by others (reviewed in Chapter 1) confirm this hypothesis. Short-term exposure to a variety of stimuli, in laboratory settings as well as in real life, has been shown to evoke increases in urinary and plasma catecholamines and 17-hydroxycorticosteroids, free fatty acids and triglycerides. At least the response in urinary catecholamine excretion seems to be highly non-specific, occurring in connection with a very wide variety of stimuli, as postulated in Selye's "stress" concept.

Similarly, a real work setting (lasting about 8 hours) and a semirealistic stressor exposure with 72 hours' continuous work in a shooting range induce protracted enhancement of adrenaline excretion levels, and—in the last-named study—increased levels of protein-bound iodine and decreased levels of serum iron. In addition, erythrocyte sedimentation rate increased, and ST and T changes occurred in the ECG. A later study, reviewed (but not presented) in Chapter 7, showed increases in free fatty acids and cholesterol and decreases in fibrinolysis.

A logical next question would be to ask whether psychosocial stimuli occurring over *weeks* and *months* would evoke physiological reactions, comprising "stress (Seyle)".

To elucidate this problem in relation to the data presented by Rahe and others (for a review, see Rahe, 1972), the following study was conducted in collaboration with our laboratory (Theorell, 1970; Theorell et al., 1972).

Twentyone male, well rehabilitated survivors of a myocardial infarction gave weekly reports for 2—4 months of all major life changes that had occurred during the previous week. A life change unit sum was calculated according to Holmes and Rahe (1967). Urine samples were collected weekly during the day prior to these reports, under strictly standardized conditions. A positive and significant intra-subject co-variation was found between the weekly sum of the life change units and the pre-interview day adrenaline output.

The results referred to above support the assumption that psychosocial stimuli of short or moderate duration, created in a laboratory or occurring in real life, all evoke changes in sympathoadrenomedullary activity, possibly as part of a phylogenetically old, non-specifically evoked reaction pattern, "stress (Selye)", inter alia often (or always?) accompanied by increased lipolysis.

Accordingly, a relationship no doubt exists between boxes 1 and 3 in figure 1:1 (see page 12).

Our next question is whether a corresponding relationship exists between psychosocial stimuli and disease (boxes 1 and 5).

Such a relationship can be specific (i.e. it relates to a particular disease) or non-specific (i.e. relating to a variety af diseases). To elucidate the first-named possibility, Theorell (1970) studied the degree of life change to which subjects had been exposed, who approximately six months later developed *myocardial infarction*. He and other investigators (cf. Rahe and Lind, 1971; Rahe and Paasikivi, 1971; Rahe, 1972) found, indeed, that exposure to many and/or dramatic life changes was associated with a subsequent increase in morbidity and mortality in myocardial infarction.

Moreover, as demonstrated by several authors, such an exposure seems to predict increased morbidity and mortality not only in myocardial infarction but in *other diseases* as well (for a comprehensive review, see Rahe, 1972).

Turing back to our model (figure 1:1), let us

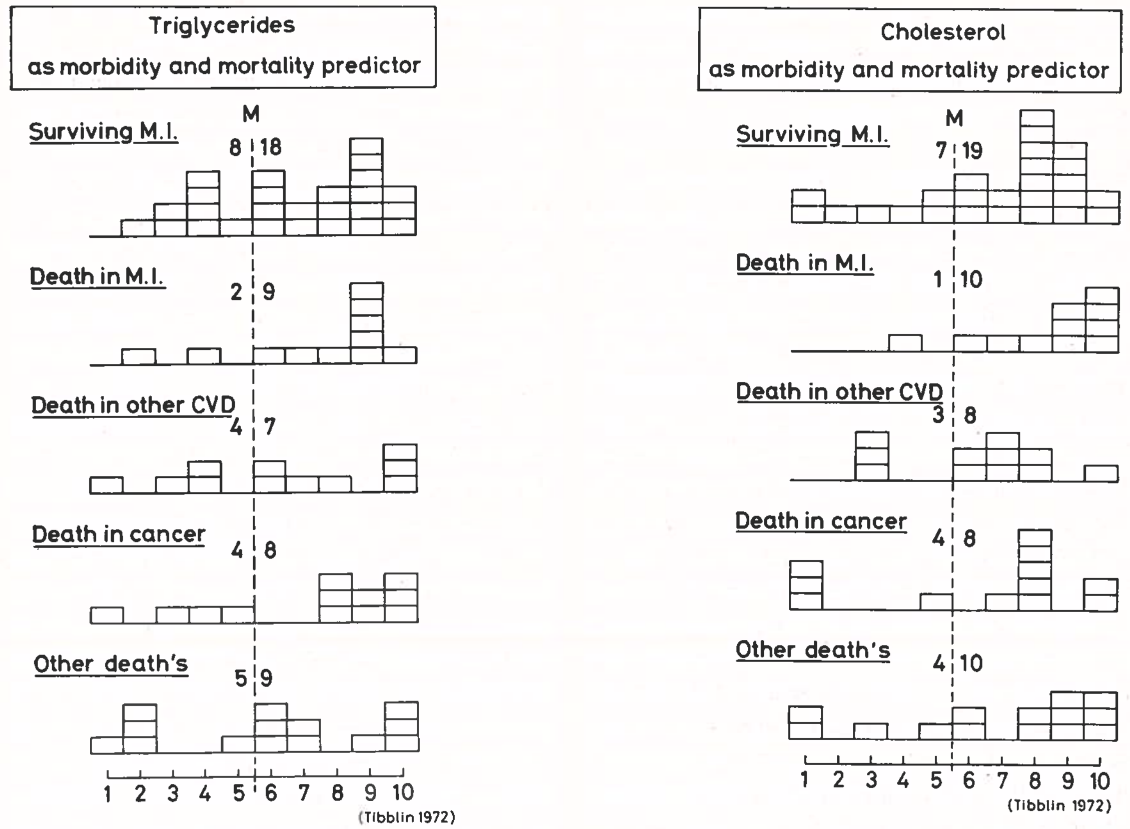

Figure 8:1. Plasma triglycerides and cholesterol as predictors of morbidity and mortality in myocardial infarction (M.I.), and of mortality in other diseases. Distribution in deciles (1—10) of plasma levels in relation to deaths. Vertical line indicates medians. Each box indicates one death or case of illness. Figures indicate distribution of below-median (left) and above-median (right) triglyceride and cholesterol levels. (Tibblin, personal communication.) Clearly, above-median levels seem to predict subsequent morbidity and mortality.

now examine the relationship between physiological reactions (i.e. mechanisms) and disease (boxes 3 and 5). Again, this relationship, if any, can be *specific* (e.g. increased plasma triglyceride and cholesterol levels predict degenerative heart disease) or *non-specific* (i.e. the plasma levels of these compounds predict increased morbidity and mortality in a *variety* of diseases).

The first-named (specific) relationship, demonstrated by many authors, can be exemplified by the well-known relationship between hyperlipoproteinemia and degenerative heart disease (cf. e.g. Keys et al., 1971). However, and more interesting, high plasma levels of triglycerides and cholesterol have also been shown to constitute a *non-specific* risk factor (induced by increased sympathoadrenomedullary activity?) predicting mortality *in general* (Tibblin 1972, personal communication), as demonstrated in a large-scale study of initially healthy males born in 1913 and followed annually since 1963, see figure 8:1. The subjects formed a representative sample of men aged 50 in Gothenburg at the time of the biochemical assessment.

True, the *entire* sequence of events shown in figure 1:1 has never been demonstrated in man. On the other hand, attempts have been made, some of them successful, to demonstrate it in animals, including primates (for review, see Levi, 1971).

Briefly, then, evidence has been presented in favour of most of the links in the hypothetical chain of events comprised in our model. Admittedly, much of the evidence is still no more than suggestive. But the data fit the hypothetical pattern sufficiently well to justify future research in the area outlined above, e.g. by methods described in the present volume.

8.3 The "stress (Selye)" concept

As demonstrated in Chapters 3—7, psychosocial stimuli do clearly influence urinary catecholamine excretion, either enhancing or lowering it, depending on the stimuli and on the psychophysiological starting-position of the organism. Enhancement occurs not only in response to stimuli which most subjects rate as predominantly "unpleasant" but also when the self-ratings indicate predominantly "pleasant" emotional reactions in most of the subjects, as in the case of viewing the comedy "Charley's Aunt". We interpret these data as supporting the hypothesis concerning "stress (Selye)" as the non-specificity (or stereotypy) of physiological reaction to a *variety* of stimuli and the hypotheses presented in figures 1:2 and 1:3, taking into account not only "unpleasant" reactions but "pleasant" ones as well. Probably, it is the intensity, and not the quality of these reactions which is the main correlate of "stress (Selye)". Our results further support the assumption that sympathoadrenomedullary activity constitutes part of "stress (Selye)" and agree with the findings recently reported by Pátkai (1971).

Of course, this is *not* meant to imply that no specific relationships exist between psychosocial stimuli and physiological response, or between subjective response and physiological concomitants. On the other hand, our findings do not support hypotheses proposed by other authors concerning a specific relationship between e.g. anxiety and adrenaline excretion, or between aggression and noradrenaline excretion. This interpretation is in agreement with findings reported by Frankenhaeuser and her group (for review, see Frankenhaeuser, 1971).

True, the "stress (Selye)" non-specificity in physiological response discussed so far relates exclusively to *psychosocial* stimuli. On the other hand, it is well known that a considerable number of *physical* environmental stimuli do evoke a similar response, inter alia involving sympathoadrenomedullary activity. In a recent study conducted in collaboration with our laboratory, a group of young, healthy male volunteers were exposed either to low environmental temperature (not combined with any psychosocial stressors) or to a sequence of psychosocial stressors (not combined with any uncomfortable climatic conditions). Both exposures lasted 24 hours and were preceded by 24-hour control periods. It was found (Lennquist, 1972; Lennquist et al., 1972) that both exposures elicited almost identical sympathoadrenomedullary and renal reactions.

Against the background of these results one may ask (cf. Mason, 1971) whether this stereotypy reflects a genetically determined psychobiological program (box 2, cf. figure 1:1) in Selye's sense, or whether the common denominator in both cases was the *experienced unpleasantness* of the exposures, the physiological concomitants of which we have registered. To check this possibility, an attempt was made in collaboration with Ove Wilson and his group to expose subjects to cold without their becoming aware of it (Wilson et al., in preparation), namely during sleep. This was accomplished by discretely removing the framed blankets (shaped like half cylinders) while the subjects were asleep in a climatic chamber (at 10 and 20° C), without wakening them. Urine samples were collected but, unfortunately, lost in transport. The study is mentioned here for methodological purposes only.

As indicated in paragraph 1.8, there can be several *degrees* of non-specificity in bodily response, the same reactions occuring in response to (a) a relatively great diversity of *situations*, (b) a relatively great diversity of *stimuli* (physical and/or psychosocial), or (c) *every* stimulus. Our results do not allow any definite statement as to which of these alternatives is most valid, but they do contribute to illustrate the non-specificity postulated by Selye and emphasize the need for further research in this field.

8.4 The physiological significance of changes in free urinary catecholamines

As indicated in paragraph 2.14, the interpretation of changes in urinary catecholamine excretion is by no means simple (cf. Sapira and Bron, 1971). As emphasized by Luce (1969), "nobody imagines that brain events are precisely measurable in urine". Neither are sympathoadrenomedullary or, say, cardiovascular events. On the other hand, the same author points out that enough information can be inferred from urine analysis to make it a kind of "chemical EEG".

Mason (1968) quite correctly asks whether "changes in urinary output of epinephrine and norepinephrine might under some conditions reflect changes in the metabolism or percentage of excretion rather than the rate of internal secretion of these compounds". Thus the urinary excretion of free catecholamines does probably not provide a quantitative but a *semiquantitative* measure of general sympathoadrenomedullary activity. Plasma catecholamine analyses and analyses of catecholamine metabolites in urine in man (for a review, see O'Hanlon, 1970) and determinations of relevant enzymes and tissue catecholamines in animals (cf. Rubenson, 1969; Kvetňansky et al., 1970; Axelrod et al., 1970), indicate that a variety of stressor exposures do, indeed, evoke an enhanced formation and/or release and/or turnover of adrenaline and noradrenaline. It can therefore be safely assumed that if there is an increase in adrenaline *excretion,* it is mostly preceded by an increase in sympathoadrenomedullary activity in the organism. If the excretion reaches *high* levels, sympathoadrenomedullary activity is probably high. It is conceivable that such a sympathotonia, if prolonged, can be of pathogenic significance (cf. Raab, 1971; Hermann and Mornex, 1964).

8.5 Catecholamine excretion as a predictor of subjective reactions

The methods for measuring subjective response and sympathoadrenomedullary activity are both, no doubt, relatively crude. In spite of this, highly significant correlations have been found between these two sets of variables. As shown in Chapter 7, the correlations could reflect circadian co-variation and/or co-variation in these responses as evoked by various stressors. The relationship is no doubt complex and probably influenced to a certain degree by stimulus as well as by response specificity. Even so, significant correlations have been found between subjective and physiological variables, and between these variables and performance, complementing the findings reported by Frankenhaeuser and her group (for a review, see Frankenhaeuser, 1971).

8.6 Some implications for evaluation of laboratory data in clinical practice

With reference, inter alia, to data presented in Chapter 7, The Lancet emphasizes in a leading article (May 20, 1967, pp. 1091-2) that environmental factors must be taken into account when evaluating laboratory data in clinical practice.

Such factors may be particularly confusing in studies where the physician almost exclusively relies on laboratory data, as in mass screening by laboratory investigations of large populations. But even in general practice and in internal medicine there seems to be a growing tendency to rely on laboratory data alone, at the expense of a thorough anamnesis and a clinical status.

A patient may, for instance, complain of fatigue, and turn out to have clearly subnormal levels of serum iron. Or he may exhibit protein-bound iodine levels that are clearly above normal, his main complaints being nervousness, anxiety and distress. But which is the hen and which is the egg? According to our hypotesis, *both* are "eggs", the "hen" being the interaction between the exposure to e.g. psychosocial stressors and the individual's psychobiological program. At all events, there seems to be good reason to inquire about sleeplessness and distress, about life changes, frustations and social conflicts in patients exhibiting e.g. a catecholamine excretion level close to what is usually considered as indicative of pheochromocytoma, increased plasma lipids, depressed ST and T in the ECG, high PBI or low serum iron levels.

Briefly, then, the patient's psychosocial situation can influence rather markedly the various measures obtained at a department for clinical chemistry or clinical physiology. Failure to realize this may lead to serious diagnostic errors.

8.7 Some clinical and research implications

Although present knowledge does not allow any definite conclusions as to the *pathogenic* significance of the physiological reactions demonstrated in Chapters 1—7, it may be tempting to speculate somewhat on this issue.

As emphasized in our review in Chapter 1 and in paragraph 8.2.2, several authors have tried to identify psychosocial stimuli that might be of pathogenic significance, as well as high risk groups that have an increased propensity to react to such stimuli by disease. In general, attempts have been made to describe the contents of the various "boxes" shown in figure 1:1 (p. 12) and to relate them to each other. So far, most of the evidence available is of an associative nature, and no serious attempts have been made to probe the entire pattern in man, probably because of the difficulty in assessing this pattern in a suitable study design.

Kagan and Levi (1972) have recently proposed that at the present stage the following hypotheses are ripe for testing:

(a) *Control of psychosocial environment* (box 1, figure 1:1) *reduces disease.*

(b) *Control of psychological and/or physiological reaction* (box 3, figure 1:1) *reduces disease.*

(c) These responses are *interrelated* and are mediated through *neuroendocrine mechanisms* as a final common pathway.

This approach might eventually reveal the "key to many problems of prevention and treatment" sought by Flanders Dunbar (cf. paragraph 1.7.1.).

One research strategy would comprise pharmacological intervention (cf. Leanderson and Levi, 1966). In addition, and probably no less important, part of this research might be conducted as an *integral part of social action programs* decided upon by health administrators, by introducing multidisciplinary *evaluation* of the effects of the social policy measures, i.e. of controlled intervention. By studying in the same setting the stimuli, the various characteristics of populations exposed (or not exposed) to these stimuli, their physiological and psychological reactions over time in longitudinal, multidisciplinary studies, and finally, the outcome in terms of health, disease, psychological, social and economic function, we may eventually be able to provide decision makers with at least some of the relevant information for their political action (Kagan and Levi, 1972).

To be able to do this we must refine our methodology for *assessing* psychosocial stimuli, psychological and physiological reactions, precursors of disease, and disease, in different cultures.

No one would deny the great difficulties involved, nor the great need for this type of large-scale multidisciplinary research programs.

So far very little has been said about *interacting variables* (cf. box 6, figure 1:1). In the present context we would like to mention just a few, namely tobacco, alcohol, and caffeine-containing beverages. As mentioned above, psychosocial stimuli have been demonstrated to influence sympathoadrenomedullary activity and lipid metabolism in a direction that might, under certain circumstances, become disease-provoking. As shown in studies conducted at our laboratory (Levi, 1967; Fröberg et al., 1969; Brohult et al., 1970) and by other investigators (e.g. Frankenhaeuser et al., 1968, 1970), these "every-day stimulants" seem to induce very similar reactions. Epidemiological studies have furnished some additional evidence of tobacco, alcohol and caffeine abuse as possible risk factors. Accordingly, effects on health and disease of these extremely widespread pharmacological influences and their possible *interaction* with the effects of psychosocial stimuli should be studied. More research should also be devoted to the corresponding influences of supposedly beneficial interacting variables such as physical activity (cf. Raab, 1966) and a balanced, adequate nutrition.

A few words should also be said concerning possible implications of the circadian rhythms demonstrated in Chapter 7. In internal medicine and psychiatry we may be on look-out for biochemical correlates of the exacerbations and remissions of various pathological states, possibly finding a key to their etiology and pathogenesis. In addition, the marked fluctuation and covariation, with or without time lag, in psychological performance and physiological variables and the sequence between their respective crests offer an opportunity to approach several interesting psychophysiological relationships. Some of the rhythms may be pharmacologically modifiable. Some may offer important information as to how to plan man's various procedures in shift work, or with regard to continuous, long-term duty.

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9 SUMMARIES

By Lennart Levi

9.1 Summary

Using Selye's physiological stress concept as a starting point, the methodologic prerequisites for a scientific study of the influence of psychosocial stimuli on psychological and physiological reactions in the human organism are described. A number of experimental studies are reported, focused on reactions assumed to be relevant for psychiatry and internal medicine. The studies comprise a number of variables, the measurement of urinary catecholamines as proposed by Euler being focused upon.

It is well known that physical stimuli can evoke disease. This has been demonstrated for a considerable number of stimuli and diseases. The relationship between psychosocial stimuli and disease is less clear. In Chapter 1 the key terms are defined and a theoretical model is presented for the possible pathogenic effects of such stimuli.

A number of studies are reviewed elucidating the relationship between psychosocial stimuli and physiological mechanisms, between these mechanisms and various diseases, and between the stimuli and the diseases. The mechanisms focused on are primarily sympathoadrenomedullary, adrenocortical and thyroidal.

The chapter concludes by presenting the primary aims of this monograph: (a) mapping out the influence of psychosocial stimuli on various physiological mechanisms, (b) study of the relationship, if any, between experimentally induced psychological and physiological reactions, (c) comparison between physiological reactions to short-term and long-term stressor exposures, and (d) discussion concerning the relationship, if any, between the physiological reactions thus evoked and the pathogenesis of various diseases.

Chapter 2 comprises a detailed presentation of various sources of error and various techniques relevant for psychophysiological research. Some guide-lines for the optimal design of such studies and the methodology of the studies comprised in the following chapters are presented.

Chapter 3 presents a study based on Selye's hypothesis that sympathoadrenomedullary and related reactions comprised in the "stress (Selye)" concept can occur as concomitants not only of psychological reactions usually rated as "unpleasant" but of "pleasant" reactions as well. In contrast, in situations evoking indifference, the level of "stress (Selye)" as reflected e.g. in adrenaline excretion, should be low. To test this hypothesis, 20 young female office clerks, acting as their own controls, were presented with a different 1 1/2-hour film on each of several consecutive evenings. It was found that the calmness and equanimity induced by viewing bland natural-scenery films was reflected on a biochemical level by a significant lowering of the catecholamine excretion. In contrast, the agitating and aggression-provoking "Paths of Glory", the anxiety-provoking "The Mask of Satan" and the amusing comedy "Charley's Aunt", all induced significant increases in adrenaline excretion. These results support the non-specificity in physiological reactions postulated by Selye.

In Chapter 4 a similar study is reported, against the background of the Kinsey hypothesis that males are more prone than females to sexual arousal from visual stimuli. Accordingly, a total of 53 female and 50 male students were shown a 1 1/2-hour film program, comprising four short, silent films chosen to induce predominantly pleasant sexual arousal. Adrenaline and noradrenaline excretion increased significantly in both groups during the film period in relation to control levels before and after. During the film period, sexual arousal was the predominant subjective reaction reported by both sexes, the self-rating scores as well as their increases, however, being significantly higher in the male group. This difference in reported subjective reactions was parallelled by a corresponding difference in the urinary excretion of adrenaline. These results are interpreted to support the "stress (Selye)" concept as well as the Kinsey hypothesis mentioned above. In this study, as well as in the previous one, significant changes occurred in urine flow, specific gravity and creatinine excretion.

The background of the study presented in Chapter 5 was a hypothesis concerning pathogenic consequences of a prolonged enhancement of sympathoadrenomedullary activity, e.g. for the cardiovascular system. It is often assumed that this may be due to cardiotoxic effects of the catecholamines per se but also to their lipolytic effects, eliciting an increased release of free fatty acids from the adipose tissue and, eventually, a hyperlipoproteinemia.

To test this hypothesis, 11 middle-aged males were exposed to a simulated industrial situation involving sorting ball-bearings for 2 hours to the accompaniment of distracting noise and lights. This exposure was found to evoke distress reactions of moderate intensity, accompanied by increases in heart rate, systolic blood pressure and catecholamine excretion but also of free fatty acids and triglycerides in arterial plasma. No such reactions occurred in a control group not exposed to this situation. The stressor-induced increases in free fatty acids and triglycerides but not in cardiovascular or sympathoadrenomedullary reactions were significantly modified by the administration of an antilipolytic drug, nicotinic acid. The results support our hypothesis concerning the genesis of hyperlipoproteinemia in response to psychosocial stimuli. It has been hypothesized that such a hyperlipoproteinemia may, in turn, be significantly related to atherosclerosis and degenerative heart disease, but possibly also to morbidity and mortality in general.

It is often claimed that psychosocial stimuli inherent in real life provoke disease. Very often, this assumption is made in relation to psychosocial aspects of working life. Should this be so, one would expect that conditions of work should be able to evoke reasonably pronounced reactions of the "stress (Selye)" type, primarily enhanced sympathoadrenomedullary activity.

In Chapter 6, the study concerned 12 healthy female invoicing clerks facing conditions very similar to those involved in their every-day work, a number of extraneous physical and psychosocial stimuli, however, being kept under control. Highly progressive piece-wages were introduced on the first and third day of the experiment, and were found to result in significant increases in output but also in rush, fatigue and physical discomfort ratings, in adrenaline, noradrenaline and creatinine excretions and in urine flow. Accordingly, every-day conditions at work can significantly modify physiological reactions in a way that *might* be of pathogenic significance for the human organism.

Chapter 7 reports sympathoadrenomedullary reactions in response to a distress- and fatigue-provoking situation lasting 3 days and nights, to which 31 young and middle-aged Army officers and corporals were exposed. It was found that the exposure was accompanied by significant increases in adrenaline excretion, and in protein-bound iodine in plasma, in individual cases to levels clearly above the normal range. Serum iron levels decreased dramatically, reaching subnormal levels in all subjects but three. Significant circadian rhythms were found in sympathoadrenomedullary, renal, performance and self-rated variables and significant psychophysiological correlations are described.

Finally, Chapter 8 discusses existing evidence supporting the hypothesis (figure 1:1, page 12) that psychosocial stimuli can, indeed, evoke disease. The author further discusses and supports Selye's stress concept, and the concept of catecholamine excretion as a correlate of subjective reactions. It is emphasized that the patient's psychosocial situation must be taken into consideration when data from clinical laboratories are evaluated. The author draws attention to the need to focus not only on studies presenting evidence of an associative nature but, in addition, on the testing of hypotheses that control of the psy-

chosocial environment and/or of man's psychophysiological reactions *reduces disease,* and that these responses are interrelated and are mediated through neuroendocrine mechanisms as a final common pathway. Finally, emphasis is placed on the need for studies also taking into account predisposing or protective interacting variables such as every-day stimulants, physical training and a balanced nutrition.

9.2 Zusammenfassung: Stress und Unlust als Reaktionen auf psychosoziale Stimuli. Labor- und Feldstudien betreffend sympathoadrenomedullare und verwandte Reaktionen.

Der Autor hat einen theoretischen Referenzenrahmen von dem physiologischen Stressbegriff Selye's ausgehend angegeben und die methodologischen Voraussetzungen eines wissenschaftlichen Studiums der Einwirkung psychosozialer Stimuli auf die psychologischen und physiologischen Reaktionen des menschlichen Organismuses beschrieben. Mehrere experimentelle Studien werden präsentiert, worin solche Reaktionen studiert worden sind, von welchen vermutet wird für Psychiatrie und Innere Medizin von Relevanz zu sein, mit u. a. von Ulf von Euler vorgeschlagenen Messungen von Katecholaminen im Urin.

Dass physikalische Stimuli Krankheit hervorrufen können, ist wohl bekannt, was eine bedeutende Anzahl Stimuli und Krankheiten betrifft. Bezüglich psychosozialer Stimuli ist der Zusammenhang bedeutend schlechter klargelegt.

Im Kapitel 1 definiert der Autor seine Fachausdrücke und präsentiert ein theoretisches Modell, wie solche Stimuli Krankheit verursachen können. Er berichtet über eine Anzahl Untersuchungen, die den Zusammenhang zwischen solchen Stimuli und physiologischen Reaktionen, zwischen den Reaktionen und verschiedenen Krankheitszuständen, und zwischen Stimuli und den Krankheitszuständen beleuchten. Das Kapitel wird mit Angabe der Hauptzwecke der Abhandlung beendet:

(a) Klarlegung der Einwirkung der psychosozialen Stimuli auf verschiedene Körperfunktionen, (b) Zusammenhang zwischen experimentell hervorgerufenen psychischen und physiologischen Reaktionen, (c) Vergleich der Reaktionen auf kurze und langwierige psychosoziale Stimuli und (d) Diskussion des eventuellen Zusammenhanges der entstandenen Reaktionen mit der Pathogenese verschiedener Krankheiten.

Im Kapitel 2 macht der Autor eine detallierte Durchnahme der verschiedenen Fehlerquellen und Techniken mit Relevanz für psychophysiologische Forschung. Er gibt einige Richtlinien an, für Anlage solcher Studien und berichtet zuletzt über das allgemeine Design und die Methodik der Studien, die in der Abhandlung enthalten sind.

Im dritten Kapitel geht der Autor von der Hypothese aus, dass sympathoadrenomedullare und andere Reaktionen, die zum Stressbegriff Selye's gehören, als Begleitphänomene nicht nur unangenehmer, sondern auch angenehmer psychischen Reaktionen entstehen können. Er beschreibt ein Experiment, in welchem man 20 Versuchspersonen während vier nacheinander folgenden Abenden unter streng standardisierten Bedingungen vier verschiedene Filme, unter Registrierung psychischer und sympathoadrenomedullarer Reaktionen, gezeigt hat. Der neutrale Kontrollfilm resultierte in einer Senkung der Katecholaminenausscheidung mit dem Urin, während der dramatische, komische bzw. schreckerregende Film trotz offensichtlichen Verschiedenheiten in den selbstbewerteten psychologischen Reaktionen der Individuen durchgehend eine Zunahme der Adrenalinausscheidung und des Urinvolumens und eine Abnahme des spezifischen Gewichts des Urins hervorrief. Dies deutet auf die von Selye postulierte Reaktionsstereotypie hin.

Im Kapitel 4 prüft der Autor mit gleichartiger Methodik noch einen Typ von Stimuli, nämlich Filme mit erotischem Inhalt. Er vergleicht dabei die Reaktionen weiblicher und männlicher Versuchspersonen und findet heraus, teils dass Versuchspersonen beider Geschlechter, obwohl die Filme hauptsächlich als angenehm empfunden wurden, mit bedeutenden Zunahmen in der Katecholaminausscheidung mit dem Urin reagieren, teils dass die männlichen Versuchspersonen, als Gruppe betrachtet, stärkere sowohl psychologische als physiologische Reaktionen auf die Filmvorführung aufweisen, in Übereinstimmung mit der Hypothese Kinsey's darüber, dass Männer in der Regel stärkere Reaktionsneigung auf visuelle sexuelle Stimuli haben.

Im fünften Kapitel werden in einer simulierten Arbeitssituation die Mechanismen hinter der Hyperlipoproteinemie studiert, die der Reaktion auf verschiedene Arten psychischer Belastungen zugeschrieben worden ist. Die Studie zeigt, dass die Stimuli, die verwendet worden sind, sowohl psychische Unlustreaktionen wie Blutdruck- und Pulssteigerungen, erhöhte Ausscheidung mit dem Urin von Adrenalin und Noradrenalin und Steigerungen freier Fettsäuren und Triglyceriden im arteriellen Plasma haben hervorrufen können.

Die letztgenannten Reaktionen konnten durch Behandlung mit Nikotinsäure stark modifiziert werden. Die Resultate sprechen dafür, dass die von den psychosozialen Stimuli hervorgerufene Sympathotonie zu einer Mobilisierung freier Fettsäuren aus den Fettdepots und sekundär zu einer Hyperlipoproteinemie führt. Die beiden letztgenannten Glieder in der Ereigniskette konnten ganz oder teilweise mit der antilipolytischen Nikotinsäurenbehandlung blockiert werden.

Im Kapitel 6 ist als Stimulus ein Leistungslohn verwendet und die Studie in einer wirklichen Arbeitssituation durchgeführt worden. Das Lohnsystem der Versuchspersonen wurde experimentell von Zeit- auf Leistungslohn geändert, und die Einwirkung auf Leistungen, selbstbewertete Erlebnisse und sympathoadrenomedullare Reaktionen wurden studiert. Die Einführung eines hohen und progressiven Leistungslohnes wurde von signifikanten Reaktionen sämtlicher studierten Variablen begleitet. Die prinzipielle Applizierbarkeit der Methodik für Studien psychophysiologischer Effekte verschiedener Umstände im Arbeitsleben und in anderen Milieus wurde betont.

Kapitel 7 berichtet über psychologische und physiologische Reaktionen auf Exposition eines 3×24 Stunden andauernden Wachhaltens unter anstrengenden äusseren Verhältnissen. Der Autor zeigt, dass die in früheren Kapiteln beschriebenen sympathoadrenomedullaren Reaktionen auch hier vorhanden sind und sogar verstärkt werden, wenn die Exposition langwierig gemacht wird. Ferner werden Daten präsentiert, die zeigen, dass das proteingebundene Jod in vielen Fällen steigt und dass das Serumeisen in der Regel auf Werte sinkt, die über respektive unter den Normalvariationen für diese Variablen liegen. Die statistischen Zusammenhänge zwischen psychischen und physiologischen Reaktionen und deren Abhängigkeit von (a) der Dauer der Belastungen und (b) deren zirkadianen Rhythmus werden präsentiert und diskutiert.

Das achte Kapitel, schliesslich, diskutiert den Zusammenhang zwischen psychosozialen Stimuli, physiologischen Reaktionen auf diese Stimuli und Pathogenesen verschiedener Krankheiten. Ferner wird der Stressbegriff Selye's diskutiert sowie die Katecholaminausscheidung mit dem Urin als Korrelat subjektiver Reaktionen. Weiter wird hervorgehoben, dass die psychosoziale Situation des Patienten bei der Auswertung von Labordaten in Betracht gezogen werden muss, dass Anhaltspunkte vorhanden sind, dass gewisse Situationen krankheitsverursachend zu sein scheinen, und dass es nun angezeigt ist, die Hypothesen zu testen, dass therapeutische Eingriffe in die psychosoziale Situation und/oder in die subjektive und physiologische Reaktionen des Individuums Krankheit verhindern können. Zuletzt wird auf die mögliche krankheitsverursachende und krankheitsverhindernde Bedeutung interagierender Variablen hingewiesen wie: Tabak, Alkohol und Kaffee als Beispiel der erstgenannten, physisches Training und eine balancierte Ernährung als Beispiel der letztgenannten.

9.3 Resumé: Stress et sentiments de malaise en tant que reactions aux stimuli psycho-sociaux. Études pratiques et de laboratoire des réactions sympatho-adrénomédullaires et apparentées.

Se basant théoriquement sur la notion de stress physiologique de Selye, l'auteur décrit les conditions méthodologiques nécessaires à l'étude scientifique de l'influence des stimuli psycho-sociaux sur les réactions psychologiques et physiologiques de l'organisme humain. Il rend compte de nombreuses études expérimentales de tels types de réactions, semblant bien être du ressort de la psychiatrie et de la médecine interne, notamment à l'aide des mesures de catécholamines dans l'urine (méthode Ulf von Euler).

Il est bien connu que des stimuli physiques peuvent provoquer des maladies. On en a la preuve pour un nombre important de stimuli et de maladies. En ce qui concerne les stimuli psycho-sociaux, la relation est notablement moins clairement établie.

Dans le premier chapitre, l'auteur définit les termes qu'il emploie et présente un schéma théorique des effets pathogéniques possibles des stimuli psycho-sociaux.

Il cite diverses études prouvant la relation entre des stimuli de ce type et certaines réactions physiques, entre ces réactions et divers états pathologiques, et entre ces stimuli et les maladies. Les réactions spécialement étudiées sont sympatho-adrénomédullaires, adréno-corticales et thyroïdiennes.

Le chapitre s'achève sur l'indication des principaux buts de la thèse : (a) détermination de l'influence des stimuli psycho-sociaux sur diverses fonctions du corps, (b) étude des relations entre réactions psychiques et physiologiques artificiellement provoquées, à titre expérimental, (c) comparaison des réactions à des stimuli psycho-sociaux de brève et de longue durées, (d) discussion des relations éventuelles entre les réactions obtenues et la pathogénèse de diverses maladies.

Dans le deuxième chapitre, l'auteur passe en revue détaillée diverses sources d'erreurs et diverses techniques en rapport avec la recherche psycho-physiologique. Il indique les grandes lignes d'une étude bien menée dans ce domaine et présente le plan général et la méthode des études incluses dans les chapitres suivants.

Le chapitre trois présente une étude fondée sur l'hypothèse que les réactions sympatho-adrénomédullaires et autres embrassées par la notion de stress de Selye, peuvent non seulement accompagner des réactions psychiques ressenties comme désagréables, mais aussi des réactions éprouvées comme plaisantes. Inversement, dans des situations « neutres » le niveau de stress (toujours selon Selye) tel que révélé par l'excrétion d'adrénaline notamment, devrait être bas. Pour vérifier cette hypothèse, 20 jeunes employées de bureau ont été invitées quatre soirs de suite, dans des conditions strictement standardisées, à voir quatre films différents, au cours desquels étaient enregistrées les réactions psychiques et sympatho-adrénomédullaires. Le calme et la tranquillité d'esprit suscités par la projection d'un documentaire présentant de jolis et doux paysages se sont traduits au niveau biochimique par une baisse significative de l'excrétion de catécholamines. Par contre un film bouleversant et éveillant l'agressivité tel que « Les sentiers de la gloire », angoissant tel que « Le masque de Satan » et une amusante comédie comme « La tante de Charley » ont tous trois provoqué une typique augmentation de l'excrétion d'adrénaline, malgré les évidentes différences des réactions psychologiques ressenties par les participantes au test. Le volume des urines s'est accru tandis que diminuait le poids spécifique de ces urines. Ces faits viennent à l'appui du postulat de Selye sur la stéréotypie des réactions physiologiques.

Le chapitre quatre est consacré à une étude similaire, tenant compte de l'hypothèse de Kinsey, selon laquelle les hommes sont plus sensibles que les femmes à une excitation sexuelle provoquée par des stimuli visuels. Quatre courts-métrages muets, choisis pour provoquer une excitation sexuelle, on été montrés à 53 étudiantes et 50 étudiants. En comparaison des niveaux de contrôle avant et après la séance, l'excrétion d'adrénaline et de noradrénaline a augmenté de manière significative dans les deux groupes, durant la projection. Au cours de celle-ci, l'excitation sexuelle a été la réaction subjective prédominante constatée par les deux sexes, qui l'ont ressentie comme avant tout plaisante, mais le groupe masculin dans son ensemble a accusé des réactions tant psychologiques que physiologiques nettement plus fortes, se traduisant par une plus importante excrétion d'adrénaline que chez les femmes. Ces résultats confirment à la fois la notion de stress de Selye et l'hypothèse ci-dessus mentionnée de Kinsey. Comme dans l'expérience citée au chapitre trois, on a pu constater des modifications significatives du volume urinaire, du poids spécifique des urines et de l'excrétion de créatinine.

Dans le chapitre cinq, l'auteur étudie les mécanismes amenant l'hyperlipoprotéinémie qu'on pense provoquée par la réaction à diverses sortes d'épreuves psychiques. L'expérience simulait une situation dans le travail, et prouve que les stimuli utilisés étaient susceptibles de provoquer non seulement des réactions psychiques (sentiment désagréable) mais encore une hausse de la pression sanguine, une accélération du pouls, un accroissement de l'excrétion de l'adrénaline et de la noradrénaline avec l'urine, et une augmentation du taux des acides gras libres et des triglycérides dans le plasma. Un traitement à l'acide nicotinique a pu modifier fortement ces dernières réactions. Les résultats semblent démontrer que la sympathotonie provoquée par les stimuli psycho-sociaux mène à une mobilisation des acides gras libres des dépôts adipeux et, à titre secondaire, à une hyperlipoprotéinémie. Ces deux derniers maillons de la chaîne des réactions ont pu être entièrement ou partiellement bloqués par le traitement anti-lipolytique à l'acide nicotinique. On a lancé l'hypothèse que l'hyperlipoprotéinémie peut à son tour être mise en relation de cause à effet avec l'atherosclérose et la dégénérescence cardiaque, ainsi peut-être qu'avec la morbidité et la mortalité en général.

On a souvent affirmé que les stimuli psycho-sociaux inhérents à la vie réelle engendrent la maladie. Très souvent cette affirmation est faite en relation avec des aspects psycho-sociaux du travail. Si tel est bien le cas, on doit pouvoir s'attendre à ce que les conditions de travail suscitent des réactions de stress (au sens de Selye), en premier lieu une augmentation de l'activité sympatho-adrénomédullaire.

Alors que dans l'expérience précédente on avait soumis onze hommes d'âge moyen à une situation industrielle simulée (tri de roulements à billes pendant deux heures avec accompagnement de bruits et de lumières gênants), l'expérience relatée dans le chapitre six s'est déroulée dans une situation réelle, avec douze femmes en bonne santé, établissant des factures. Néanmoins un certain nombre de stimuli physiques et psycho-sociaux n'ayant rien à voir avec le problème ont été maintenus sous contrôle. Les premier et troisième jour de l'expérience, le traitement mensuel de ces femmes a été remplacé par un salaire à la pièce, stimulant la productivité. Il en est résulté une augmentation significative de la production mais aussi de la presse, de la fatigue, de l'inconfort physique, des taux d'adrénaline, noradrénaline et créatinine, et du volume urinaire. Par conséquent les conditions de travail quotidiennes sont manifestement susceptibles de modifier les réactions physiologiques humaines dans un sens pathogénique. La méthode s'avère capable d'une application pratique dans l'étude des effets psychophysiologiques des diverses conditions de travail.

Le chapitre sept rend compte des réactions psychologiques et physiques d'un groupe de trente et un officiers et sous-officiers, jeunes ou d'âge moyen, soumis durant trois journées de 24 heures, sans sommeil, à des conditions extérieures éprouvantes. L'auteur montre ici que les réactions décrites dans les chapitres précédents non seulement se révèlent mais encore sont renforcées par la longueur de l'épreuve. On retrouve l'augmentation significative de l'excrétion d'adrénaline et en outre on a pu noter dans plusieurs cas un accroissement de l'iodine liée aux protéines dans le plasma ainsi qu'une baisse en général de la teneur en fer du sérum, l'un et l'autre supérieurs aux variations normales de ces variables. La baisse de la teneur en fer a été spectaculaire, sauf dans trois cas. Des rythmes circadiens typiques ont été découverts dans l'activité sympatho-adrénomédullaire et rénale et dans les variables subjectifs et de performance. Les relations statistiques entre réactions psychiques et physiologiques et leur dépendance de (a) la durée des épreuves et (b) leur rythme circadien sont présentées et discutées.

Le huitième chapitre, enfin, discute les relations entre stimuli psycho-sociaux, réactions physiologiques à ceux-ci et la pathogénèse de diverses maladies. Les preuves existantes confirment l'hypothèse que les stimuli psycho-sociaux peuvent réellement engendrer des maladies. L'auteur discute et soutient, en outre, la notion de stress selon Selye, et le concept de l'excrétion de catécholamines avec l'urine, corrélative aux réactions subjectives. Il souligne le fait que la situation psycho-sociale du patient doit être prise en considération lors de l'appréciation des données de laboratoire clinique, qu'il existe des preuves que certaines situations peuvent engendrer des maladies, et qu'il est désormais important de tester les hypothèses selon lesquelles des interventions thérapeutiques dans la situation psycho-sociale peuvent contrer la maladie et des interventions dans les réactions subjectives et physiologiques de l'individu à l'exposition à une situation provoquant normalement la maladie peuvent neutraliser la maladie. Les mécanismes neuro-endocriniens relient ces réponses—correlatives en tant que canal commun final. Pour terminer, l'auteur souligne l'importance possible de l'interaction de certaines variables pouvant provoquer la maladie (tabac, café, alcool par exemple) ou au contraire la combattre (éducation physique, diète équilibrée, notamment).

ЛЕННАРТ ЛЕВИ.

СТРЕСС И ИСТОЩЕНИЕ КАК ОТВЕТ НА ПСИХОСОЦИАЛЬНЫЕ ВЛИЯНИЯ.

9.4 Заключение.

Отправной позицией проведенных исследований послужила концепция стресса Г. Селье. В монографии дается описание основных методических приемов используемых для изучения роли психосоциальных влияний в возникновении психологических реакций у человека. Излагаются результаты экспериментальных исследований различных патологических реакций наблюдаемых в психиатрической и соматической клиниках. Работа содержит большое число данных полученных в результате исследования содержания катехоламинов в моче по методу Эйлера и Лишайко.

Известно, что различные физические стимулы могут приводить к возникновению тех или иных заболеваний. В тоже время, остается далеко еще не ясным характер связей между психосоциальными влияниями и различными соматическими заболеваниями. В первой части монографии определяется исходная позиция автора и дается теоретическая модель предполагаемых патогенетических механизмов возникающих в результате такой стимуляции. Описываются ход и результаты исследований, которые позволили установить определенные связи между указанными стимуляциями, развивающимися под их влиянием патогенетическими механизмами и рядом патологических состояний. В процессе работы внимание автора в первую очередь было обращено на изучение механизмов связанных с симпатоадреналовой, адренокортикальной и тиреоидной функциями. В заключение излагаются основные задачи работы:
а/ Изучение эффектов возникающих под влиянием психосоциальной стимуляции на различные физиологические механизмы; б/ Исследование связей между экспериментально вызванными психологическими и физиологическими реакциями; в/ Установление различий между физиологическими реакциями под влиянием коротко действующих и длительно действующих стрессовых воздействий; г/ Обсуждение предполагаемых связей между вызванными таким образом физиологическими реакциями и патогенезом ряда заболеваний.
Часть вторая посвящена детальному изложению технических приемов используемых для психофизиологических исследований и обсуждению различных источников ошибок возникающих в процессе этих экспериментов. Приводятся некоторые оптимальные варианты таких исследований, а также основные методики применявшиеся в процессе данной работы.

Третья часть монографии включает в себя исследования основывающиеся на положении Селье о том, что симпатоадреномедуллярные реакции и другие проявления стресса могут возникать не только как результат " неприятных " воздействий, но обнаруживаются также при " приятных " влияниях. В противоположность этому индифферентная стимуляция не вызывает значительного изменения уровня проявления стресса. В целях проверки этой гипотезы 20 молодым женщинам были ежедневно продемонстрировано несколько 1,5 часовых фильмов имеющих различное содержание. Было установлено, что видовые фильмы вызывающие чувство успокоения и расслабления, приводили к значительному снижению экскреции катехоламинов. Наоборот, фильмы вызывающие состояния напряжения, страха и агрессии, а также комедийные фильмы, вызывали выраженное повышение экскреции адреналина. Эти данные подтверждают неспецифичность реакций описанных Селье.

В четвертой части даны результаты экспериментов направленных на выяснение достоверности гипотезы Кинси, согласно которой мужчины имеют более высокий чем женщины уровень сексуальной возбудимости к зрительным стимулам. В соответствии с этим, было исследовано 53 женщины и 50 мужчин / студенты /, которым были показаны 1 1/2 часовые фильмы выбранные таким образом, чтобы их содержание могло вызвать сексуальное возбуждение. Выявилось, что в период демонстрации этих фильмов экскреция адреналина и норадреналина достоверно повышалась в обеих группах по сравнении с контрольными определениями до и после киносеансов. Во время просмотра фильмов, согласно данным специально ориентированных психологических исследований, сексуальное возбуждение доминировало в обеих группах. Однако у мужчин оно было выражено в значительно большей степени. Эти различия, выявившиеся при психологической оценке, коррелировали с данными полученными при исследовании экскреции адреналина. Результаты интерпретировались в поддержку концепции стресса Селье и гипотезы Кинси. В процессе этой части исследования, также как и в предыдущих, наблюдались выраженные изменения в выделении ряда веществ с мочей, ее удельном весе, экскреции креатинина.

Во главе угла исследований, которым посвящена пятая глава, находилось положение, согласно которому длительное напряжение симпатоадреномедуллярной системы является важным потогенным фактором, особенно для сердечно-сосудистой системы. Предполагается, что это может быть вызвано собственно кардиотоксическим эффектом катехоламинов и их липолитическим эффектом выражающимся в увеличении освобождения свободных жирных кислот и липопротеинемии. С целью проверки этой гипотезы 11 мужчин среднего возраста были подвергнуты влиянию обычных для них условий работы, которая, однако, проводилась в сопровождении отвлекающего шума и вспышек света. Было установлено, что данное воздействие привело к возникновению определенных реакций выражавшихся увеличением числа сердечных сокращений, повышением систолического давления, усилением экскреции катехоламинов и повышением содержания в плазме свободных жирных кислот и триглицеридов. В контрольной группе, не подвергавшейся воздействию указанной ситуации, подобных реакций не наблюдалось. Применение антилиполитических веществ / никотиновая кислота / могло в значительной мере ослабить сердечно-сосудистую и симпатоадреномедуллярную реакции. Полученные результаты подкрепляют гипотезу касающуюся генеза гиперлипопротеинемии в ответ на психосоциальные стимулы. Высказывается предположение, что такая липопротеинемия может находиться в этиопатогенетической связи с атеросклерозом и дегенеративными поражениями миокарда. Возможно также она оказывает влияние на общий процент заболеваемости и смертности населения в целом.

Принято считать, что различные психосоциальные воздействия, являющиеся выражением обычных условий жизни, провоцируют возникновение тех или иных заболеваний. Очень часто такое предположение высказывается в связи с психосоциальными аспектами трудовой деятельности. В таком случае следует согласиться, что в зависимости от характера и условий работы могут развиваться те или иные проявления стресса и в первую очередь повышение симпатоадреномедуллярной активности.

В шестой части монографии приводятся результаты исследований 12 здоровых женщин / служащих / в условиях очень схожих с их обычной трудовой ситуацией. Одновременно они подвергались некоторым внешним воздействиям: прогрессивно-сдельная форма оплаты в первый и третий день эксперимента. В результате было установлено значительное повышение чувства усталости, физического дискомфорта / регистрация велась по соответствующим шкалам /. Кроме того обнаружилось повышение экскреции адреналина, норадреналина и креатинина в моче. Таким образом, повседневные условия трудовой деятельности могут в значительной мере модифицировать физиологические реакции у человека, что в свою очередь может иметь патогенное значение.

В седьмой части работы приводятся данные исследований симпатоадреномедуллярных реакций возникающих в ответ на ситуации, которые приводят к выраженному утомлению и истощению. Изучение проводилось на 31 молодого или среднего возраста военнослужащих, которые в течение трех суток были лишены сна. Обнаружилось, что эти условия сопровождались выраженным повышением экскреции адреналина и концентрации связанного с белком иода в плазме. В некоторых случаях уровень этих веществ значительно превышал пределы нормы. Содержание железа в плазме резко снизилось, достигая субнормального уровня, у 28 из 31 испытуемых. Кроме того выявился выраженный циркадный ритм в симпатоадреномедуллярной, почечной и других системах. Были установлены некоторые психофизиологические корреляции.

Восьмая часть монографии содержит данные подтверждающие гипотезу о возможности возникновения ряда заболеваний в результате определенной психосоциальной стимуляции. Далее автор обсуждает и поддерживает концепцию стресса Селье. Приводятся доказательства в пользу того, что экскреция катехоламинов коррелирует с субьективными реакциями. Предлагается учитывать психосоциальные реакции больных наряду с данными клиники и лабораторного исследования. Привлекается внимание к необходимости изучения психосоциальных влияний и психофизиологических реакций у человека в связи с тем, что установление действенного контроля за ними может привести к уменьшению общего числа заболеваемости. Эти аспекты взаимосвязаны и опосредуются через нейро-эндокринные механизмы, которые являются выражением общего конечного пути. В заключение говориться о необходимости исследований в плане поисков возможностей предотвращения этих проявлений как, например, ежедневная стимуляция, физическая тренировка, меры приводящие к сбалансированности обмена.

9.5 Acknowledgements

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Arbetarskyddsfonden
The Swedish Work Environment Fund
Wenner-Gren Center
Sveavägen 166, 8 tr
113 46 STOCKHOLM

08/30 65 00 08/30 06 50

ALLF 532 72 002 Kihlström & Söner 1972

THE SWEDISH WORK ENVIRONMENT FUND

a brief information

BACK GROUND

The Work Environment Fund was established by act of the Swedish legislature on 28 April 1971. The Fund is financed by means of an increase in the compulsary fee paid by employers for occupational injuries and diseases insurance. It is estimated that these contributions will amount to over 20 million Swedish crowns (approx. $ 4 million) per year, which shall be used for research, education, and information in the field of working environments.

ORGANI ZATION

The Fund is administered by a board that determines the use and distribution of the Fund's resources. The board includes representatives of the various parties on the labor market and the director general of the National Board of Industrial Safety. The board assumed office on 1 January 1972.

PURPOSE

The Work Environment Fund shall, in accordance with its instructions, support such research, education and information as can counteract the occurence of occupational injuries and diseases and other adverse health conditions that can arise as a result of working environments, or can improve working environments and thereby on-the-job health and safety.

- **Grants for research shall apply primarily to such research as can be expected to achieve practical on-the-job implementation. Grants may also be awarded for purpose of furthering contact with research underway abroad.**
- **Grants for education shall apply primarily to the training of plant industrial safety representatives as well as to the further training of other occupational and safety personnel.**
- **Grants for information shall apply primarily to broadly devised informational programs aimed at large groups of people in industry and other working places.**

PLANS

As a basis for the Fund's operation in the field of research, a special report was presented in April 1972. Partly on the basis of this, the board has drawn up certain guidelines for the activities of the Fund, in which the importance of concentrating the Fund's resources on larger projects was emphasized. Research, having a practical orientation, is to be accorded special priority. Further, the board emphasizes the importance of adapting research results already obtained elsewhere to practical implementation at the working place. The Fund will also be working for a coordination of research in the area of working environment. Money will be appointed in answer to requests as well as on the Fund's own initiative. Some of the research areas that will be accorded considerable attention by the Work Environment Fund are the following:

- **Research into the problems of working hours, including the length and distribution of working hours, shift and night work, etc.**
- **Research intended to reduce the frequency and severity of occupational accidents.**
- **Broad cross-discipline investigations of working environment conditions within various branches of industry.**
- **Research on deleterious chemical substances in working environments.**

The Fund's support of education and information shall apply to limited projects relevant in principle to health and safety conditions in various work-environments; however, it shall not apply to continuing activities within these areas.
The Work Environment Fund is also eager to collaborate with authorities and institutions in the field of work-environment in other countries for purpose of exchanging experiences. Concrete joint projects in the area of research are also conceivable.
If you are interested in receiving further information on the activities of the Fund, kindly contact the Head Office of the Swedish Work Environment Fund.

Droits sociaux en Suède

De la même série : *Droits des handicapés en Suède*
Les handicapés mentaux en Suède
Politique sociale et application
La santé publique en Suède
Vie nouvelle après la retraite

Ces brochures peuvent être commandées auprès de l'Institut Suédois, Hamngatan 27, Boîte postale 7072, S-103 82 Stockholm 7, Suède, ou auprès des missions diplomatiques suédoises.

Publié par l'Institut Suédois

L'Institut Suédois, créé en 1945, est une fondation gouvernementale chargée d'établir des relations culturelles avec d'autres pays et de faire connaître la vie et la civilisation suédoises. Son service d'information couvre tous les sujets suédois d'intérêt général.

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La médecine du travail en Suède

A

La médecine du travail en Suède

Milieu de travail, sécurité et services de la médecine du travail

par SVEN FORSSMAN

L'INSTITUT SUEDOIS

Le professeur SVEN FORSSMAN, docteur en médecine, conseiller scientifique et membre du conseil d'administration du Fonds suédois pour la protection du milieu de travail, a été directeur de l'Institut de la médecine du travail de 1966 à 1972.

Les opinions énoncées dans cette brochure n'engagent que la seule responsabilité de l'auteur.

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Introduction

Parallèlement à la croissance industrielle et économique au cours de ces vingt-cinq à cinquante dernières années, la Suède a progressivement développé ses organismes de médecine du travail. La Suède s'est fait connaître comme le pays du juste milieu ou comme le pays du bien-être avec une progression régulière du bien-être et de la sécurité sociale. Le produit national brut a augmenté, l'espérance de vie s'est considérablement accrue, la mortalité infantile a été réduite. Des maladies infectieuses, comme la tuberculose, ont été réduites, d'autres, comme la diphtérie et la poliomyélite, ont disparu.

Cependant, au cours des 5—10 dernières années, il est devenu évident que certains aspects humains ont été oubliés dans ce développement de la santé, du bien-être et de la productivité. Les soins médicaux dans les hôpitaux sont de haute qualité en ce qui concerne l'équipement et le personnel, mais l'aspect humain a, dans une certaine mesure, été laissé de côté et les malades se plaignent quelquefois que les médecins n'ont pas assez de temps pour parler avec eux.

Le processus de l'industrialisation avec le transfert de la population agricole vers l'industrie et de districts ruraux vers les centres urbains industriels s'est accéléré pendant les vingt dernières années, mais les gens qui emménagent maintenant dans les grandes villes, venant de la campagne, sont souvent isolés et se sentent dépaysés dans les immeubles modernes. La pollution de l'air et de l'eau et le bruit ont créé des problèmes dans la société moderne suédoise. Le silence est devenu un luxe. La mécanisation et la rationalisation ont réduit beaucoup de métiers à des routines monotones et beaucoup de gens se plaignent d'aliénation au travail, de manque de responsabilité et de satisfaction. Un grand nombre de jeunes en Suède hésitent aujourd'hui à prendre un travail dans l'industrie en raison de leurs exigences croissantes de santé et de sécurité aussi bien que de confort et de satisfaction dans le travail. La situation de chômage est préoccupante. Le chômage s'est produit dans certains métiers ou types d'industrie comme les textiles ou dans certaines régions comme le Nord de la Suède. Beaucoup de gens ont dû se reconvertir mais, à partir d'un certain âge, il peut être difficile d'apprendre un nouveau métier et de se déplacer d'une région à une autre pour trouver un emploi.

Le nombre des personnes âgées dans la population a augmenté. Un grand nombre d'entre elles ont besoin d'importants soins médicaux et beaucoup sont isolés de leurs enfants et amis. La solitude des personnes âgées est un grand problème. Il arrive qu'elles restent dans leurs vieilles maisons au centre des villes ou à la campagne, tandis que les jeunes vivent souvent dans des appartements neufs avec tout le confort moderne dans les grands ensembles des villes.

Il y a des failles dans le « welfare state » qui ont été débattues au cours de ces dernières années et qui seront certainement prises en considération par le gouvernement et le Parlement (le *Riksdag*) pendant les dix prochaines années. Une des leçons importantes des années récentes est que l'aspect humain ne doit pas être oublié dans la planification des progrès de la société.

En ce qui concerne la médecine du travail, la situation en Suède est semblable à celle de beaucoup de pays industrialisés, mais dans certains domaines, la Suède est plus avancée, tandis que dans d'autres, nous avons à apprendre des expériences d'autres pays.

La législation sur la médecine et la sécurité du travail s'est développée selon des lignes communes dans les pays scandinaves, mais en Suède, la coopération entre les autorités gouvernementales, les employeurs et les syndicats a été particulièrement marquante.

La sécurité s'est améliorée au cours des cinquante dernières années. Les services de médecine du travail qui comportaient à l'origine surtout des soins médicaux aux travailleurs et à leurs familles, se sont étendus progressivement aux services préventifs, aux examens de santé, aux problèmes de l'adaptation au travail, à l'ergonomie et à l'hygiène industrielle.

Les principes des services de la médecine du travail ont été définis dans un accord entre les organisations des employeurs et des travailleurs. Les risques d'accidents du travail ont été réduits. Avec l'introduction de l'ergonomie et le développement de la mécanisation, les demandes de travail ont diminué et beaucoup de postes exigent maintenant moins d'efforts physiques que psychologiques.

Au cours des deux—trois dernières années, on a critiqué cette évolution, qui, dans certains domaines, a été considérée comme trop lente. L'élévation du niveau de vie et le développement de l'éducation ont modifié l'attitude de beaucoup de travailleurs à l'égard de leur travail et de son milieu. L'accent est maintenant mis sur l'amélioration du milieu de travail, la protection du travailleur contre les risques d'accidents du travail et la promotion de sa santé. On attache davantage d'importance à rechercher une meilleure satisfaction dans le travail, à assurer la coopération entre employeurs et travailleurs pour la santé et la sécurité dans l'usine et à permettre au travailleur lui-même de décider de ses conditions de travail ou de les influencer.

Un grand nombre d'études ont été faites pendant ces dernières années ou sont en cours dans le domaine du milieu de travail. Le comité d'études sur le milieu de travail met au point des propositions pour une nouvelle loi sur la sécurité du travail. La recherche dans le domaine du milieu de travail a été

l'objet d'une étude où l'on tient compte aussi bien des travaux de recherche actuels que des besoins futurs. L'Académie des sciences techniques a réalisé une étude sur les questions de milieu de travail en se référant particulièrement aux besoins de recherches et de formation dans les sciences du comportement. Une étude inspirée par le Ministère des affaires sociales et de la santé publique, commencée en 1972, a pour objet les engagements de l'Etat dans la recherche ainsi que l'application pratique des sciences du comportement dans les problèmes du milieu de travail. Un fonds de l'Etat pour la recherche, la formation et l'information dans le domaine du milieu de travail a commencé à fonctionner en 1972.

La médecine d'entreprise, qui s'était surtout développée dans le secteur privé, a été l'objet d'études et d'essais dans le secteur public, où l'on a appris beaucoup de choses intéressantes. Des essais de planification régionale de la médecine d'entreprise par départements ont été faits par la délégation nationale de la médecine d'entreprise.

Au niveau national, en Suède comme ailleurs, on trouve quatre aspects principaux de la médecine du travail. *La législation sur la sécurité des travailleurs,* qui garantit *un minimum de sécurité et de santé* sur le lieu de travail. Elle est contrôlée par un organe gouvernemental. *Les problèmes quotidiens à l'usine* doivent cependant être contrôlés ou supervisés par une organisation au sein de l'usine, chargée de la santé et de la sécurité, ce sont les services de la médecine du travail.

Des problèmes de portée plus générale sont pris en main par des instituts régionaux ou nationaux se livrant à *la recherche* ou à des enquêtes à la demande des autorités, d'organismes, d'usines, d'hôpitaux ou de médecins. Il faut également organiser *la formation* de spécialistes en sécurité, santé, ergonomie, hygiène industrielle aussi bien que former dans ces matières chefs d'entreprises, ingénieurs, contremaîtres et travailleurs.

Législation sur la sécurité des travailleurs et son contrôle. Niveau minimum de sécurité et de santé

La première loi date de 1889. Elle fut ensuite progressivement étendue et les premiers inspecteurs de la sécurité industrielle commencèrent leurs activités en 1890. Une loi spéciale sur la sécurité des travailleurs entra en vigueur en 1913 et la loi actuelle en 1949, avec la création d'une Direction nationale de sécurité et d'hygiène du travail et de l'Inspection générale du travail, toutes deux sous l'égide du Ministère des affaires sociales et de la santé publique. Un rapport sur leurs activités, appelé « Sécurité du travail » a récemment été publié par la Direction nationale d'hygiène et de sécurité du travail et je voudrais me référer à ce document pour certains détails. Le comité, chargé en 1970 par le gouvernement de préparer une nouvelle législation, a publié une étude partielle en 1972. Le gouvernement a proposé des amendements de lois au Parlement en 1973.

La loi sur la sécurité des travailleurs présente des données de base sur la santé et la sécurité sur les lieux de travail. La législation couvre maintenant tout le personnel employé. Son but est de fournir une protection générale dans les processus de fabrication et les postes de travail, comme la ventilation, l'éclairage, la prévention de l'exposition aux poussières, aux fumées, aux gaz, aux vapeurs, les conditions d'emploi des jeunes travailleurs âgés de moins de dix-huit ans et des femmes. Elle spécifie aussi la mise en place d'une section spéciale de coopération entre employeurs et travailleurs. Un décret plus détaillé fondé sur cette législation a été pris par le Ministère des affaires sociales et de la santé publique. La Direction nationale de sécurité et d'hygiène du travail publie des prescriptions plus détaillées et des instructions pour le travail dans les fonderies, les forêts, les carrières, les chantiers de construction, sous forme de manuels et de guides afin d'assurer une protection pratique à l'usine. Ces publications sont destinées aux employeurs et aux employés ainsi qu'à ceux qui dessinent, fabriquent, vendent et installent des machines.

La sécurité des travailleurs en Suède est fondée sur une combinaison de législation et d'activités volontaires, grâce à une coopération entre patrons et travailleurs aux niveaux national, régional et local. Chaque usine employant plus de cinquante travailleurs doit avoir un comité de sécurité, comportant des membres représentant les employeurs et les travailleurs et agissant comme un organe consultatif. Un accord entre la Confédération patronale suédoise

(SAF) et la Confédération générale du travail de Suède (LO) développe et spécifie les règles de cette coopération à l'usine.

Il existe environ 3,9 millions d'hommes et de femmes employés dans 300 000 lieux de travail. De ces derniers, 72 000 sont contrôlés par l'Inspection du travail, 6 000 par des inspections spéciales et 85 000 par les autorités locales, couvrant 2 millions de personnes au total. Les travailleurs qui ne sont pas contrôlés par l'Inspection du travail sont des hommes d'affaires indépendants, des fermiers exploitant leurs propres terres, des artisans, etc.

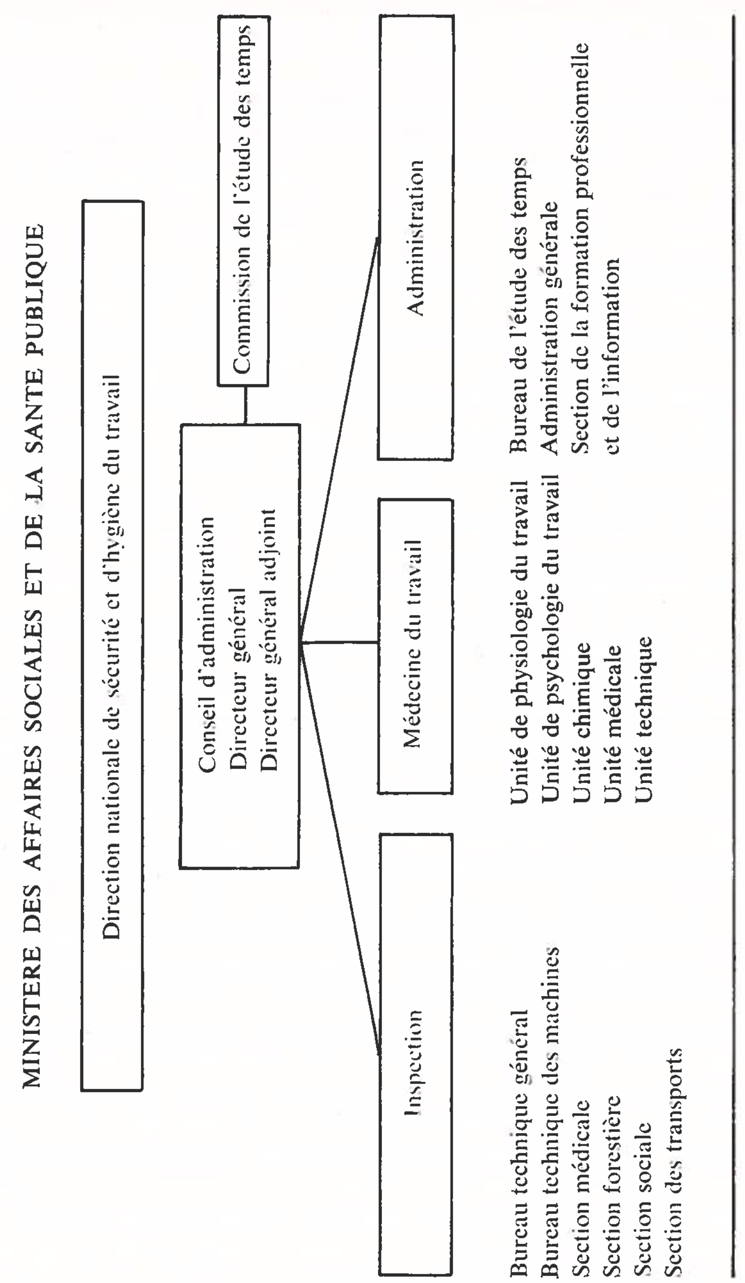
La Direction nationale de sécurité et d'hygiène du travail comprend à son niveau le plus élevé le directeur général et son adjoint, ainsi que neuf autres membres représentant surtout les organisations centrales du marché du travail. La Direction est chargée de promouvoir des méthodes de protection contre les risques du travail et de maintien de la santé et de la sécurité du travail. La Direction s'occupe des problèmes des heures de travail, de la durée des journées de travail et des pauses. Elle émet des directives et des recommandations au sujet de la législation sur la sécurité des travailleurs et de l'horaire de travail. La Direction donne également des conseils sur la sécurité et la santé, sur la formation à la sécurité, dirige et supervise les activités de l'Inspection du travail. Au total 300 personnes surveillent l'application de la loi sur la sécurité des travailleurs et s'astreignent à promouvoir la santé et la sécurité des travailleurs aussi bien par conseils et recommandations que par la formation à la sécurité. L'Inspection du travail préfère de loin donner des conseils et des recommandations, bien qu'elle ait tout le pouvoir nécessaire pour imposer la loi sur la sécurité des travailleurs y compris celui de fermer une usine si les conditions de sécurité ne sont pas jugées satisfaisantes.

Les conseils municipaux des villes et des communes rurales désignent des inspecteurs par l'intermédiaire des comités de santé publique et ces inspecteurs contrôlent les petites entreprises de moins de 10 employés et qui n'ont pas de machines.

Pour l'année budgétaire 1972—73, le Riksdag a voté un budget de 26 millions de couronnes à la Direction nationale de sécurité et d'hygiène du travail et de 23 millions à l'Inspection du travail.

L'Inspection du travail visite les usines et autres lieux de travail, soit régulièrement, soit à la demande, soit dans des cas précis, comme après un accident du travail. Les plans des nouvelles constructions sont contrôlés par l'Inspection du travail, spécialement les projets de nouvelles usines ou de constructions destinées au personnel. L'Inspecteur du travail et son équipe donnent des conseils sur les améliorations à apporter à la santé et à la sécurité du travail. Les inspecteurs du travail contrôlent près de 72 000 lieux de travail et en visitent à peu près 30 000 par an. Les autorités locales de la santé publique en inspectent environ 40 000 par an.

1 couronne suédoise = env. 1,03 FF



La Direction nationale de sécurité et d'hygiène du travail et l'Inspection du travail agissent en étroite coopération avec les organisations des employeurs et des travailleurs et le Conseil bipartite pour la sécurité du travail, mis en place par la SAF et la LO.

En 1970, le gouvernement a désigné un comité chargé d'étudier et de préparer une nouvelle législation sur la sécurité des travailleurs. Cette étude a pour but de rechercher dans la présente législation ce qui n'a pas été efficace et de promouvoir une loi mieux adaptée aux réalités actuelles en renforçant les pouvoirs des délégués à la sécurité. L'étude partielle publiée en décembre 1972 concerne les délégués à la sécurité ainsi que l'organisation de la Direction nationale de sécurité et d'hygiène du travail et de l'Inspection du travail.

Problèmes quotidiens de sécurité et de santé à l'usine. Services de la médecine du travail

Les ingénieurs de la sécurité qui s'occupent de la prévention des accidents et des maladies du travail ont été actifs dans l'industrie suédoise sur une base volontaire depuis plusieurs années. Toutes les grandes industries ont leurs propres ingénieurs de sécurité employés à plein temps et beaucoup d'entreprises moyennes ont des ingénieurs de sécurité employés à mi-temps. L'Association pour la sécurité du travail, organisme volontaire, fondé en 1906, encourageait l'étude de la sécurité et l'échange des expériences à un stade précoce, à ses assemblées annuelles. La Compagnie d'assurances mutuelles des employeurs contre les accidents a pendant plusieurs années été très active en promouvant la sécurité, en mettant au point du matériel de sécurité et en organisant des conférences annuelles sur la sécurité. En 1952, cette compagnie a créé un comité chargé d'étudier le travail de l'ingénieur de sécurité et son rapport a servi de base à un programme de formation des ingénieurs de sécurité.

La tendance est maintenant de faire coopérer plus étroitement l'ingénieur de sécurité avec le médecin d'entreprise. Son rôle traditionnel de prévention des risques du travail susceptibles de causer des accidents et des maladies du travail a été étendu à l'adaptation du travail à l'homme, c'est-à-dire l'ergonomie. Plusieurs médecins d'entreprise travaillaient dans l'industrie suédoise, il y a de cinquante à cent ans, pour les soins médicaux généraux des travailleurs. Le premier médecin d'entreprise connu, plutôt un chirurgien, fut nommé en 1545 dans une mine de cuivre pour soigner les mineurs, spécialement leurs blessures. Cette société, Stora Kopparberg, fondée en 1367, a pratiquement eu des médecins d'entreprise depuis 1545.

Dans les années 40, les activités de la médecine du travail ont été progressivement ajoutées aux fonctions des médecins d'entreprise, qui avaient déjà la charge des examens avant embauchage, des contrôles réguliers de santé et de la surveillance des conditions de santé au travail.

A la suite d'expériences internationales sur les services de la médecine du travail présentées aux premiers séminaires de l'OMS consacrés à la médecine du travail, en 1952 et 1953, aussi bien que des expériences en Norvège d'un accord volontaire entre employeurs, syndicats et l'association des médecins sur les principes des services de la médecine du travail, un accord similaire a été proposé et accepté en 1954 par un comité commun au sommet de la SAF et la LO. Depuis, un manuel pour les services de la médecine du travail a été publié et régulièrements mis à jour (dernière édition : 1966).

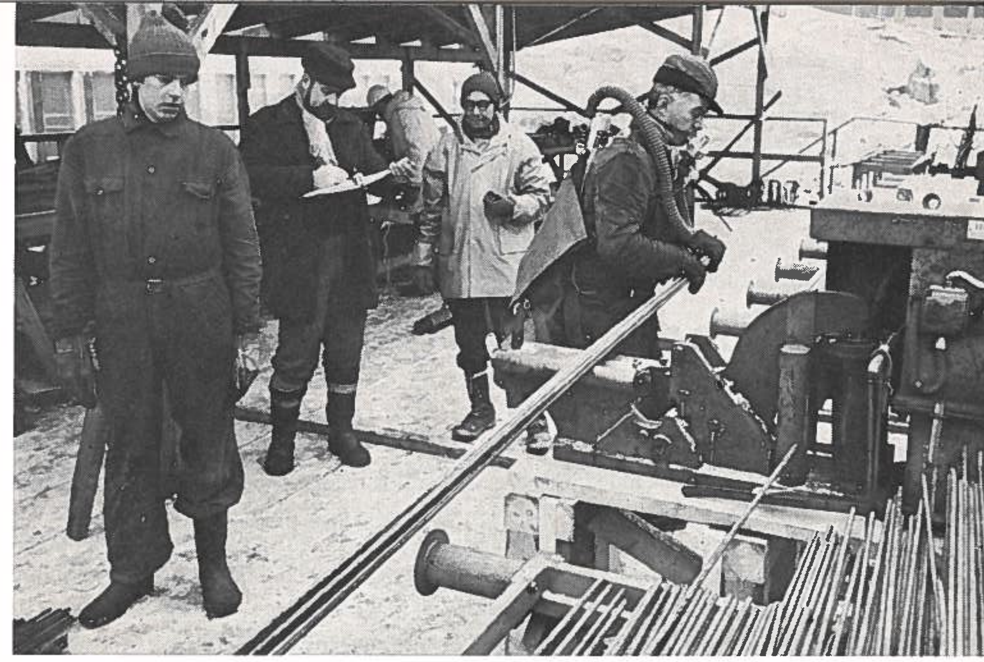
Les services de la médecine du travail avaient pour objectif de :

a) protéger contre les risques du travail
b) promouvoir la meilleure adaptation possible de l'homme à son travail et du travail à l'homme (ergonomie)
c) promouvoir et préserver la capacité de santé et de travail
d) promouvoir le rétablissement de la santé et de la capacité de travail aussi rapidement et efficacement que possible après blessures et maladies
e) intégrer la médecine du travail dans la production industrielle

Selon ce manuel, les services de la médecine du travail doivent englober les principales activités suivantes :

Mesures préventives techniques
Mesures préventives médicales
Première aide et traitement médical mineur
Réadaptation

Un nouvel accord plus détaillé sur les services et la sécurité de la médecine du travail a été adopté par les deux organisations en 1967. Les quatre principales activités des services de la médecine du travail — à savoir ceux de l'ingénieur de l'hygiène et de la sécurité et ceux du médecin d'entreprise et de



Une équipe, qui étudie la charge du travail (inspiration d'oxygène), dans une station d'armature de béton.

Couler du béton dans les jointures entre les éléments de béton est extrêmement pénible pour le dos.

Des études ergonomiques ont abouti à la construction d'une sorte de brouette qui permet une position de travail plus confortable et présente en outre l'avantage de réduire le temps du travail de façon appréciable.

son équipe — étaient les mêmes, mais leurs fonctions étaient définies comme suit :

« — aider à la planification et à l'exécution des changements dans le milieu de travail des travailleurs en ce qui concerne l'ergonomie, les conditions relatives à l'hygiène de l'industrie, les mesures prises pour éviter les blessures, l'équipement pour la protection du personnel ;

— diriger ou aider à des analyses techniques des facteurs chimiques et physiques susceptibles de causer des accidents ou des maladies, faire des tests à la demande dans le but de déterminer, par exemple, le niveau du bruit et le degré de la pollution de l'air et analyser les lieux de travail du point de vue ergonomique et d'autres aspects d'adaptation ;

— apporter de l'aide en donnant des avis dans la planification du personnel de l'entreprise et, dans ce contexte, veiller à ce que la santé des employés nouvellement recrutés soit contrôlée et que des contrôles réguliers de santé soient faits pour les groupes qui doivent être l'objet d'une attention spéciale, comme les mineurs, les personnes âgées et les employés sujets à des risques d'accidents particuliers ou exposés aux risques d'une mauvaise adaptation ;

— donner des avis à la direction et aux employés pour les déplacements de travailleurs ;

— promouvoir des mesures efficaces pour la réadaptation des travailleurs après des maladies et autres incapacités ;

— seconder en organisant la première aide en cas de maladie ou d'accident subits ;

— organiser des activités de sécurité industrielle et, dans le travail fait par le comité de sécurité, comme, par exemple, la préparation des rapports annuels et, chaque fois que le besoin s'en fait sentir, émettre des avis et des instructions au comité de sécurité et aux agents de sécurité ;

— surveiller le niveau de santé du personnel de l'entreprise, par exemple, au moyen d'un registre des absences, d'une statistique des maladies et blessures et enfin

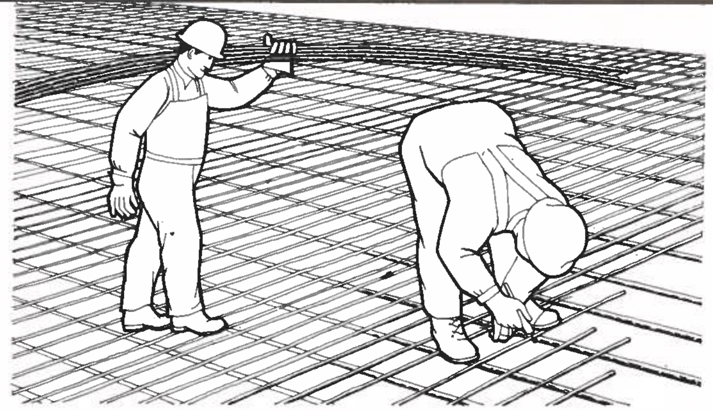
— aider l'entreprise dans ses activités de formation du personnel. »

Les tâches des équipes du médecin et de l'infirmière d'entreprise doivent comprendre les activités suivantes :

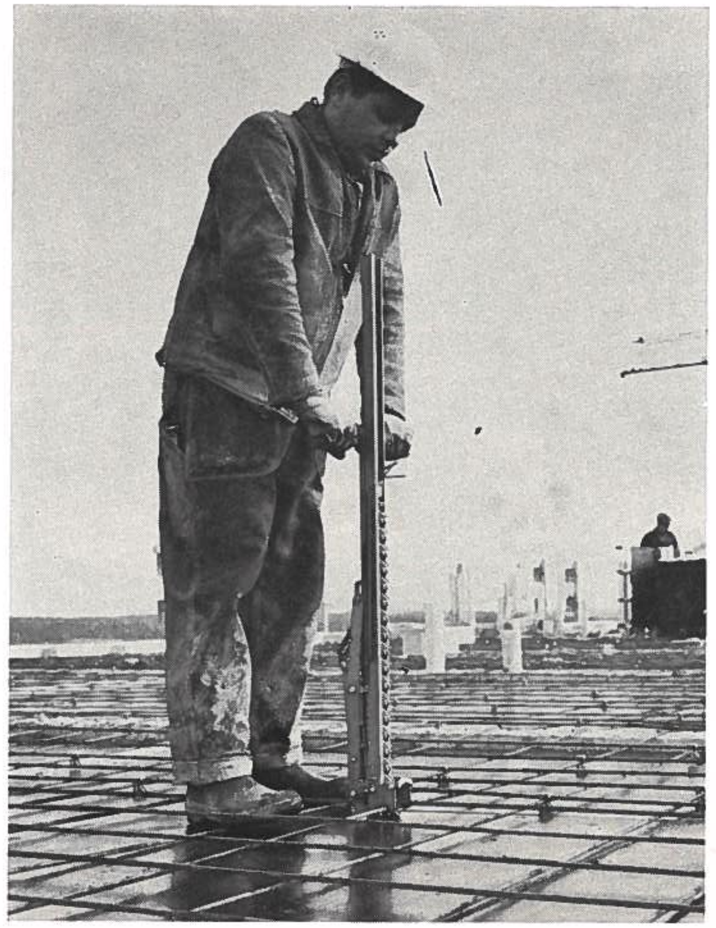
« — accomplir les tâches d'un médecin-inspecteur ;

— faire ou organiser des vaccinations ;

— donner des avis en matière de mauvaise santé causée ou aggravée par



Une position astreignante pour le dos : l'arrimage des armatures métalliques de béton.



Cet appareil résout le problème : l'ouvrier n'a plus besoin de se pencher tellement en avant.

Dans cette entreprise, un coin détente-café a été installé. Les ouvriers peuvent prendre leur pause quand ils en ont envie.

le travail et, si un accord a pu se faire, administrer des soins ambulants aux travailleurs lors de blessures dues à des accidents ;

— administrer des soins médicaux aux employés, sauf désaccord, et en respectant le principe du libre choix du praticien, la préférence devant être donnée aux cas où le traitement peut être administré pendant que le patient est encore au travail ou lorsque la connaissance spéciale du milieu de travail et des tâches professionnelles acquise par le service de la médecine du travail est susceptible de contribuer pour une large part à une réadaptation rapide. »

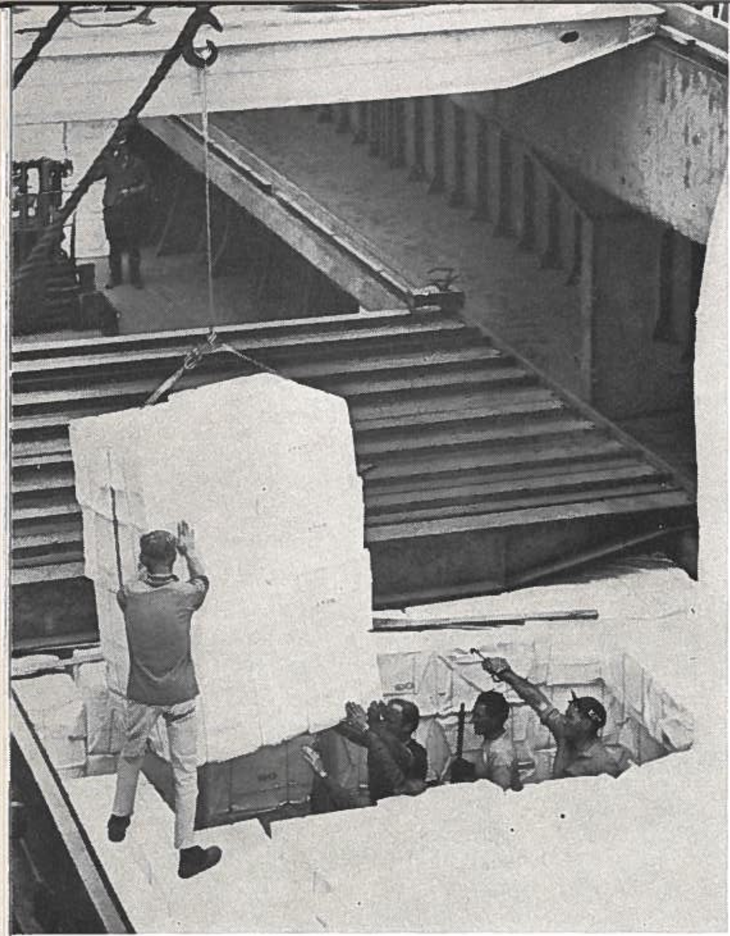
Les deux organisations se sont mises d'accord pour promouvoir le développement des services de médecine du travail en accord avec ces principes.

Ce qui est particulièrement intéressant dans cet accord, c'est qu'il incorpore le principe que les services de la médecine du travail doivent comporter deux parties, une technique et l'autre médicale, mettant en relief l'étroite coopération entre l'ingénieur de la sécurité et le médecin du travail et que les services de la médecine du travail devraient autant que possible être intégrés dans l'entreprise afin de fonctionner de la façon la plus efficace possible et enfin que le traitement médical, traitement de maladies du travail ou d'autre origine, y était inclu comme un service offert sur le lieu de travail aux employés.

Le gouvernement a désigné un comité chargé d'étudier les services de la médecine du travail à la suite des recommandations du Bureau international du travail en 1959. Le comité a proposé à l'unanimité dans son rapport de 1967 que les services de la médecine du travail se développent pour le moment sur une base volontaire, fondée sur cet accord entre les organisations des employeurs et des travailleurs.

Une délégation spéciale sur les services de la médecine du travail a été désignée par le gouvernement en 1971 dans le but de suivre les développements de la promotion des services de la médecine du travail et de coordonner le travail dans ce domaine entre les autorités de santé publique et de soins médicaux, de la sécurité des travailleurs et entre employeurs et travailleurs. Cette délégation dépend de la Direction nationale de sécurité et d'hygiène du travail et comprend des représentants de la Direction générale de la santé publique et de la prévoyance sociale, des organisations des travailleurs et des employeurs, de la Fédération des Conseils généraux et de la Société des médecins d'entreprise. Des délégations pour la planification régionale de la médecine d'entreprise sont progressivement mises en place dans chaque province.

Un rapport de 1963 a révélé que les services de médecine du travail n'existaient alors que dans les grandes industries, beaucoup plus rarement dans les petites.



Charger des ballots de pâte à papier est un travail lourd et risqué qui exige des mesures de sécurité efficaces.

La mécanisation s'intensifie dans le travail forestier. Au cours des dix dernières années, l'ébranchage des arbres, qui est l'opération la plus longue lors de l'abattage, se fait à la scie mécanique. Les risques d'accidents à l'ébranchage sont grands et beaucoup de travailleurs ont eu des ennuis avec les vibrations de la scie.

Tableau 1
Services de médecine du travail en 1963
Nombre et pourcentage de lieux de travail dotés de ce type de services et ayant plus de 100 employés. L'étude comprend 1 700 lieux de travail, principalement des industries

Nombre d'employés	Nombre de lieux de travail	Services de médecine du travail			
		A		B	
		Nombre	%	Nombre	%
100— 200	628	25	3,9	3	0,5
201— 500	598	82	13,7	13	2,0
501—1 000	200	56	28,0	17	8,5
1 001—	133	105	78,9	6	4,5

A Services de médecine du travail avec médecins et infirmières
B Services de médecine du travail avec infirmière et « contact » régulier avec un médecin

Source : Recueil des Enquêtes Gouvernementales, SOU 1968: 44.

C'est pourquoi des efforts considérables ont été faits pour créer des services de médecine du travail pour de petites industries. Dans deux régions industrielles, des études-pilotes sur la nécessité de tels services ont été faites par la Confédération patronale (SAF), déterminant les nécessités, d'après l'expérience d'experts de la médecine et de la sécurité du travail et les souhaits des employeurs et des travailleurs. Deux centres médicaux pilotes ont ensuite été mis en place. L'industrie et les syndicats s'intéressent en ce moment beaucoup à la création de tels centres médicaux (services interentreprises) et, en 1973, il y a 97 centres médicaux dans le pays, couvrant 299 550 travailleurs dans 1 385 entreprises. Un manuel décrivant l'organisation de ces centres médicaux sera publié en 1973 par la SAF.

Le besoin de services de médecine du travail dans de très petites entreprises de 5 à 10 employés n'a pas été clairement constaté et des études-pilotes vont être faites pour déterminer ces besoins, la façon d'y répondre, le genre d'organisation qui serait la plus efficace, la meilleure manière de coordonner les services de la médecine du travail et ceux de la santé publique et la façon de former les médecins de la santé publique aux problèmes spécifiques de la médecine du travail.

Dans ce domaine, le problème le plus important en Suède est celui du développement futur des services de médecine du travail dans les petites et moyennes entreprises en appliquant le principe de centres médicaux sur une base régionale.

Un autre problème est celui de développer les services de médecine du travail de l'industrie à d'autres secteurs de l'emploi, comme les bureaux, les forêts, l'agriculture, les docks et les transports. L'Institut national de la médecine du travail s'est livré à des études sur la santé dans l'industrie forestière, l'agriculture et les docks. Un service de médecine du travail a été mis en place pour les dockers du port de Göteborg et un autre pour les travailleurs forestiers dans le Nord de la Suède. Une étude-pilote sur les services de médecine du travail dans l'agriculture va être entreprise dans le Sud du pays.

Tableau 2
Centres médicaux pour petites industries (services interentreprises) en 1973

Conseils généraux des départements	Nombre de centres médicaux	Nombre d'entreprises	Nombre d'employés
Stockholms läns landsting	9	155	23 100
Uppsala läns landsting	1	24	4 050
Södermanlands läns landsting	7	95	16 050
Östergötlands läns landsting	5	46	12 450
Jönköpings läns landsting	6	172	11 150
Kronobergs läns landsting	2	42	8 800
Kalmar läns landsting	5	53	11 850
Gotlands läns landsting	1	8	1 800
Blekinge läns landsting	2	21	4 550
Kristianstads läns landsting	4	45	7 800
Malmöhus läns landsting	9	112	19 650
Hallands läns landsting	4	34	7 450
Göteborgs och Bohus läns landsting	4	61	11 350
Älvsborgs läns landsting	2	15	2 650
Skaraborgs läns landsting	4	64	8 400
Värmlands läns landsting	7	60	13 600
Örebro läns landsting	4	78	16 700
Västmanlands läns landsting	5	73	8 850
Kopparbergs läns landsting	4	63	9 350
Gävleborgs läns landsting	3	50	7 850
Västernorrlands läns landsting	3	33	8 650
Jämtlands läns landsting	1	16	1 750
Västerbottens läns landsting	4	45	9 950
Norrbottens läns landsting	1	20	1 750
Total	97	1 385	229 550

Au cours de ces dernières années, le système des services de médecine du travail a été critiqué parce que les médecins engagés par les employeurs ne seraient pas impartiaux et ne se préoccuperaient pas convenablement de la santé des travailleurs. Ce à quoi les employeurs répliquent que le système suédois des services de médecine du travail est fondé sur un accord entre la SAF et la LO. Toutes les activités de l'industrie reposent donc sur des principes qui ont été acceptés par les organisations des travailleurs. La délégation aux services de la médecine du travail, qui vient d'être désignée comprend également des représentants de la LO.

Le développement rapide des services de la médecine du travail en Suède est fortement soutenu par les employeurs, les syndicats et le gouvernement. Le manque actuel de médecins a créé des difficultés ainsi que la capacité limitée de formation. On s'attend à ce que, d'ici 5 à 10 ans, la médecine du travail dans son ensemble se soit considérablement développée.

Recherche

En Suède, comme dans beaucoup d'autres pays, la création d'instituts de médecine du travail a été un processus graduel.

En 1938, un Institut national de la santé publique a été créé avec trois divisions : hygiène générale, hygiène de la nutrition et hygiène du travail.

En 1946, un service des maladies professionnelles a été mis en place au centre hospitalier universitaire de Stockholm (*Karolinska Sjukhuset*) et à l'hôpital municipal de Stockholm (*Södersjukhuset*).

En 1952, création du Conseil pour l'administration du personnel. Cet organisme étudie les problèmes humains au travail, spécialement leurs aspects psychologiques et sociologiques. Il se livre à des examens dans les industries et fait de la recherche appliquée.

Il a été suivi en 1955 par un Institut de la physiologie du travail. Il apparut bientôt qu'il était indispensable de coordonner tous ces organismes qui s'occupaient de différents secteurs de la médecine du travail. On peut trouver une situation analogue, caractérisée par plusieurs activités séparées dans beaucoup d'autres pays.

En 1964, le Ministère de la santé, du travail et des affaires sociales a désigné un comité pour étudier ce problème. Dans son rapport, le comité a proposé la création d'un Institut national de la médecine du travail, auquel la plupart de ces organisations devaient être transférées ou coordonnées. Le projet a été adopté par le Riksdag en 1966. L'Institut a commencé à fonctionner le 1er juillet 1966 mais a été intégré en 1972 dans la Direction nationale de sécurité et d'hygiène du travail avec les mêmes fonctions et comme une unité monolithique.

Les principales activités de l'Institut et, depuis 1972, du Département de la médecine du travail au sein de la Direction, sont la recherche, le service et l'enseignement, tout comme dans la plupart des instituts d'autres pays. Selon une étude internationale publiée en 1969*), le rapport entre ces activités varie d'un pays et d'un institut à l'autre. En Suède, la tendance est qu'environ 50 à 60% des ressources du Département sont consacrées à la recherche et 30% à l'enseignement. A l'avenir, un maximum de 20% sera consacré au service. Pour le moment, le service ne représente qu'une faible partie des activités mais il est en voie de développement.

Quand l'Institut a démarré en 1966, il y avait une équipe de 90 personnes. En 1969, elle est passée à 120 et en 1971 à 150, dont 30 liées à l'université. Une unité régionale va être organisée à Umeå, dans le Nord de la Suède, en étroite coopération avec l'Université d'Umeå et l'hôpital régional.

Les différentes unités se livrent à la recherche et développent de nouvelles méthodes. L'unité chimique, par exemple, étudie des méthodes susceptibles d'analyser des substances toxiques dans l'air ou dans des matériaux biologiques. Une nouvelle méthode semi-automatique pour analyser le mercure dans l'urine a récemment été développée. L'unité de physiologie du travail étudie la charge du travail dans différents métiers. Des électrocardiographes portatifs permettent d'enregistrer en permanence la fréquence du pouls pendant une journée de 8 heures. L'unité technique procède à des examens d'hygiène sur, par exemple, l'exposition à la concentration de poussières dans toutes les opérations où il y a un risque de silicose, afin d'acquérir des données solides pour la prévention des poussières.

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*) voir bibliographie

Le Département de la médecine du travail au sein de la Direction nationale de sécurité et d'hygiène du travail

(L'Institut national de la médecine du travail avait une organisation analogue.)

Unités

Administration

Médicale :

- Section de l'hygiène du travail
- Section de l'hygiène physique du travail
- Section de toxicologie
- Section des maladies du travail
- Section de la dermatologie du travail

Chimique :

- Section de la recherche et du développement des méthodes d'analyses
- Section de service

Technique :

- Section des problèmes généraux
- Section des gaz et des solvants
- Section des poussières minérales et des métaux
- Section des techniques d'élimination des risques

Physiologique :

- Section du travail et de la physiologie de l'environnement
- Section de la physiologie technique
- Section de la physiologie clinique

Psychologique et sociologique

Beaucoup de problèmes de la médecine du travail doivent être étudiés par des recherches de caractère interdisciplinaire, où plusieurs ou même toutes les unités participent.

Ces vastes projets de recherche ont été divisés en quatre groupes principaux :

a) *Risques du travail.* Des études médicales épidémiologiques sont combinées avec des examens hygiéniques industriels par exemple sur la silicose, l'asbestose, le bruit, les vibrations, dans le but de développer des mesures préventives médicales et techniques. Une étude sur les solvants est projetée.

b) *Méthodes spéciales de travail et processus de production,* comme la soudure, la peinture, le travail par équipe, doivent être étudiés en coopération par des méthodes médicales, physiologiques, psychologiques, chimiques et hygiéniques.

Un vaste projet de recherche sur le travail par équipe est en cours, qui étudie, entre autres choses, les éléments de stress et l'adaptation de l'homme par exemple au changement du travail de jour au travail de nuit. Le sous-comité de la commission permanente et de l'Association internationale de la médecine du travail a organisé une conférence sur le travail par équipe à Oslo en 1969. Un rapport sur ces délibérations a été publié par l'Institut national de la médecine du travail. Il comporte des rapports très intéressants de différents pays. Le compte rendu d'une deuxième conférence sur le travail par équipe, en Bulgarie, en 1971, a également été publié par l'Institut.

c) Des groupes importants de la population active peuvent avoir des problèmes communs ou *des difficultés à s'adapter au travail.* Des études ont été lancées sur des projets concernant le travailleur âgé et la réadaptation du chômeur.

Il semble qu'il y ait une tendance dans beaucoup de pays industrialisés, qui veut que, quand de nouveaux procédés de fabrication sont développés, les nouveaux postes conviennent mieux aux jeunes travailleurs, puisqu'ils exigent beaucoup de connaissances et une plus grande rapidité dans le travail. L'Institut a publié une vaste étude sur l'adaptation des personnes âgées au progrès des techniques, en insistant sur l'importance de l'ergonomie. Dans beaucoup de pays industrialisés, 40 à 50% des travailleurs ont plus de 45 ans et il est donc très important, également sur le plan international, de s'assurer que les ouvriers âgés puissent s'adapter à leur travail et que le principe de l'ergonomie de l'adaptation du travail à l'homme soit appliqué.

d) *Groupes de travail.* Une vaste étude des problèmes de santé de professions entières avec des méthodes médicales, physiologiques, psychologiques, sociologiques, chimiques et hygiéniques combinées, en vue d'étudier la santé et la capacité de travail de l'homme, aussi bien que le poids du travail, l'ergonomie et les risques du travail, a été lancée. Les groupes sélectionnés pour ces études appartiennent à des professions où les risques du travail peuvent être considérables, où la rationalisation et la mécanisation peuvent amener un changement rapide de la situation du travail et où un grand nombre de travailleurs sont employés. De telles études ont été faites dans les forêts et parmi les dockers. D'autres sont menées en

permanence dans l'agriculture moderne et on en prépare pour les conducteurs de chariots élévateurs à longue distance.

Le premier projet important de recherche a démarré en 1967. Il concernait les problèmes de santé dans les forêts. Le travail dans les forêts est en pleine mutation en raison de la mécanisation et de la rationalisation qui peuvent impliquer beaucoup de problèmes d'adaptation aux nouvelles conditions de travail. Une équipe de docteurs, de physiologistes, de psychologues, de sociologues et d'ingénieurs examinent la santé et la capacité au travail de 500 travailleurs forestiers dont les différentes formes de travail ont été étudiées sous le rapport du poids du travail et des risques d'accidents. Des informations ont également été recueillies sur l'adaptation, les attitudes et la satisfaction au travail. Une étude spéciale a été faite sur l'ergonomie des tracteurs et sur les vibrations des scies mécaniques. Une recommandation a été émise au sujet des services de la médecine du travail dans les forêts, spécialement pour aller au-devant des problèmes de santé dans la forêt, problèmes d'aujourd'hui et de demain. Un rapport sur ce projet de recherche a été publié en 1968.

L'Institut, et, depuis 1972, le Département de la médecine du travail, poursuit donc des recherches, mais travaille aussi à l'application pratique des résultats obtenus. Des conférences ont été organisées avec des ingénieurs de production et des experts forestiers en vue d'améliorer les tracteurs et les scies mécaniques. Une liste de contrôle sur les plans de tracteurs a été publiée par l'Institut comme un guide pour les dessinateurs, les ingénieurs de construction et les experts des industries forestières et du bâtiment. Une étude sur les facteurs humains dans les accidents de forêts a été menée à bien. Un centre médical spécial pour les travailleurs de la forêt a été mis en place dans le Nord de la Suède.

Il y a beaucoup de problèmes de recherches sur la médecine du travail plus importants, aujourd'hui et dans le futur, comme les risques d'exposition aux poussières, aux fumées, aux vapeurs, aux gaz, au bruit et aux substances chimiques qui irritent la peau.

Une cadence trop rapide du travail et une haute productivité peuvent provoquer le stress chez ceux qui sont les plus vulnérables à l'augmentation de ce phénomène. D'un autre côté, la monotonie peut être un problème dans les industries hautement mécanisées. Puisque les travaux les plus pénibles disparaissent progressivement et que la durée du travail diminue, l'entraînement physique aux heures de loisirs sera d'une importance croissante, comme un moyen de promouvoir la santé. La recherche dans ce domaine a déjà commencé.

Le nombre croissant des personnes âgées dans la population exigera des études spéciales sur l'adaptation du travailleur âgé.

Le nombre des femmes au travail va en augmentant. Des études ont été faites et d'autres seront nécessaires. Les problèmes des femmes au travail le rôle que l'on veut voir joué par les femmes au travail et à la maison qu'à doivent être mis en rapport avec leur « double travail » dans l'industrie et à la maison. « Le travail typiquement féminin » est davantage en relation avec leurs qualités spécifiquement féminines.

Il est extrêmement important pour les résultats des recherches et des études dans les industries qu'ils soient largement répandus par des publications. Ces documents étaient distribués par l'Institut de la médecine du travail de trois façons :

I. Information aux organisations des employeurs, des syndicats, aux industries, aux instituts, aux ingénieurs, aux médecins, aux infirmières, à la presse et au grand public par un bulletin de nouvelles sur 8 pages *(AI-aktuellt),* paraissant tous les deux mois et contenant des résumés des activités de l'Institut — en suédois.

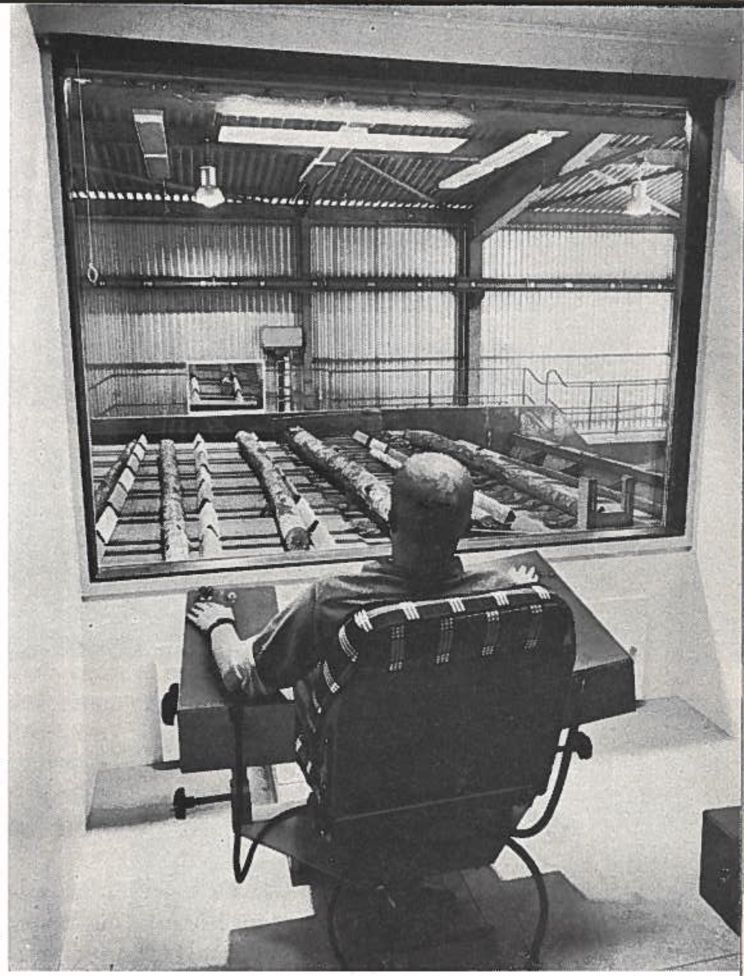
II. Une série de rapports *(AI-rapport)* comportant des résultats de recherches appliquées ou des études réalisées dans des industries, habituellement en suédois, toujours avec des résumés en anglais.

III. Une revue scientifique, Studia Laboris et Salutis, pour des rapports scientifiques en anglais.

Les résultats des recherches sont naturellement souvent publiés dans les revues scientifiques connues. Des aspects d'applications pratiques de certaines recherches sont publiés dans des feuilles d'entreprises et dans les journaux des organisations des employeurs et des travailleurs.

Depuis 1973, AI-aktuellt (Nouvelles de recherches) sont intégrées dans *Aktuellt från arbetarskyddsverket* (Actualités de la Direction nationale de sécurité et d'hygiène du travail) qui va continuer de publier aussi AI-rapport (Rapports de recherches appliquées) comme une série *Arbete och hälsa* (Travail et santé).

Des services ou des études, entrepris à la demande des autorités, d'industries, d'hôpitaux, de médecins, sont progressivement développés et un grand nombre ont été réalisés. Des médecins du travail et des ingénieurs de la sécurité en ont inspiré plusieurs et coopèrent à leur réalisation et, le plus souvent, des représentants des syndicats suivent de très près leurs travaux. Les études varient beaucoup en nature : détermination des analyses de postes dans une usine mécanique ; analyse ergonomique de machines au stade de prototype ; détermination de l'ordre de préférence pour différentes méthodes destinées à améliorer l'environnement ; inventaire des possibilités de travail



Ajustage des troncs avant broyage. La mécanisation a permis l'élimination de beaucoup de travaux physiques pénibles, mais en même temps accru les exigences psychiques.

Le soufflage par sable siliceux est un procédé qui produit beaucoup de poussières. On n'a pas encore trouvé de solution satisfaisante à ce problème. Cet ouvrier porte un capuchon de ventilation, qui contient un filtre déterminant la quantité de poussières dans l'air qu'il respire. Une pompe placée sur son dos aspire une partie des poussières.

pour les vieux travailleurs ; cours pour les personnes chargées des problèmes d'environnement dans les entreprises. Les personnes chargées du travail reçoivent un rapport écrit, comportant une section spéciale pour des propositions sur l'amélioration de l'environnement.

Les années passées ont montré qu'il y a un grand besoin de recherche et aussi de suivre les données rassemblées. Parfois, certains travaux ont besoin d'être poussés plus avant. Ainsi, par exemple, une étude a débouché sur une conférence pour les fabricants d'outils pour machines, qui s'est tenue en 1972. Le but de la réunion était de discuter des principes ergonomiques à respecter dans la construction de ces outils.

Un autre problème important nécessitant une poursuite des recherches est l'élaboration de normes ergonomiques en général.

Des travaux de recherche sur la médecine du travail et les domaines adjacents sont également menés en dehors du Département de la médecine du travail.

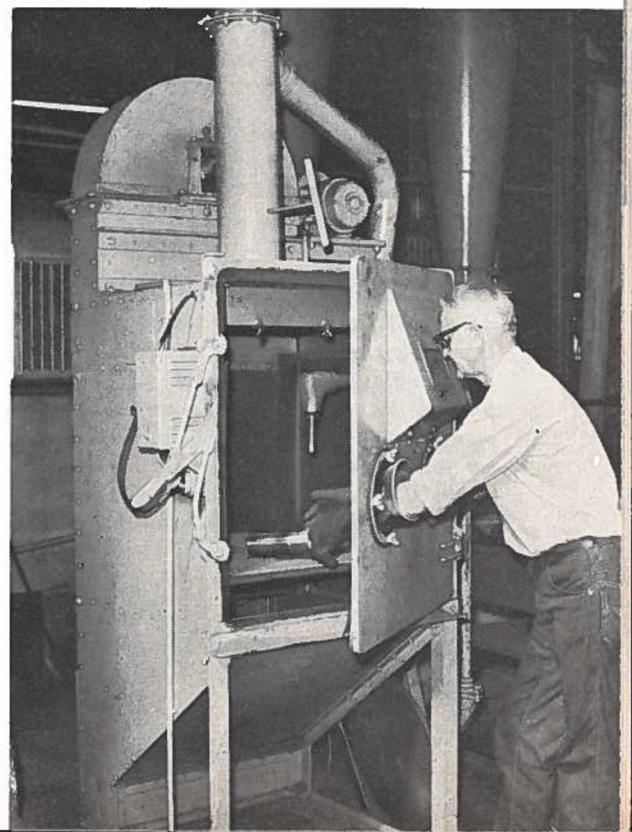
En 1962, le gouvernement a désigné un comité chargé d'étudier les possibilités d'organiser les soins médicaux des maladies du travail. Dans son rapport, le comité a proposé l'organisation d'unités de médecine du travail dans les huit hôpitaux régionaux suédois, chacun desservant une population d'un million d'habitants. En 1971, quatre unités étaient formées, deux à Stockholm, une à Lund et une à Örebro. Deux autres vont voir le jour incessamment à Göteborg et Umeå. Une des unités de Stockholm est étroitement liée au Département de la médecine du travail et celle d'Umeå le sera également dans sa ville. Il y a de toute façon une étroite coopération entre le Département et toutes ces unités.

La SAF a quatre experts de la médecine du travail, de l'hygiène et de la sécurité, deux médecins et deux ingénieurs. Tous ces experts font des recommandations aux sociétés membres de la SAF sur les questions de santé et organisent des cours pour rafraîchir les connaissances des médecins du travail, des ingénieurs de sécurité et des infirmières de la médecine du travail. Ils organisent aussi ou soutiennent des programmes de recherches et d'études sur des aspects comme la santé et la sécurité du travailleur âgé, les absences dues à la maladie, la santé des ouvriers des fabriques d'explosifs.

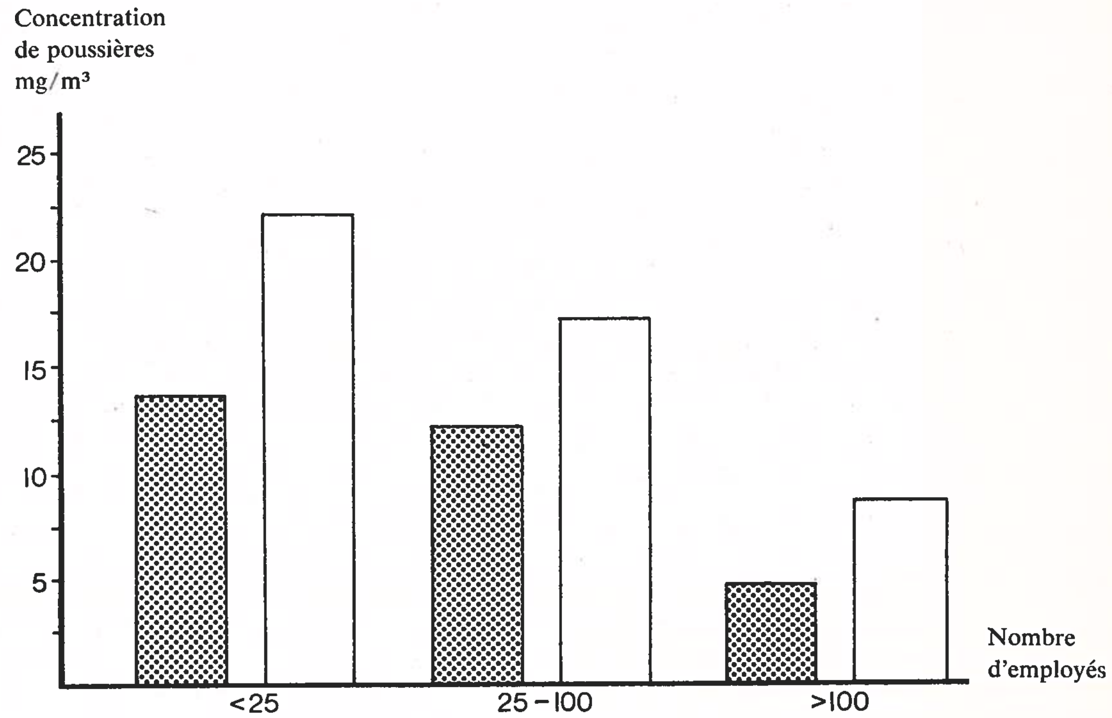
La LO a également deux experts, un médecin et un ingénieur, menant des études sur, par exemple, les problèmes du chômage et l'attitude des ouvriers envers leurs problèmes de santé au travail. Ils organisent aussi des cours de formation pour les délégués syndicaux chargés des problèmes de santé et de sécurité et pour les travailleurs responsables des mêmes problèmes. Il y a une étroite coopération entre ces deux groupes d'experts.

Plusieurs organisations sont intéressées par la recherche dans la médecine du travail. Le Conseil suédois de recherches médicales a mis en place un

Une pièce en fonte d'acier est nettoyée par une machine à émoudre au fuseau oscillatoire. L'exposition de l'ouvrier aux poussières est mesurée par un appareil portatif qui prélève des échantillons.



Un « placard de décapage », hermétiquement fermé pendant le décapage : la pièce est manœuvrée à l'aide des gants montés dans la porte.



De Forssman, S. : Kartläggning av silikosrisken. (Analyse des risques de silicose.) Hygienisk Revy No. 5/1970.

Dans les fonderies, les plus grands risques de silicose se présentent lors de l'opération appelée revêrement. Le diagramme montre que les conditions sont les meilleures dans les grandes entreprises employant plus de 100 employés, sans doute en raison de leurs plus grandes ressources. Les colonnes ombragées représentent des mesures prises à des points fixes à des postes de travail, tandis que les colonnes blanches montrent la concentration de poussières enregistrée lorsque les travailleurs portent sur eux l'appareil qui recueille les échantillons de poussières. Le dernier procédé donne des valeurs plus élevées, ce qui montre que le travailleur s'est approché davantage des sources de poussières pendant son travail quotidien.

groupe de travail spécialement chargé de la médecine du travail avec cinq comités s'occupant de problèmes spécifiques. La Direction nationale pour le développement technique a organisé un comité sur la science du travail, qui étudie le milieu et les conditions du travail d'un point de vue humain. Le Conseil pour l'administration du personnel a, depuis sa création en 1952, consacré beaucoup d'efforts à la recherche de l'homme au travail, spécialement à partir d'aspects psychologiques et sociologiques. Au cours de ces dix dernières années, de grands travaux de recherches ont été réalisés dans des instituts d'universités par le Conseil pour l'administration du personnel et d'autres organisations sur la psychologie et la sociologie en relation avec des problèmes comme celui des exigences psychiques du travail et celui de l'évaluation de la capacité de l'individu, son adaptation au travail ainsi que sur la sociologie du travail, comme les attitudes et la satisfaction au travail et les facteurs susceptibles de les influencer.

En 1972, un fonds spécial a été créé, le Fonds suédois pour la protection du milieu de travail, financé par une augmentation des cotisations d'assurance des employeurs contre les accidents et les maladies du travail. Ce fonds, environ 20 millions de couronnes par an, va financer des recherches, de l'information et la formation à la médecine et à la sécurité du travail.

Pour jeter les bases des activités du Fonds dans la recherche, une étude a été réalisée sur la recherche en cours dans le domaine du milieu de travail et des documents ont été rassemblés au sujet des désirs et des besoins qui sont susceptibles de s'imposer dans les cinq années à venir, si l'on tient compte du développement technique, de l'évolution de la société et des changements sur le marché du travail à la suite de la restructuration et de l'urbanisation attendues. Dans cette étude, présentée en 1972, réalisée en contact avec des experts d'autres pays, on a proposé de prioriter onze domaines de recherche : toxicologie industrielle, méthodes d'élimination technique des pollutions de l'air, effets et élimination des bruits, climat, par exemple froid et courants d'air, organisation et contenu du travail, maladies du dos, accidents, études par branches, durée et lieu du travail, surtout du travail en équipes, absences et rotation du personnel, main-d'œuvre âgée et moyennement âgée.

Le Fonds a choisi quatre de ces domaines pour commencer et désigné des groupes de travail pour planifier la recherche dans les domaines suivants : substances chimiques, travail par équipe, accidents et études pluridisciplinaires par branches industrielles. De plus, le Fonds a désigné un groupe de travail spécial pour revoir la formation dans le domaine du milieu de travail, en pensant spécialement à la formation des délégués à la sécurité. La formation supérieure sera elle aussi prise en considération. Dans le domaine technique, il est évident qu'il y a de grandes lacunes dans le milieu de travail. C'est

Les services de médecine du travail pour les travailleurs du bâtiment sont organisés en unités-modèle. Une caravane avec un équipement spécial pour des examens de santé est stationnée près du chantier.

pourquoi l'on est en train de préparer de nouveaux programmes afin de renforcer et d'améliorer cette formation.

Une seule industrie a appliqué une autre solution. Pour les ouvriers du bâtiment, une organisation spéciale, *Bygghälsan,* a été créé. Elle a 17 centres régionaux et comprend des unités mobiles avec des ingénieurs de sécurité, des médecins et des infirmières du travail. Elle est responsable de la santé et de la sécurité de tous les travailleurs du bâtiment en Suède, environ 250 000 hommes. *Bygghälsan* a eu des ingénieurs de sécurité dès le début. La partie médicale est maintenant progressivement mise en place et quatre centres régionaux sont déjà entièrement équipés.

Selon les traditions scandinaves, la médecine du travail est également l'objet d'une étroite collaboration entre les pays scandinaves. Des représentants des institutions de médecine du travail de Danemark, Finlande et Norvège se rencontrent dans des conférences chaque année pour échanger leurs expériences. Des groupes de travail sont organisés sur certains problèmes, comme la chromatographie des gaz ou l'analyse des poussières. Des projets communs sont également réalisés par les différentes institutions. Le Conseil nordique a organisé en 1971 un comité sur la médecine du travail en vue de continuer à promouvoir la coopération et la coordination des activités dans les différents pays. Ce comité se réunit deux fois par an et a présenté un rapport en 1973.

Les échanges d'expériences par-dessus les frontières, en particulier sur la recherche et l'enseignement, ont pris une grande importance. Le Département de la médecine du travail reçoit un grand nombre de groupes en voyages d'études et des conférenciers venant d'instituts étrangers. Les collaborateurs du Département ont travaillé comme conseillers du Bureau international du travail et de l'OMS, dans des pays en voie de développement, où l'industrialisation et l'urbanisation créent souvent de graves problèmes de santé.

Enseignement et information

De brefs cours pour médecins d'entreprise ont été organisés pour la première fois en 1948 par l'Institut national de la santé publique. Depuis, ils se sont bien développés. Entre 1966 et 1972, ils ont été organisés par l'Institut national de la médecine du travail, et depuis 1972 par le Département de la médecine du travail, au sein de la Direction nationale de sécurité et d'hygiène du travail. De brefs cours de « rafraîchissement des connaissances » pour des médecins d'entreprise ont été organisés chaque année depuis 1951 par la Confédération patronale (SAF). Des cours pour les infirmières du travail ont été mis en place depuis 1955 par l'Institut national de la santé publique, puis par la SAF, puis par l'Institut national de la médecine du travail, dès sa création en 1966. Ils ont maintenant été repris par le Département de la médecine du travail. Des cours de formation pour les ingénieurs de sécurité ont été arrangés depuis 1958 par la SAF, puis par l'Institut en 1966 et maintenant par le Département. La SAF organise chaque année des cours de « rafraîchissement » pour les ingénieurs de sécurité.

Il est permis d'espérer que le cours de formation actuel pour le personnel des services de la médecine du travail (médecins, infirmières et ingénieurs de sécurité) au Département s'étendra sur toute une année universitaire. Maintenant que tous les participants à ces cours ont acquis une expérience pratique dans l'industrie, seule la partie théorique du cours est enseignée. La longueur de ces cours varie de 4 à 12 semaines et ils sont divisés en périodes de 1 à 2 semaines. L'enseignement est ainsi plus efficace. Les élèves reçoivent des livres et des documents à lire, des problèmes à étudier jusqu'à la période suivante, au cours de laquelle ils sont invités à présenter leurs « devoirs ». Instruits par l'expérience, les responsables de l'Institut tendaient à penser que la longueur idéale d'une telle période est d'une semaine. A l'avenir, le reste de l'année sera employé à des études pratiques ou à des stages de formation dans les différentes unités du Département de la médecine du travail, dans des unités hospitalières de maladies du travail et dans des industries sélectionnées, comportant des services ed médecine du travail de haute qualité. Un groupe de travail a été mis en place par l'Institut pour recommander au directeur une politique susceptible de résoudre les problèmes des programmes d'enseignement. Le Riksdag a décidé en 1971 de faire participer à ces cours chaque année 45 médecins, 45 ingénieurs, 60 infirmières et 45 ingénieurs en ergonomie.

Les étudiants en médecine ne reçoivent que très peu ou pas du tout de formation en médecine du travail, habituellement quelques heures de conférences pendant les cours de physiologie, de pharmacologie, de médecine interne, de santé publique ou de médecine sociale. Les étudiants à l'Ecole royale polytechnique supérieure de Stockholm ont quelques cours de médecine du travail, mais les autres écoles supérieures n'en ont que très peu ou pas du tout. Un centre technologique humain a été mis en place en 1971 à l'Ecole polytechnique de Stockholm sous l'autorité de son directeur en vue de stimuler la recherche et l'enseignement supérieur et d'inciter le développement technologique à tenir davantage compte de l'homme dans la production. Il est maintenant prévu de consacrer 10% de tout l'enseignement à l'environnement humain, y compris le milieu de travail, à l'université technique de Luleå, dans le Nord de la Suède. Récemment, on a organisé des stages de formation en ergonomie et en sécurité pour les étudiants de toutes les écoles d'ingénieurs.

De par la loi, chaque usine ou entreprise comportant plus de cinquante travailleurs est tenue d'avoir un comité de sécurité. Les représentants des travailleurs, « les ouvriers de sécurité », sont nommés par l'organisation locale des travailleurs. Le Conseil bipartite pour la sécurité du travail, organisé par les employeurs et les travailleurs, a arrangé des cours par correspondance pour les ouvriers de sécurité ainsi que des conférences de formation régionale ou spéciale. Dans de grandes industries, où il y a de nombreux ouvriers de sécurité, l'un d'eux est nommé ouvrier de sécurité principal. La Confédération

syndicale (LO) a organisé pour eux un cours intensif de trois semaines à son centre de formation.

Un nombre considérable d'ouvrages ont été publiés en suédois sur la médecine du travail, l'ergonomie et la sécurité du travail au cours de ces dix dernières années. Des livres et des brochures ont été écrits sur différents aspects de la médecine du travail par les experts de l'Institut, des hôpitaux universitaires, des organisations des employeurs et des travailleurs.

Les experts de la médecine et de la sécurité de la SAF ont publié une série de brochures sur différents sujets, comme les services de la médecine du travail, le travailleur âgé, les risques de maladies dans les industries du plastique et du caoutchouc, les dangers de la radiation ionisante, les services de la médecine du travail interentreprises etc.

Les experts de la LO ont publié une série de livres et de brochures sur ces problèmes afin d'informer les travailleurs et les délégués syndicaux. Les brochures sont très bien présentées et donnent des informations sur des sujets tels que la silicose, l'ergonomie, l'hygiène industrielle, l'adaptation au travail, le bruit, les dermatoses, le stress au travail.

Des campagnes d'information ont été menées sur le plan national pour informer les travailleurs, les contremaîtres et les directeurs aussi bien que le grand public.

Le Conseil bipartite pour la sécurité du travail publiait vers 1950 des informations sur la sécurité et la prévention des accidents. Vers 1960, une compagnie d'assurances, *Folksam*, a publié des informations sur le milieu du travail et sur la promotion de la santé par l'entraînement physique et, depuis 1970, la même compagnie d'assurances publie des brochures sur la santé mentale au travail.

Ces campagnes ont eu pour résultats la diffusion d'informations sur une large échelle à un grand nombre de gens. L'intérêt pour toutes ces questions s'est accru et a stimulé l'organisation de groupes qui se sont mis à étudier ces problèmes. Le résultat permanent a principalement été la publication d'un très grand nombre d'ouvrages de valeur sur ces sujets.

Perspectives nouvelles

En même temps que le niveau de vie a augmenté, la façon de l'évaluer s'est modifiée. On s'intéresse beaucoup plus aujourd'hui à la finalité du travail et au milieu dans lequel on exerce son activité professionnelle. A l'exigence de conditions de santé et de sécurité au travail, est venu s'ajouter l'intérêt pour le confort et la satisfaction. Un grand nombre de jeunes se détournent actuellement de l'industrie dont les conditions de travail les rebutent. Quelques industries ont du mal à recruter de la main-d'œuvre jeune et elles s'appliquent de plus en plus à améliorer les conditions de travail et à modifier l'organisation du travail, afin de rendre le travail à l'usine plus attrayant. Plusieurs industries expérimentent actuellement de nouvelles méthodes en vue d'augmenter la production et la satisfaction au travail.

Résumé

La médecine du travail en Suède est fondée sur des activités dans quatre domaines :

1. *Niveau minimum statutaire pour la santé et la sécurité au travail (inscrit dans la législation).* C'est la loi sur la sécurité des travailleurs, contrôlée par la Direction nationale de sécurité et d'hygiène du travail et l'Inspection du travail.

   La combinaison de la législation et des activités volontaires entre les organisations des employeurs et des travailleurs est typique de la Suède.

2. *Les problèmes quotidiens à l'usine* sont résolus par les services de la médecine du travail, qui sont en Suède volontaires mais fondés sur un accord entre les organisations des employeurs et des travailleurs.

   Les services de la médecine du travail comportent une partie médicale et une partie technique, mettant en évidence l'étroite coopération entre les ingénieurs de sécurité, les ergonomes, les médecins et les infirmières du travail.

   En vue de résoudre les problèmes des petites industries, les centres médicaux régionaux ont été largement développés. Les services de la médecine du travail sont maintenant progressivement organisés pour des secteurs non-industriels, comme les docks, les forêts et l'agriculture.

3. *La recherche* a été menée principalement par l'Institut national de la médecine du travail, créé en 1966, et depuis 1972 par le Département de la médecine du travail au sein de la Direction nationale de sécurité et d'hygiène du travail. Elle est également faite par les unités des hôpitaux régionaux chargées des maladies du travail, également, dans une certaine mesure, par d'autres organisations et instituts universitaires. La recherche se concentre sur les problèmes pratiques de l'industrie suédoise et d'autres secteurs de l'emploi. Le Département s'occupe également de l'application pratique des résultats des recherches.

4. *Enseignement et information.* La formation des étudiants en médecine et en polytechnique dans le domaine de la médecine du travail n'est pour le moment développée qu'à une petite échelle. La plus grande partie de la formation en médecine du travail a été faite par l'Institut, et depuis 1972 par le Département, au niveau universitaire. Des médecins et des infirmières du travail, des ingénieurs de sécurité sont formés et les cours de

formation ont déjà été organisés, ou vont l'être de manière à couvrir une année universitaire.

Un cours supérieur en ergonomie pour les ingénieurs et dessinateurs du bâtiment a été lancé. Il a été très favorablement accueilli. Des cours de formation pour les ouvriers de sécurité ont été organisés par le Conseil bipartite pour la sécurité du travail, émanation des confédérations patronale (SAF) et ouvrière (LO). Des cours pour ouvriers de sécurité et délégués syndicaux ont été créés par la LO ; des cours de « rafraîchissement des connaissances » par la SAF pour les médecins et les infirmières du travail et les ingénieurs de sécurité.

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Conseil bipartite pour la sécurité du travail — Arbetarskyddsnämnden
Conseil suédois de recherches médicales — Statens Medicinska Forskningsråd
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Society, Stress and Disease

VOLUME 1
THE PSYCHOSOCIAL ENVIRONMENT AND PSYCHOSOMATIC DISEASES

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SOCIETY
STRESS AND DISEASE

VOLUME 1

THE PSYCHOSOCIAL ENVIRONMENT
AND
PSYCHOSOMATIC DISEASES

16 ALIENATION AND MENTAL HEALTH IN THE MODERN INDUSTRIAL ENVIRONMENT

BERTIL GARDELL

THE PROBLEM

What influence does the modern industrial environment have on human work satisfaction and general life adjustment? This question has been discussed by Western social scientists for many decades. In recent years similar scientific discussions from the Eastern countries have also become available to a wider audience.

Researchers have called attention to a fundamental conflict btween the goals and structure of the enterprise and the individual's need of autonomy and identity. Particularly great concern has been voiced over the negative influences on individual work satisfaction and general life adjustment which are imputed to the conditions of work at large plants engaged in mass production—a concern which may be most simply interpreted as the threat posed to human dignity by mechanization and bureaucratization. This scientifically rooted criticism has focused on two of the basic tenets of classical organization theory: authoritarian leadership, and segmented and constrained tasks. In the Western world a criticism that is partly scientific and partly political has also been aimed at the capitalistic ownership structure. That part of the criticism which appears to have the greatest relevance for present purposes proceeds from analyses of the individual's status at the work place, and of how self-determination and contributory influence over working conditions affects interest in work, and the experience of participation in the production system.

It will have emerged from the foregoing that the interaction between the structure of industrial production and the individual's emotional relationship to his work is extremely complicated. The discussion makes use of explanations at widely varying levels, concerning the structure of ownership and power in society and industry, the system of authority, the division of labour, and mechanization.

In planning the study which is reported here, we thought it an impossible task to tackle this whole complex of problems. Indeed, even if an empirical investigation of Swedish conditions was to be kept within manageable bounds, our terms of reference would have to be limited. The position we took was that the political system and ownership pattern probably had less bearing on the problem of alienation in the job world. Existing research in the field gave us no evidence to think otherwise. On the other hand, we found that the problems were similar in socialistic and capitalistic countries, and the same could be said of capitalistic and of mixed economic systems, regardless of ownership pattern. The findings of research, it seemed to us, tended instead to suggest that the problem of alienation in the job world emanated from the industrial production system as such, and that the causes should be chiefly sought in the authoritarian system of power and leadership, as well as in the segmented and constrained work, that is, in circumstances which we subsumed under the heading of traditional organization ideology (Dahlström, Gardell *et al.* 1966).

A hypothesis we thought reasonable to formulate on the basis of earlier studies was this: In certain cases, modern, highly rationalized types of production appear to come into conflict wth fundamental needs of self-esteem, such as to have influence and control over one's work situation, to perceive work as meaningful and socially important, to perceive affinity with the firm as a social system, and to feel identity through one's work. Unless these needs are satisfied at the work place, the individual experiences a basic frustration that manifests itself in different efforts to achieve adjustment. Here we can discern different types of *active* adjustment, e.g. the desire for change, voluntary termination of service, presentation of grievances, or participation in a wildcat strike. It is likely, however, that the most prevalent type of adjustment is of a *passive* (alienative) nature, i.e. the individual depreciates his work as a source of needs satisfaction and asks no more than that it pay him a good wage and should continue under safe and hygienic physical conditions. The individual adopts an instrumental attitude to his work; it becomes no more than a means to the end of providing resources for needs satisfaction away from work by different forms of consumption. The work itself is perceived to be basically uninteresting and non-involving. In this study, we shall focus primarily on the passive types of adjustment, that is to say, we want to investigate how the design of work and its content covary with involvement, feelings of monotony and freedom, and the absence or not of instrumental attitudes.

As indicated earlier, a central theme of Western research on work has been to study whether high work satisfaction improves performance, and/or reduces labour turnover and absence. This interest reflects a business justification for the research and for practical measures calculated to improve work satisfaction. Obviously, to root industrial-psychology research and application so exclusively in economic values is an unsatisfying state of affairs, and this has also exposed the discipline to a running fire of heavy criticism. As a matter of course, interest in the problems of work satisfaction must be justified with reference to work satisfaction in its own right. Democratically governed societies have generally accepted values to the effect that the individual has the right to meaningful and interesting work, the right to influence his own work situation, the right to freedom from arbitrary behaviour, from physical and mental attrition, etc. The individual's perception of work thereby becomes essential for its own sake, regardless of whether any direct connexion with productivity or other economic yardsticks can be demonstrated. The incidence of work satisfaction or dissatisfaction may be seen as expressing how well the machinery of production has been organized to meet certain real human needs. This is the primary ideological point of departure for the project described here.

But given this point of departure, it becomes no less significant and interesting if it can be established that work satisfaction, and the conditions of work that covary with such satisfaction, exhibit concurrent variations with other variables related to other essential values for the individual and society. In this study, we have borne two such value areas in mind, namely health and efficiency.

Concerning the value area of health, we have first of all tied in with the international discussion on the relationship between work experience and certain criteria that may be considered relevant for general psychical well-being or mental health. In so doing, we proceed from the concept of self-esteem, which is central not only to our principal criteria of work satisfaction but also to theories of positive mental health. We shall discuss these matters at greater length in a later section, and also specify the criteria on which we have drawn; here, we wish merely to delineate the line of reasoning that has guided us.

We postulate that self-esteem is strongly rooted in work for most people in our society. Work and its connexion with education and income, constitute the cardinal stratification variable in Western societies. Due to the influences exerted by the Protestant ethic and other culturally conditioned factors, it is probable that most people look upon work as a socially necessary, and hence positively sanctioned, act. These factors, moreover, make it probable that most people perceive work to be one of the most important life areas for the individual's general satisfaction. According to a study by Friedlander (1966), activities related to work are regarded both by blue-collar and white-collar workers as more important for the individual's general life adjustment than non-work-related activities, such as education, leisure pursuits and club life. Similar findings have been obtained in Sweden from studies of life goals for blue-collar groups in manufacturing and forestry (Forslin, 1969). In both of these random samples, having an interesting job was reported to be one of the most important life goals. Thoughts of this kind have been presented in the international research (see e.g. French and Kahn, 1962; Kornhauser, 1965) and are also discussed in conjunction with the inquiry into trade unionism and technological advance sponsored by LO, the Swedish Confederation of Trade Unions (Dahlström, Gardell *et al.* 1966). Unsystematic, yet important observations have also been made by doctors and others, who point out how the self-esteem of certain individuals is eroded by expulsion from the labour market through no fault of their own, for instance in consequence of plant shutdowns, curtailed operations and the like.

Against this background, it seems reasonable to assume that the potentials of work for satisfying needs, bound up with self-esteem, bear not only upon work adjustment but also upon general life adjustment or mental health. Working conditions that afford limited opportunities for influence, perceived meaningfulness and self-realization also tend to instill feelings of inferior ability and prestige in the larger society, and to diminish general life satisfaction.

Concerning the value area of efficiency, we have dwelt upon the correlation that earlier studies have found between work satisfaction and absenteeism (Vroom, 1964). We have thought it reasonable to assume that the alienative or instrumental attitude to work entails low work motivation, i.e. low utilization of the individual's capacity, energy and willingness to assume responsibility on the job. One consequence of the division of labour in highly rationalized, large-scale industries has been to preclude large groups of employees from taking part in the planning and control of their own work. The narrow scope for exerting influence over one's own work situation, together with the limited knowledge of production relationships, means that the individual has been deprived of the chance to make a positive commitment to work. The result is to eliminate the most significant, energy-releasing motivational factors, with concomitant narrowing of effort on economic or coercive inducements, and on 'hygienic' measures which aim to remove stress factors and other conditions that can contribute to the genesis of dissatisfaction. This process generates an indifferent attitude to work and diminishes responsibility for it. The individual focuses his interest instead on earnings and on the needs satisfaction away from work which these can give him through different forms of consumption. It seems reasonable that such an attitude to work will, under certain labour market conditions, also lead to high labour turnover and absence rates. The relations found between job content, alienation, and absences will not, however, be reported in this article.

THEORIES, RESEARCH METHODS AND DESIGN

Content of Work and Subjective Rewards from Work

A general assumption of this study is that the content of work affects in a central way the satisfactions to be gained from work of ego-relevant needs. This influence of work content is not limited to the formation of attitudes around work but also extends to more general perceptions and emotional states, which we assume to be relevant for the individual's mental health.

Needs, expectations, level of aspiration, psychological rewards, and objectively existing conditions of work are the most important concepts that enter into the hypotheses which this study formulates as to the connexion between conditions of work on the one hand, and perceptions of, and satisfaction from, work on the other.

Data presented by researchers, such as Kornhauser (1965) and Blauner (1964), show that work satisfaction tends to rise with higher occupational level, but the tendency is relatively moderate. This might indicate that certain needs occur in different strengths if we compare individuals at different occupational levels, which would explain why work satisfaction can also be felt at low levels. Here, however, we should like to enter the assumption that the manifested need does not necessarily have to be synonymous with the 'actual' need. Needs may be latent or suppressed owing to insufficient stimulation or frustration from the environment. In other words, individuals are capable of adapting their requirements or their level of aspiration to the prevailing conditions of work. It has also been demonstrated experimentally (Israel, 1956) that individuals are inclined to adapt their level of aspiration to psychological rewards. The level of aspiration fluctuates with the individual's experience of psychological reward in a certain situation. From the mental health aspect such an adjustment of the aspiration level may be seen as a criterion of reality comprehension. Accordingly, work satisfaction can be seen as a result of the level of aspiration devised by the individual in the face of the work situation and the prospects for psychological reward actually inherent in the situation. This might be illustrated as follows:

The individual with his level of aspirations	→	Objective conditions of work	→	Perceived (subjective) working environment and degree of satisfaction related thereto

However, the emphasis of the present study is not so much on satisfaction with work as a whole, as on different factors in work which may be assumed to meet different psychological needs. Among these, it is the so-called ego-relevant needs, i.e. desires for self-realization in the performance of work, which stand at the centre of our interest. The content of work is rated along two main dimensions, namely the independence of work and the qualifications required to perform it. We assume that these dimensions underlie the extent to which ego-relevant needs can be met at the work place.

The relationship between objective conditions of work and mental health, as studied here, is illustrated in Figure 16.1. Work satisfaction specified in terms of different factors in work is here regarded as an intervening variable between objective conditions of work and mental health. We are aware that the satisfaction of needs in other life areas affects the individual's mental health. By limiting the researched group to LO-affiliated blue-collar workers, employed under the terms of collective agreements, and by selecting firms outside metropolitan areas in places with similar consumption patterns and recruitment bases (foreign labour has been excluded), we feel we have obtained a measure of control, albeit limited, over some of the factors which conceivably influence mental health. The studied groups differ instead with reference to work content, and therefore enable us to study whether the satisfaction of needs correlates with mental health and whether any differences of mental health by occupational level can be explained by differences in needs satisfaction gained from work.

tions indicate that tasks which require high qualifications often leave the worker free to improve and broaden his performance, whereas tasks requiring low qualifications do not involve freedom possibilities of this kind. Correlations between qualification requirements and freedom possibilities apply to tasks performed by the investigated groups, relating to 147 blue-collar occupations (414 individuals) in the pulp and paper industry, and 134 blue-collar occupations (640 individuals) in the engineering industry.

The information obtained by ratings of every task (=job), according to the main aspects mentioned above, constitutes environmental data.

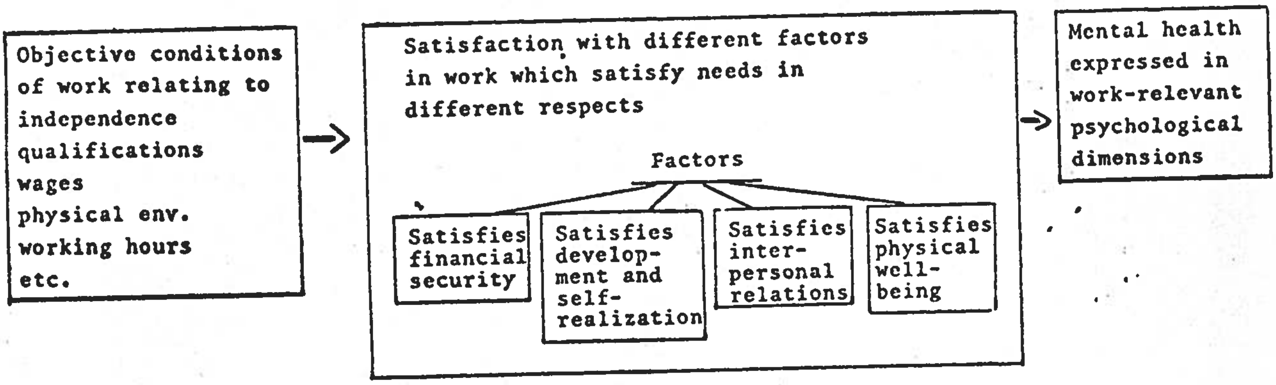


FIG. 16.1. Relationships between objective conditions of work and mental health.

Expert Ratings of Work Content

The content of work is described from two main aspects:

1. The degree of independence enjoyed by the individual in deciding on the organization of work, working methods, pace, initiating contacts, doing a task in any of several different ways, improving his performance, and developing what further aptitudes he may have.
2. The qualifications required of the individual, i.e. his know-how, initiative, ability to work without supervision, and ability to form contacts, so that work tasks will be satisfactorily performed.

The ratings were made by an engineer attached to the project, who for this purpose collaborated with technical experts from the firms and the trade unions.

A component analysis of the rating questionnaire produced positive correlations between variables assignable to the freedom aspect and variables assignable to the qualification aspect. The correla-

Other particulars, such as income, wage payment plans, types of shift operation, different aspects of the physical environment, while they amplify the description of objective environment, play a more subordinate role as far as the theory is concerned.

Self-ratings of Rewards from Work

The conventional, generally worded questions asked about job satisfaction do not get at the freedom aspects of work performance, nor at the degree of individual motivation, i.e. the extent to which the work satisfies important psychological needs. For that purpose we have formulated special questions. With the alienation theory as our starting-point, we assume that work must first of all satisfy the following needs, if it is to have any needs satisfaction value and to make the individual feel involved in, and highly motivated psychologically by, his work (Blauner, 1964):

1. Need of influence and control over his own work situation.
2. Need of a meaningful job.

3. Need of interaction and fellowship with other people.

These needs are related to the individual's self-esteem and prestige. To the extent they are not satisfied by work, the individual may react actively in several different ways: by aggression or complaints, by trying to change his tasks or switch jobs, by falling ill or by absenting himself. However, one of the most common adjustment models seems to be that the individual lowers his expectations that the work shall be interesting, independent and developing, and limits his evaluation of the job to its financial return. While this attitude need not be equated with unhappiness or dissatisfaction, it does signify lower satisfaction in work of ego-relevant needs.

A basic postulate of our theory is that the technological factors, i.e. the design of the manufacturing process and the organization and content of work, largely determine the formation of individual work-related attitudes. We shall touch upon those characteristics of work organization which bear upon the psychological needs we talked about and upon individual work motivation.

Need of Personal Say and Personal Control. This need can be said to be most directly affected by three aspects of the design of the manufacturing process, namely:

1. The individual's influence over corporate policy and management.
2. The individual's control over terms and conditions of employment.
3. The individual's control over the immediate work process.

Our interest here will be confined to the third item, i.e. that which directly affects the organization and content of a work task. Moreover, it would seem that this aspect is the most crucial for satisfaction of the ego-relevant needs through work.

The opportunities to exercise influence and control over one's own work situation are determined by many factors connected with the design of the work task, of which some of the more important will be mentioned.

1. The individual's personal control over his own working pace and rhythm.
2. The individual's scope for regulating the pressure to which he is subject.
3. The individual's personal control over physical motions, breaks and the like.
4. The individual's scope for influencing production quantitatively and qualitatively.
5. The individual's scope for selecting methods a tools to perform a task.

The design of work tasks in these respects dete mines the individual's sense of on-the-job indepen dence, and his sense of constraint and stress on the job, mental stress in particular.

Need of Interesting and Meaningful Work. This need has to do with how the individual perceives the content of his occupational role. According to the scientific management philosophy, efficiency and earning power will be improved if the work is segmented into small components that are carried out by different persons. But because of this specialization and segmentation of work, it becomes more difficult for the individual to see how his operation relates to those performed by others or to production as a whole. In today's large-scale industrial enterprise, this overall grasp is possessed by no more than a few. The majority of employees are only familiar with what is happening in their immediate vicinity.

The meaningfulness of work, largely depends on the individual's relationship to three of its aspects, namely:

1. The product.
2. Organization of the work process.
3. The skill required.

A unique (individual) product, such as a ship or a house, constitutes a meaningful task in its own right. A worker finds it much more difficult to comprehend the purpose of his own effort when he works on a standardized product that takes shape from repetitive work cycles.

The second aspect is concerned with how large a part of the manufacturing process the employee comes in touch with in his work. Where he is called upon to perform a major sequence of operations, his work will be more meaningful than if he is restricted to only one or a few operations. Experiments have shown that interest in work increases if the individual can take part in the pre-planning and control of his own output.

The third aspect can be seen as a function of the other two. Segmented, repetitive tasks often impose extremely small demands on the individual, which makes him feel that his knowledge and skills are not being used to the full. In extreme cases that may persuade the individual to feel he is dispensable: the task is so simple that anybody can do it.

The Individual's Participation in the Firm as a Social System. Research in industrial sociology indicates that the technical and administrative structure of a firm has great bearing upon individual participation in the firm as a social system. Social isolation arises when the individual does not feel any form of affinity with the work situation and is incapable of, or unwilling to, identify himself with the organization (or part of it) and its objectives. Contact with other people during work is of great importance, partly because it can psychologically compensate for shortcomings of control over one's own work situation, for the absence of meaningfulness, and the opportunities for stimulation and commitment which the work gives. The perception of isolation may be broadly interpreted to include the following components:

1. Perception of not being in touch with people and not entering into a fellowship of any kind (estrangement).
2. Perception of not belonging to and feeling affinity with a group (group homelessness).
3. Perception of not accepting the standards and goals which apply in the job world (anomie).

In the job world, we can sort out many different kinds of groups and alternative approaches to group commitment. In the literature of industrial sociology, special emphasis has been put on the work group, the worker collective, the occupational group, the formal corporate organization and its subgroups, and the trade union organization.

Sociological research has shown that even though the employee perceives himself to be rather aloof from the formal corporate organization and its objectives and standards, he may still be firmly anchored in the work group, the worker collective and/or the trade union organization. This means that the isolation dimension may pertain to the formal organization, and the informal organization. The ends and means of the latter may diverge in varying degree from the firm's standards and objectives and from the objectives of the union. In this study, we have mainly interested ourselves in the individual's relation to the informal organization, his contact with workmates and his participation in the norm system of the work group and the worker collective. The individual's relation to trade unionism at the work place has also been assessed, as well as his relation to the firm, but these aspects have been excluded from the present article.

To test the connexion between the different questions that were asked to measure perception of personal control, perception of meaningfulness of work and social isolation, we did a factor analysis based on Jöreskog's transformation method (Jöreskog, 1963), which involves orthogonal rotation. We picked this so-called 'varimax' method because we sought the highest possible correlations between items in each attitude dimension, and the lowest possible correlations between the different attitude dimensions. In other words, the object of the factor analysis is to investigate the possibilities of forming theoretically and statistically meaningful indices. Factor analyses were carried out in different industries and at different levels with recurring similarities of factor structure, which has permitted the formation of a number of different attitude indices of this kind. The five indices to be presented here are the following (throughout this chapter K signifies the number of items):

Interesting work	(K=7)
Personal control over work	(K=6)
Mental stress	(K=6)
Social interaction	(K=5)
Group cohesion	(K=8)

Index reliability is determined by means of Cronbach's alpha coefficient, which is a measure of the correlation between component questions of the indices (Cronbach, 1951). We think the scales are reliable measures of the studied attitudes and can be used for group comparisons if the alpha coefficient goes above 0·60. For all the scales here reported, the alpha coefficient varies between 0·74 and 0·85.

Self-rating of Dimensions Relevant for Mental Health

In order to compare different working environments with reference to the significance of work content for ego-relevant satisfaction of needs, we have developed a mental health construct whose theoretical structure deviates from that traditionally employed in medical science. We assume that mental health cannot be discussed apart from norms and values in the larger society. We move in a superficial layer of personality and do not talk about illness or mental disorder (Gardell and Westlander, 1968).

A separate report entitled *Om industriarbete och mental hälsa* (*On Industrial Work and Mental Health*) discusses various criteria of mental health, where, for the purpose of studying the influence of environment on mental health in the job world, we propose 'that the following perception dimensions with high abstraction level form a multivariate criterion of mental health:

1. Perceptions of personal competence and ability without reference to any one activity area, expressed in the form of self-evaluation. The following self-evaluation aspects ought to be important in this context:
(a) a self-evaluation which refers to the individual's value in a very general sense (intrinsic value);
(b) a self-evaluation which refers to the individual's ability and performances (competence perception);
(c) a self-evaluation which refers to the individual's prestige perceptions, i.e. how he believes himself to be regarded and evaluated by others (prestige perception).
2. Perceptions of self-realization possibilities without reference to any one activity area:
(a) where opportunities for change and variety are concerned;
(b) where opportunities for self-development and improvement are concerned.
3. Perceptions of other individuals in contact situations, more specifically toward positive—negative interaction tendency in contact situations.
4. Emotional rewards of life in general.'

We think these emotional states can be regarded as relevant criteria of 'positive mental health', but, naturally, we do not claim any exhaustive description of mental health for them. As a matter of course, the dimensions we have chosen are exclusively based on certain values or ideals. In our opinion, a democratic society of the Swedish type strives for and deems it positive if the individual holds himself in high esteem, perceives that justice is being done to his aptitudes and abilities, perceives that he can act freely and independently, and perceives life to be rich and meaningful. These ideals, we feel, have been embraced by most individuals and groups in our country. Accordingly, opportunities for the fulfilment of these goals ought to be relevant for the individual's mental health.

After performing factor analyses in accordance with the same principles as before, we considered it appropriate to use five attitude scales which we have called:

General life satisfaction	(K=4)
Self-esteem—feeling of competence	(K=8)
Self-esteem—feeling of prestige	(K=8)
Contact-avoiding attitude	(K=9)
Feeling of self-realization	(K=5)

The reliability coefficients (Cronbach's alpha) vary for these indices between 0·65 and 0·79.

The criteria were tested for their relevance to mental health in three ways.

1. Correlation with certain clinical variables measured by responses to questionnaire (Gardell and Westlander, 1968, Ch. 7.1).
2. Correlations with visits to doctors (Gardell and Westlander, 1968, Ch. 7.2).
3. Correlation with certain medically diagnosed symptoms (Gardell, 1969, Chs. 5.4 and 5.6).

In the present article, inclusion has been made of the clinical self-rating inventory, from which two variables were derived by factor analysis: tendency towards neurosis (K=17) and psychosomatic symptoms (K=6) (Lidvall and Jonsson, 1964).

Research Data

The principal research data are taken from two pulp and paper mills (companies belonging to the same concern), and two engineering plants (companies belonging to the same concern), all sited in non-metropolitan areas.

Every person selected for interview had been in the service of his employer for at least one year. All the interviews were conducted during the period of economic downturn between the spring of 1966 and the spring of 1968.

To obtain reference points outside the manufacturing sphere, we did a study of 290 unappointed clerks in a cooperative insurance firm (Gardell, 1967) and a study of 370 lumberjacks drawn from two private and one state-owned forestry enterprises (Gardell, 1969). A special study of work satisfaction and absenteeism for men and women —where skill level and job content were controlled —was carried out in a chemical products plant (Gardell, Baneryd *et al.* 1968). In the present article we will discuss some results from the principal research data only.

RESULTS

In the following, some of the main research findings will be presented in the form of tables and diagrams. Only brief comments will be made on the material.

Work Content and its Relation to Age, Sex and Income

Component and factor analysis of the rating questionnaire shows that variables from the 'freedom' and 'qualification' aspects of work design correlate with one another. A general factor has emerged in both the engineering and pulp and paper industries, on the basis of which we have constructed a general measure of psychologically relevant working conditions which we call 'work complexity'.

Eight variables are common to both industries. These variables relate to freedom of physical movement, variation of task, general say in work decisions, required interaction, responsibility and vocational training required. Added for the engineering industry are five variables relating to personal control over work pace and working methods, and freedom of social interaction. Added for the pulp and paper industry are three variables concerned with economic responsibility and attentiveness.

There is no apparent connexion between age and work complexity in either type of industry. The absence of a correlation between age and work complexity is important; otherwise, differences of alienation in groups with different degrees of work complexity could be explained by differences of age.

Selectivity in terms of sex is distinctly operative in both industries. Jobs of high work complexity are performed by four women in the engineering plants, and in the pulp and paper mills by none. Hence, the dominant impression is that women are assigned to unskilled and repetitive tasks, i.e. they are in jobs of low work complexity. For this reason, women have been excluded from certain analyses where the number of individuals in the cells is small, and where the interpretation entails risks of confusing sex effects with effects from the work content.

In both industries there are weak but inverse

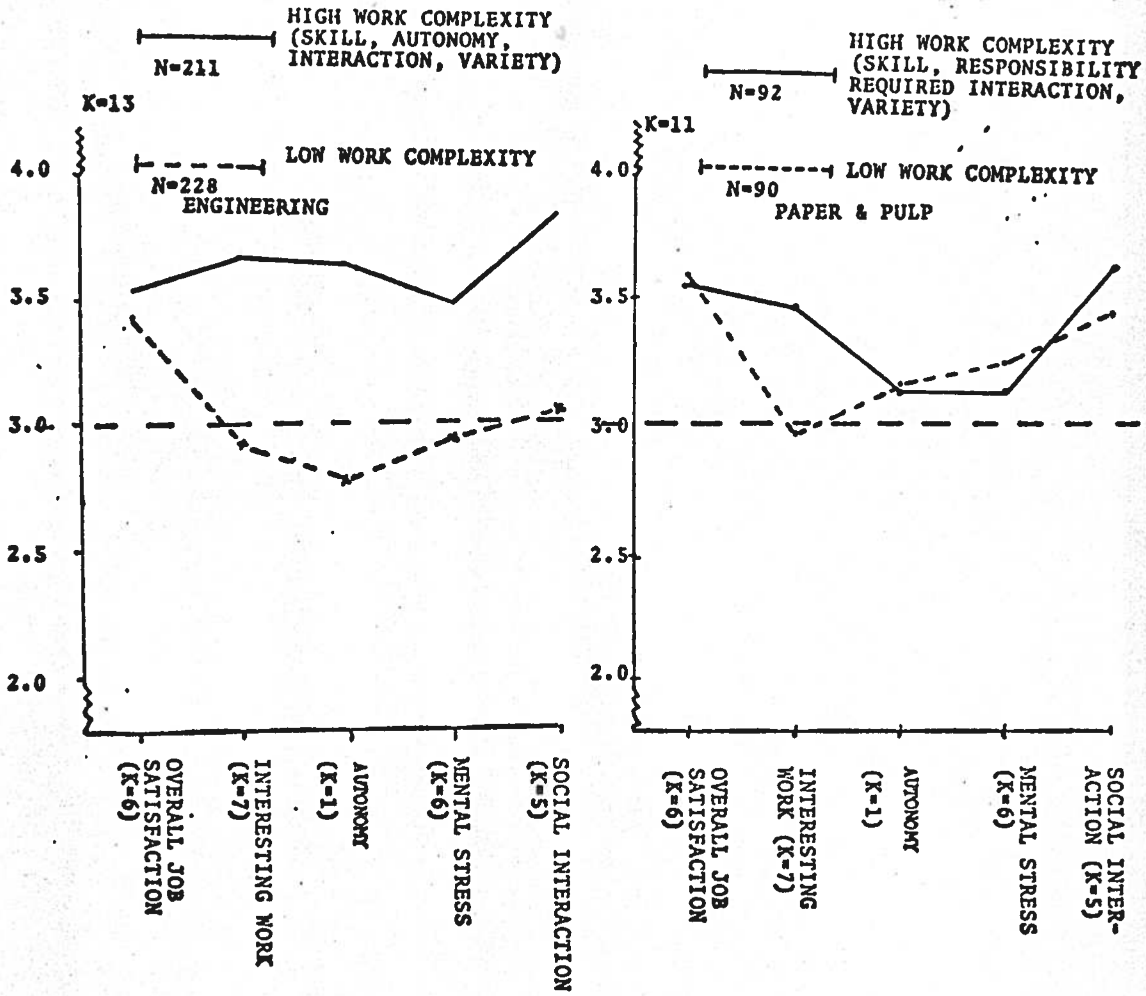


FIG. 16.2. Relation between job content (work complexity) and job satisfaction/work alienation.

correlations between income and work complexity. The tendency in engineering is for a larger proportion of high-income individuals to have jobs of low work complexity. That is, no doubt, because these jobs are paid for almost entirely out of piece-rates and as such offer opportunities for high earnings.

An opposite tendency holds for the pulp and paper industry, i.e. income and work complexity correlate positively.

Correlations between Work Complexity, Overall Job Satisfaction and Work Alienation

The figures will illustrate the relation between work complexity on the one hand and different dimensions in job-perception on the other.

In addition to work complexity (and certain subgroups of work complexity) the structural variables consist of income and method of wage payment. Income is based on the annual wage paid out in the year preceding the interviews. This variable has been divided into three groups: low, average and high income originating in the income distribution. Our aim here was to make the wage classes as equivalent as possible in size. The methods of wage payment are two: hourly rates and piece-rates. Piece-rates as applied in our engineering industries are exclusively based on straight individual or

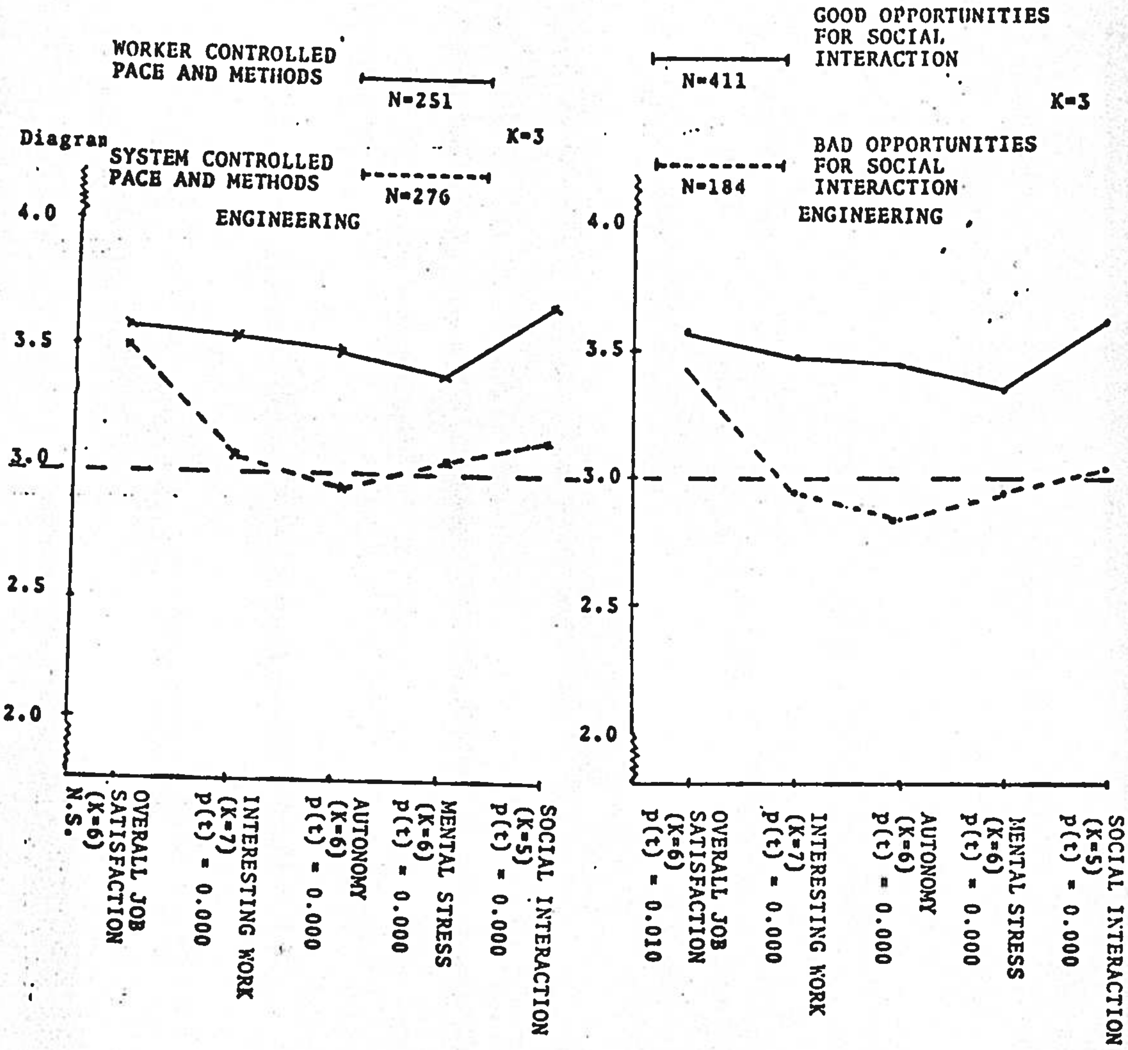


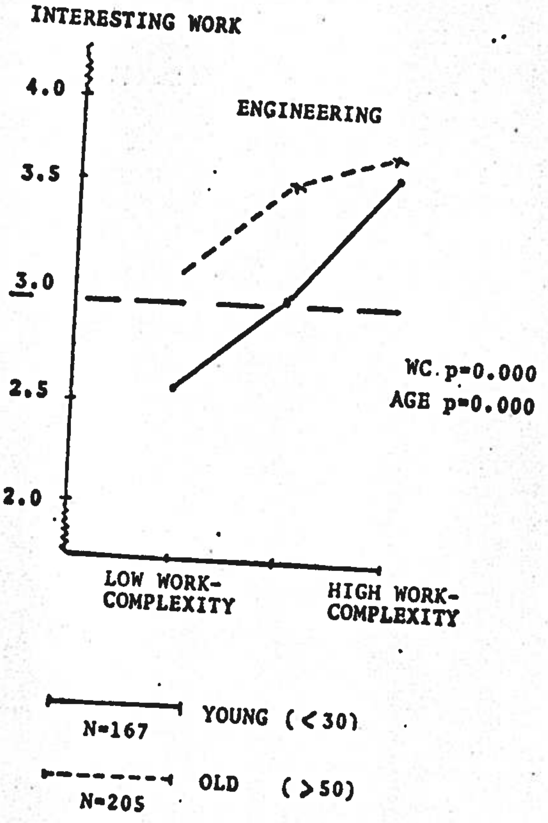
FIG. 16.3. Relation between job content (control over pace and methods, opportunities for social interaction) and job satisfaction/work alienation.

group plans, while the pulp and paper industries also make provision for mixed, individual and group plans. In as much as our data are limited and our principal interest attaches to freedom aspects of the wage payment method, we have elected to merge all types of piece-rates into a single category.

Figure 16.2 shows the relation between the general structural measure of work complexity and the different perception dimensions. We have taken out the extreme groups, high and low work complexity, in both industrial types and ticked off the mean on the five-point attitude scales for each group. The figure shows the following:

1. Perceptions of work as interesting, i.e. the variable we have used to measure the meaninglessness aspect of work alienation, varies with work complexity in both industries. Those who hold jobs characterized by low work complexity feel their work to be more monotonous and uninteresting.
2. Other alienation measures—autonomy, mental stress and social interaction—exhibit significant correlations with work complexity in the engineering industry only.[1]
3. The results from the pulp and paper industry show an ambivalence in the perception of work in that it betokens increased feelings of mental stress in the highly skilled jobs but at the same time increased involvement—freedom from feelings of monotony. In terms of psychological stress reactions, this ambivalence suggests that perceptions of work as involving and mentally strenuous may be experienced concurrently. This ambivalence in the perceptive dimensions does not show up in data from the engineering industry, where

[1] The index of 'autonomy', based on six items, was not developed when the studies at the pulp and paper industries were made. One item, 'control over work planning', was used at both industries and is therefore used in Figures 16·2a and 16·2b where comparisons are made between engineering and pulp and paper industries. This item has a loading of 0·65 in the factor of autonomy based on six items, and within the engineering industries the relation between work complexity and autonomy is practically identical for both measures of autonomy.



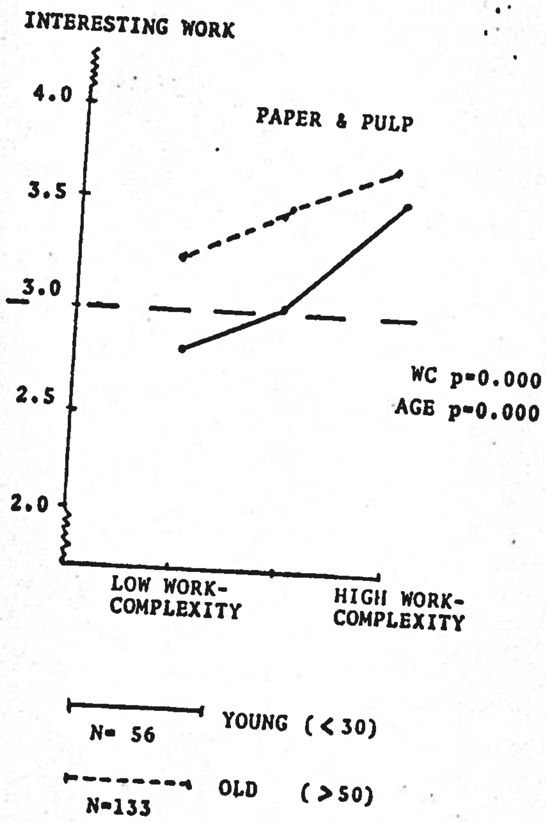


Fig. 16.4*a*. Relation between work complexity and work alienation (interesting work) with control for age.

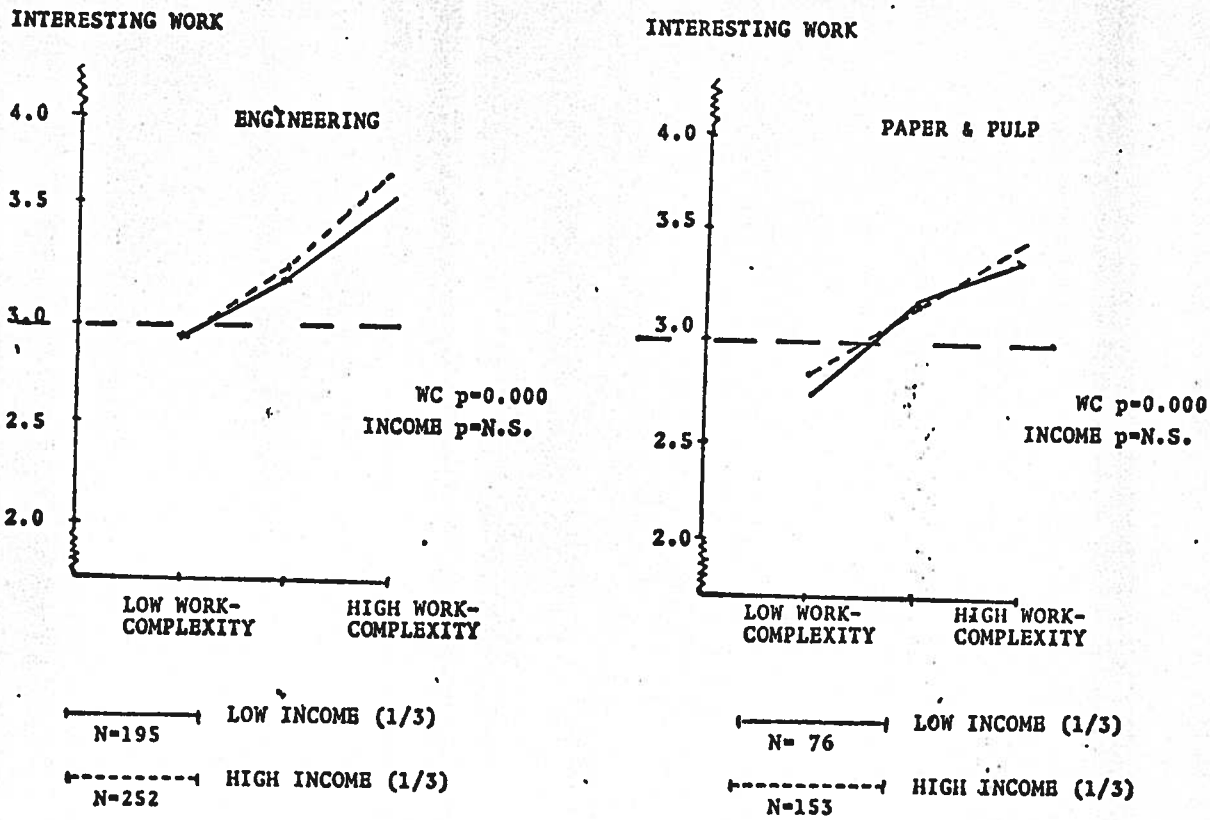


Fig. 16.4*b*. Relation between work complexity and work alienation (interesting work) with control for income.

the pattern instead is for involvement to covary throughout with freedom from feelings of stress.

4. The conventional measure—overall job satisfaction—does not correlate with work complexity in the pulp and paper industry, and only slightly so in the engineering industry. Here, we again call attention to the distinction between general job satisfaction and expressions for satisfaction of ego-relevant needs in work, where we noted that questions concerning general job satisfaction do not get at the psychologically central issue of meeting ego-relevant needs through work.

Figure 16.3 illustrates two factors that have emerged in the engineering industry, namely 'worker control over pace and methods' and 'opportunities for social interaction'. Both these measures consist of variables which we previously assigned to the freedom aspect of work design. For both these aspects of working conditions, the diagram demonstrates clear connexions with the different dimensions of work alienation. The corollary of greater freedom on the job is lesser alienation from work.

Correlation between Work Complexity and Work Alienation with Controls for Age, Income, Type of Supervision and Pay Satisfaction

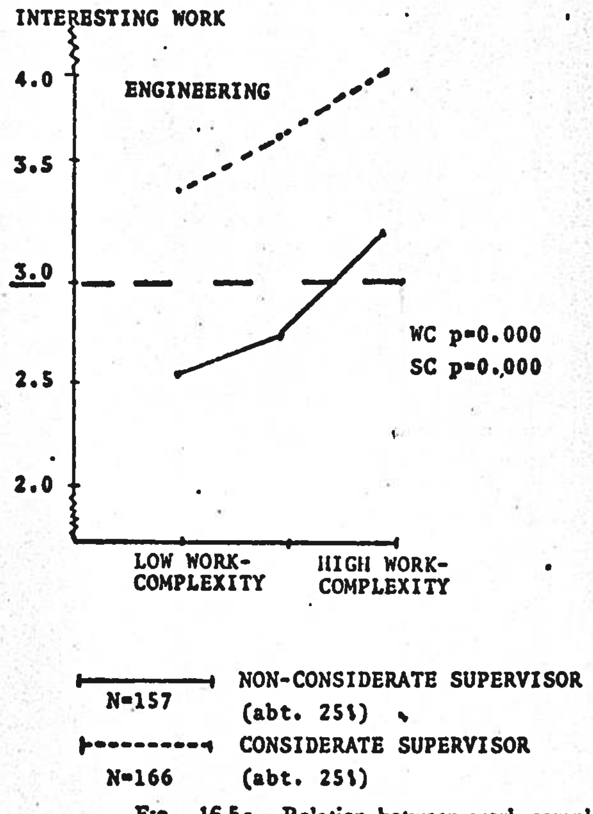
Figures 16.4 (*a* and *b*) and 16.5 (*a* and *b*) illustrate the connexion between work alienation (interesting work) and work complexity with controls for age, income, type of supervision and pay satisfaction. In Figure 16.6 (*a* and *b*) the same controls are used to show the connexion between work complexity and perceptions of freedom and control over work in the engineering industry. Figure 16.4*a* shows:

1. That the connexion between work complexity and the perception of work as interesting holds even after allowance is made for age and income.
2. That younger workers feel monotony to a greater extent than the older ones in jobs of low work complexity. A similar difference is observable for other degrees of work complexity, but tends to even out with increasing work complexity. This

may be interpreted to mean that younger persons have higher aspirations than older persons —partly because they have a better basic education—and that their disappointment at having ended up in unskilled and repetitive jobs manifests itself in stronger feelings of the work as meaningless and uninteresting. But if the younger workers are assigned to tasks which engage their resources to a greater extent and which are freer, the alienative attitudes strongly diminish. By means of one question put directly we sought to measure the instrumental attitude to work—i.e. the extent to which work is merely seen as a means for the satisfaction of needs away from the work place by contrast with being an end in itself. When we compare younger and older persons doing the same kind of work and entailing the same degree of work complexity, it turns out that 38 per cent of the younger and 66 per cent of the older in jobs of high work complexity exhibit an instrumental attitude to their work. This finding holds for the engineering industry. The corresponding proportions for pulp and paper come to 43 per cent and 57 per cent. A comparison of younger and older workers where both groups hold unfree and unskilled jobs—low work complexity—discloses that an instrumental attitude applies to 79 per cent of the younger and 71 per cent of the older workers in the engineering industry, and 92 per cent and 66 per cent in pulp and paper. This disappointment over unfree and unskilled jobs felt by members of the young generation may serve to explain e.g. why many well-paying large factories situated in areas of Sweden where labour is scarce can no longer recruit Swedish manpower for this type of work.

FIGURE 16.4*b* also shows:

3. That persons earning high and low incomes do not differ in their perception of work as interesting for any degree of work complexity. Naturally, this must not be interpreted to mean that income has no bearing on the attitude to work; what it does suggest, however, is that differences of income do not relevantly explain the differences of work alienation which arise for different degrees of freedom-qualification demands from work.



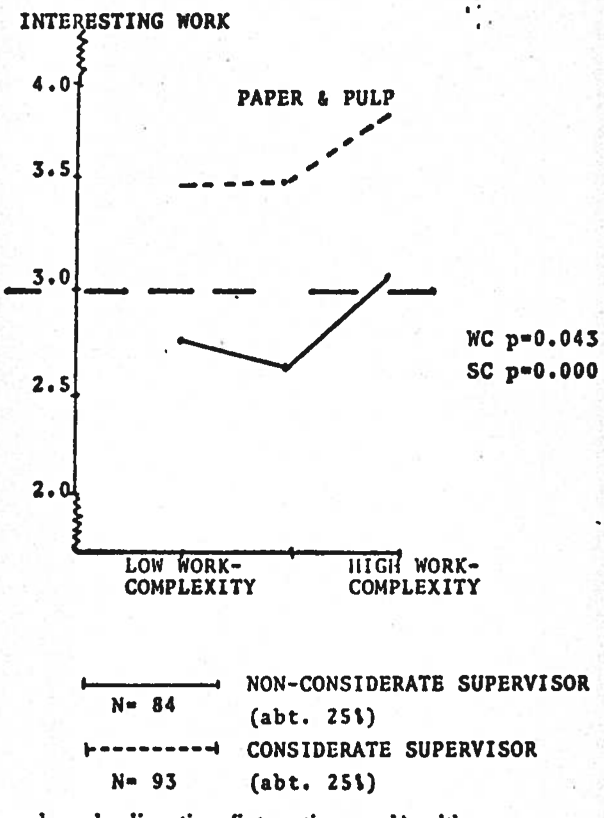


FIG. 16.5*a*. Relation between work complexity and work alienation (interesting work) with control for supervisory behaviour.

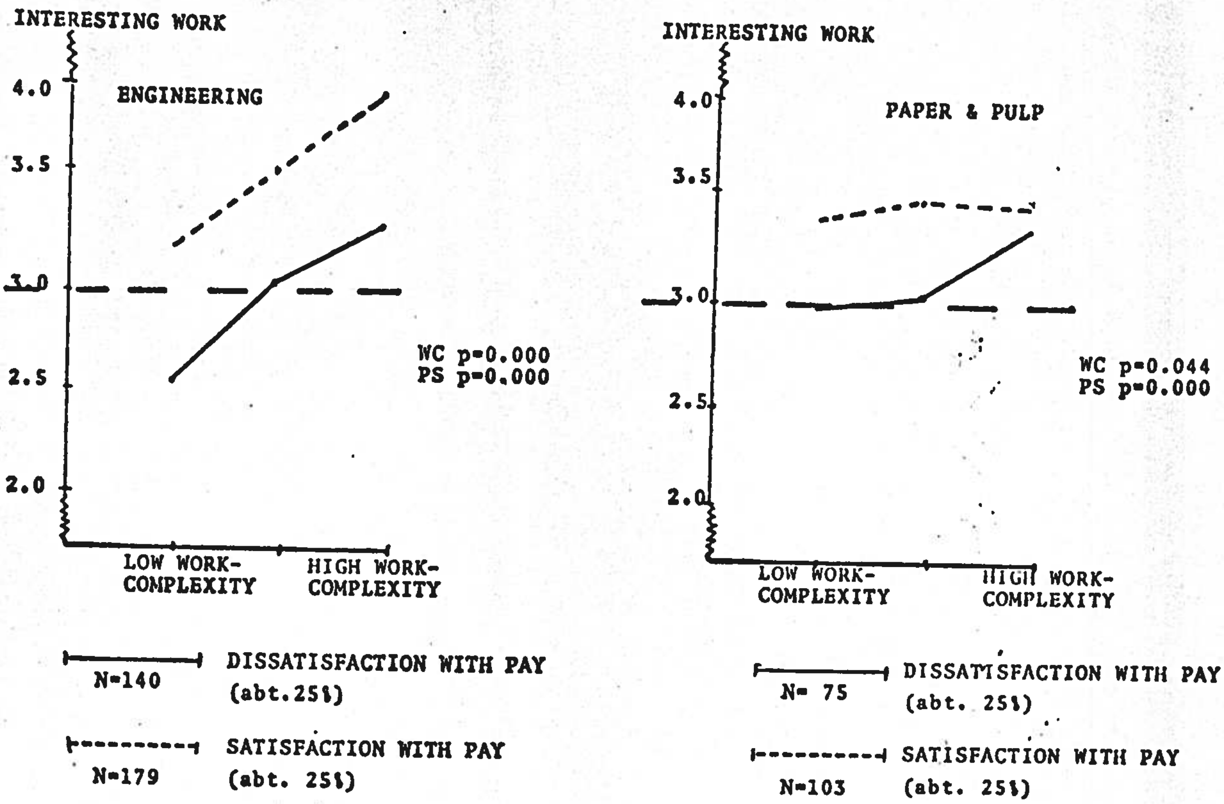


Fig. 16.5*b*. Relation between work complexity and work alienation (interesting work) with control for pay satisfaction.

Figure 16.5 (*a* and *b*) illustrates the connexion between work complexity and work alienation with controls for perception of personnel treatment by immediate superiors and satisfaction-dissatisfaction with earnings. By contrast with earlier control variables these are subjective variables, i.e. they build upon the individual's own perceptions. This fact complicates the interpretation of work alienation differences *between* the positive and negative extreme groups, but lacks relevance for interpreting the correlations *within* each extreme group. The extreme groups as regards attitudes to foremen and to pay satisfaction are defined by delimiting the distributions as closely as possible to the first and third quartiles. In other words, we have sought to identify the 25 per cent most positive and the 25 per cent most negative in the variables concerned. The variable called 'supervisor consideration' builds upon Fleishman's theories of consideration and initiating structure (Fleishman *et al.* 1955) as relevant descriptions of supervisory behaviour, and on the development of these theories and measuring methods by Lennerlöf (1968). The pay-satisfaction variable contains questions dealing with size and fairness of earnings, and has been devised within the framework of this study in accordance with the principles we have applied to other variable constructs.

The diagram delineates a relatively clear-cut picture for the engineering industry: the connexion between work complexity and work alienation persists after allowance is made for the individual's perceptions of his foreman and of his earnings. Between the extreme groups, however, considerable differences are observable for every degree of work complexity. What may be especially important to note is that the combination of low work complexity and dissatisfaction with immediate superior and with earnings is associated with strongly pronounced alienative attitudes. Work alienation is less marked when dissatisfaction with supervisor and earnings is combined with high work complexity. Be that as it may, differences of work alienation between the extreme groups are hazardous to interpret since they can be said to express the positive correlation between different attitude scales. Such a correlation can be seen as a methodological defect, as a sign of a general 'personality factor', or as indicating that the worker's perceptions of supervisor consideration and of his own earnings also bear crucially upon the question of work alienation. Since the concern of this study is with the connexion between technological structure and work alienation, we can ignore differences *between* the extreme groups and confine ourselves to the connexion between work complexity and work alienation *within* the positive and the negative extreme groups. That will suffice for our purpose, and is also the relationship to which we attach primary importance.

Even though it is tricky to interpret the differences of work alienation between the extreme groups, one fact deserves particular attention: the number of individuals in unfree and unskilled jobs (low work complexity) who perceive their supervisor to be inconsiderate is much larger (N=68) than the number performing the same kind of work who perceive their supervisor to be considerate (N=46). This suggests a correlation between kind of work and type of supervision which goes in the same direction that Woodward claimed to have found in her analyses of the connexion between technology and different organizational variables (Woodward, 1965). The previously mentioned study by Lennerlöf (1968) demonstrated a larger proportion of inconsiderate supervisors at establishments where the workers were engaged in monotonous and unskilled tasks. In Lennerlöf's study, ratings of supervisory behaviour were made by outside observers (psychologists) at one of the engineering plants which enter into our own study. Thus, if we interpret differences of work alienation between the extreme groups with reference to supervisor consideration to mean that the supervisor can compensate in his behaviour for the lack of freedom and the inadequate stimulation which characterize the work content (low work complexity), we must necessarily admit that the probability of obtaining supervisors with this behaviour is lowest for these particular jobs.

FIGURE 16.6 (*a* and *b*) illustrates the connexion between work complexity and the worker's personal control over his job and its performance within the engineering industry, with controls for age, income, perception of supervisor consideration, and satisfaction with earnings. This aspect of work

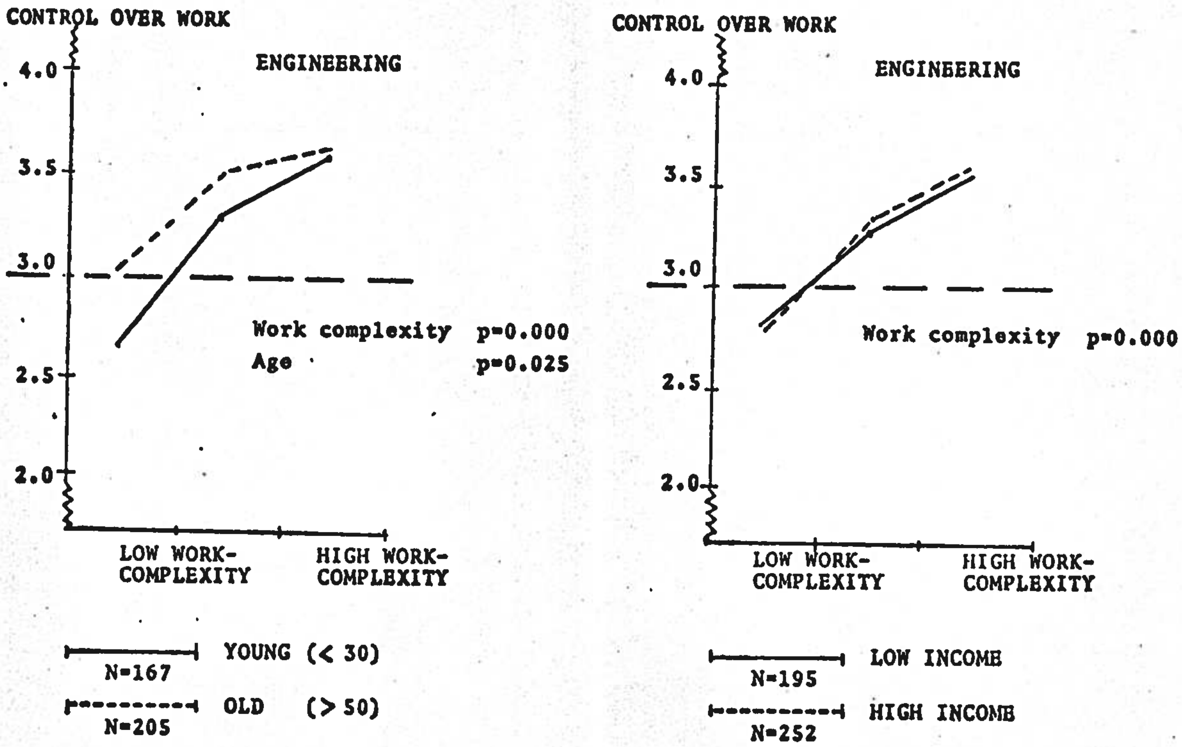


FIG. 16.6*a*. Relation between work complexity and work alienation (control over work) with control for age and income.

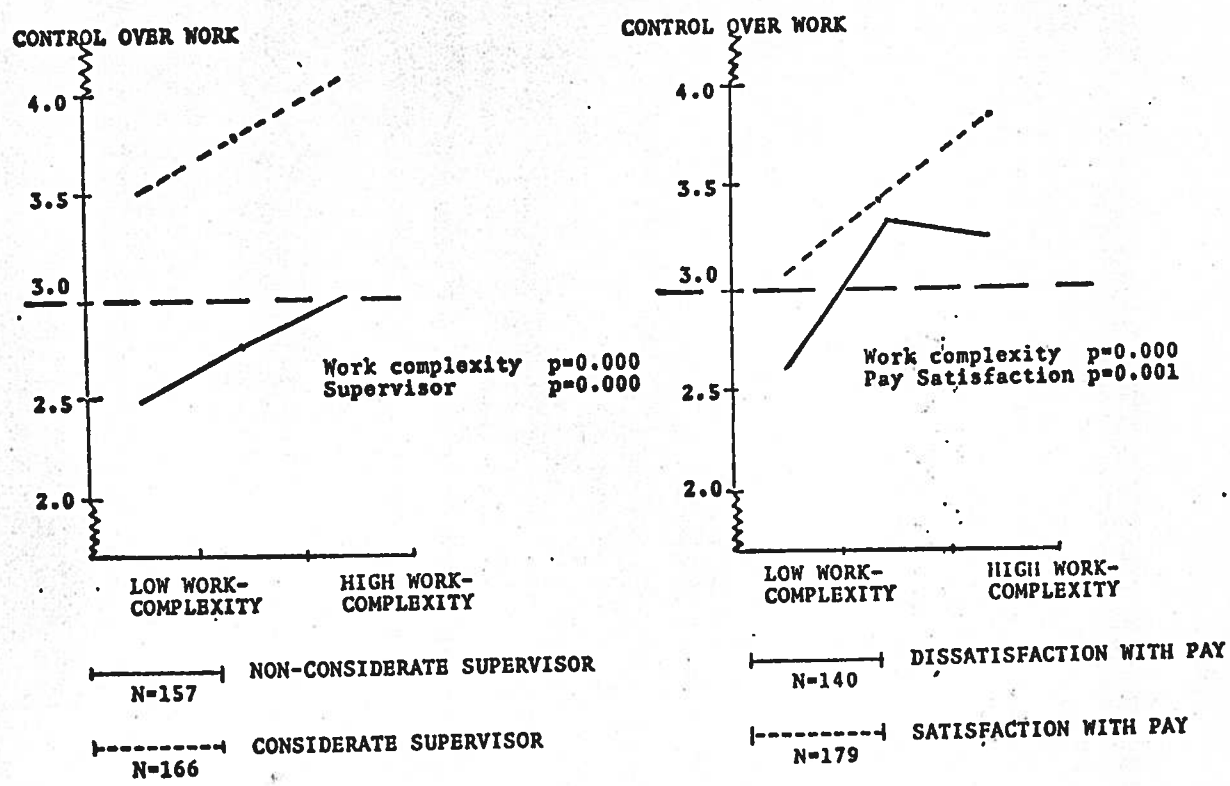


FIG. 16.6*b*. Relation between work complexity and work alienation (control over work) with control for supervisory behaviour and pay satisfaction.

alienation (powerlessness) exhibits an unambiguous correlation with the freedom and qualification aspects of work content even after allowance is made for the named control variables. Younger persons assigned to unfree and unskilled jobs show a pronounced feeling of powerlessness, which is also true of persons engaged in similar work who perceive their supervisor to be inconsiderate. Reference is made here to our earlier discussion concerning the perception of work as interesting, and here we should like to stress the similarity of correlations and interpretations [pp. 158 and 159].

Connexion between Freedom and Qualification Demands in Work and Different Criteria Relevant for Mental Health

Introductory Viewpoints

Our theoretical model builds upon a basic assumption, namely that the conditions of freedom, and the qualification demands which follow from the technological structure and the work design bear upon the ability to satisfy ego-relevant needs from work. This satisfaction of needs is reflected not only in the different aspects of freedom-alienation which we touched upon earlier, but also in the more general emotional states which we have considered relevant for mental health. We have already discussed the theoretical content of our mental-health concept as well as the value-based postulates, and also specified the criteria we thought of interest for studying the impact of the working environment on the individual's experiences. In that connexion, we stressed that we are dealing with a superficial layer of personality, that we are not talking about 'disorder' or 'health' in the clinical sense, but that we are working only with average values for groups who differ from one another with reference to sociotechnical and economic conditions of work, and that individual reactions cannot be regarded as 'attributes' which can be explained on the basis of psychological-biological models or theories about personality-governed perception. The variables we shall be using here have to do with the individual's feelings about himself, especially feelings of competence in a broader and more abstract sense than in relation to present occupation alone, as well as his feelings of prestige in his immediate surroundings. Further, we have considered these self-concept aspects to be salient to the broader concept of mental health. We have sought to enlarge the concepts of job satisfaction and work alienation so as to impart added weight to the discussion of the psychological and sociological effects that working environment and work design have on the human organism. We have demonstrated in earlier works (Gardell and Westlander, 1968; Gardell, 1969) that these variables are also related to conventional clinical variables pertaining to stress symptoms and psychosomatic symptoms. To augment our own variables pertaining to self-esteem and general life satisfaction, we therefore draw upon two clinical variables derived from self-ratings (Lidvall and Jonsson, 1964). As an aggregate concept for these five variables we shall employ the term 'mental health' in this text. In other words, 'mental health' will refer for present purposes to these five variables alone and to no others.

We shall be using our 'mental health' variables in three different ways. In this section we take up the question of the direct connexion between freedom-qualification aspects of work and 'mental health'. This will be done by relating the work-complexity variable (and some of the factors subsumed under this variable) and income to the different mental health variables. The sociotechnical conditions of work and income are regarded as independent variables and mental health as a dependent variable. In a second section we shall relate work alienation to mental health where work alienation is regarded as the independent variable and mental health as dependent. In a third section, which ties in directly with our theoretical model, we shall relate the conditions of work to mental health, with work alienation as intervening variable.

Connexion between Work Content and Mental Health

FIGURE 16.7 (*a* and *b*) illustrates the mean differences in the mental health variables for groups with low and high work complexity in the engineering

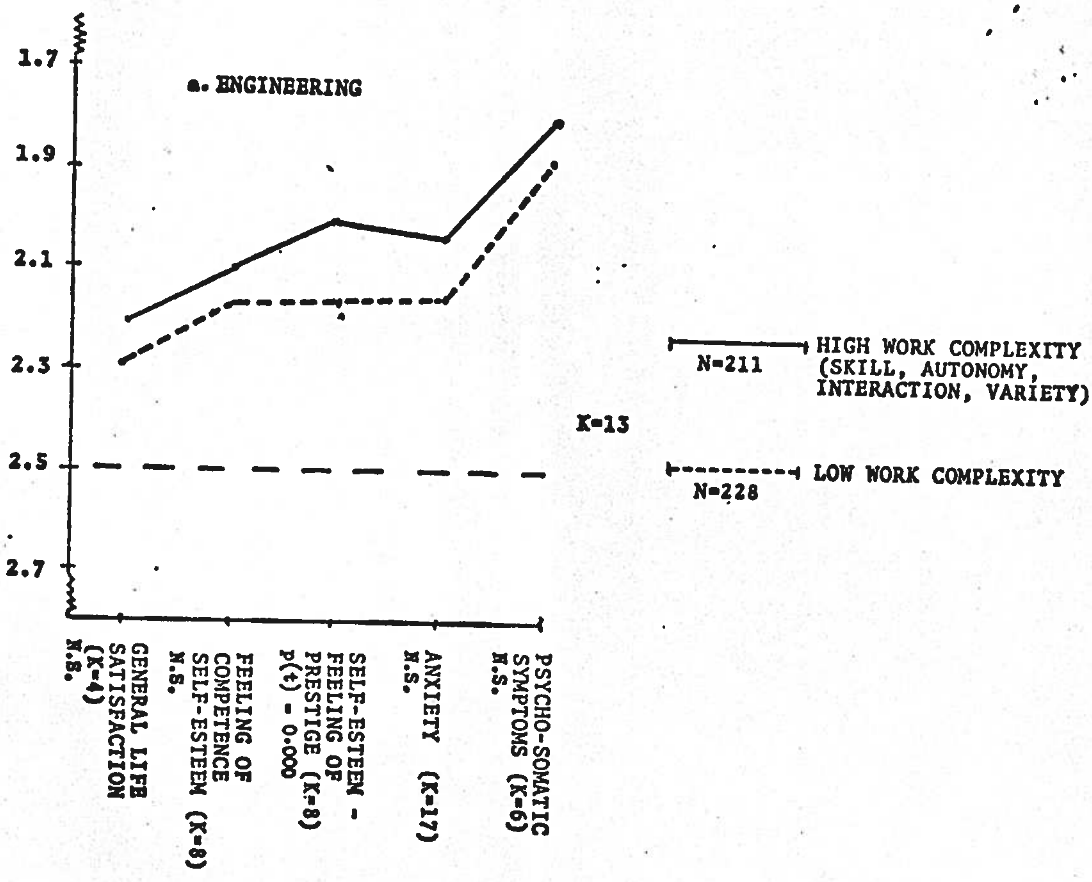


FIG. 16.7*a*. Relation between work complexity and mental health.

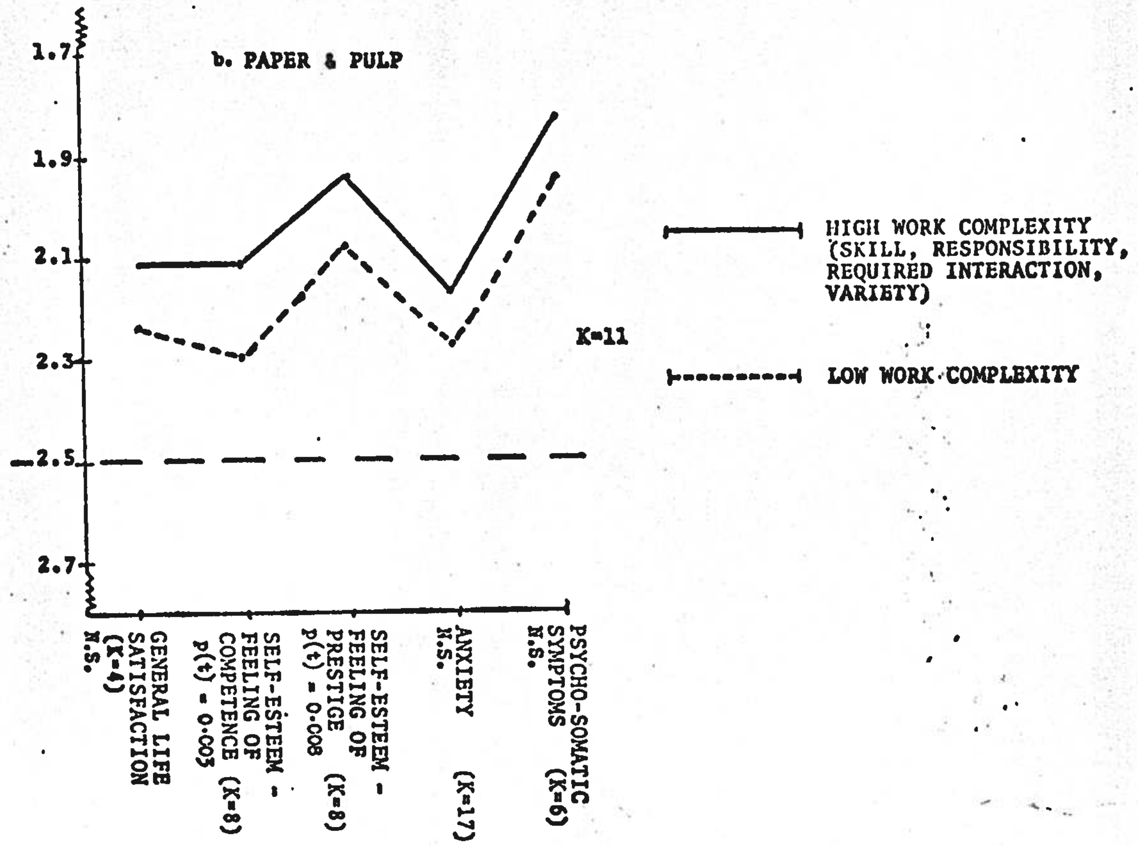


FIG. 16.7*b*. Relation between work complexity and mental health.

and pulp and paper industries. In both industries there is a weak but consistent tendency towards higher mental health for those individuals who have jobs marked by freer working conditions and more complex tasks. The aspect of self-esteem which describes the feeling of prestige exhibits significant differences in both industries. A significant difference also holds in the pulp and paper industry for that aspect of self-esteem which describes the feeling of competence. For the rest, the differences are insignificant.

FIGURE 16.8 shows the differences of mental health between high-income and low-income groups in terms of the definitions given earlier [p. 157]. Here, there is a consistent tendency towards higher mental health in those groups which earn the highest incomes within the respective population. For both industries significant differences arise in those variables which have been derived from the clinical questionnaire, i.e. tendencies towards anxiety and psychosomatic syndromes are somewhat more pronounced among the low-income groups. In addition, the pulp and paper industry discloses strongly significant differences between the income groups in those variables which describe self-esteem and general life satisfaction.

FIGURE 16.9 and TABLE 16.1 show differences of mental health between groups that have been identified by combining the work complexity and income variables. The most distinct differences emerge when we combine the two theoretically most favourable conditions of work (high work complexity and high income) and juxtapose this group with the one which combines the two theoretically least favourable conditions. This has been done in FIGURE 16.9, which accordingly discloses considerably lower values on all mental health variables for persons engaged in unfree and unskilled jobs with their concomitant of low income.

In FIGURE 16.10 yet another structural variable, method of wage payment, has been combined with the others. In so doing, we have regarded piece-rates as a further restraint on free-working condi-

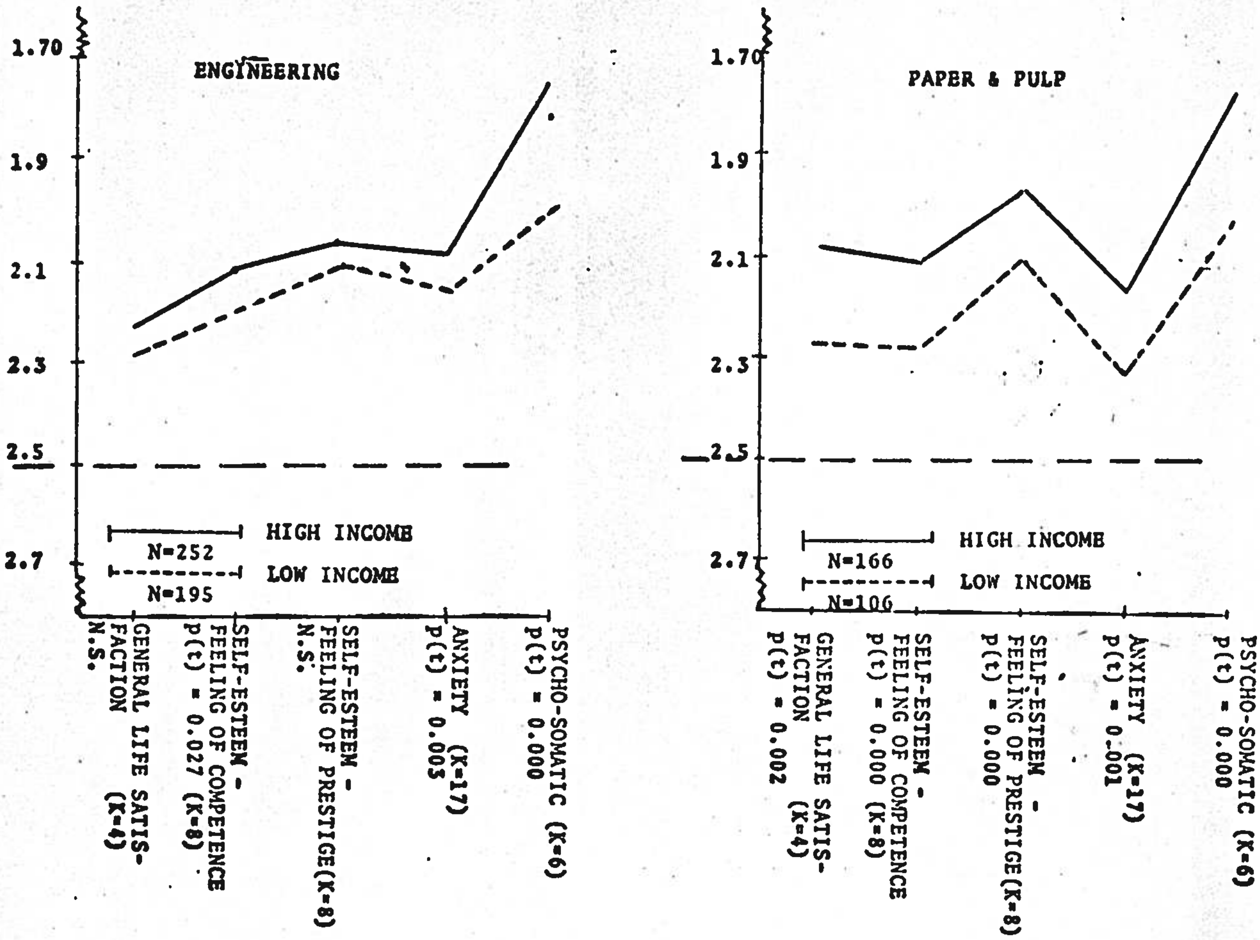


Fig. 16.8. Relation between income and mental health.

TABLE 16.1

RELATION BETWEEN WORK COMPLEXITY—INCOME AND MENTAL HEALTH

WORK COMPLEXITY	GENERAL LIFE SATISFACTION (K = 4)		SELF-ESTEEM—FEELING OF COMPETENCE (K = 8)		SELF-ESTEEM—FEELING OF PRESTIGE (K = 8)		ANXIETY (K = 17)	
	Engineering	Paper and Pulp	Engineering	Paper and Pulp	Engineering	Paper and Pulp	Engineering	Paper and Pulp
Low work complexity Low income	2.38	2.35	2.33	2.40	2.32	2.11	2.32	2.40
Low work complexity High income	2.26	2.16	2.11	2.05	2.14	2.06	2.06	2.23
High work complexity Low income	2.15	2.27	2.13	2.18	2.01	2.00	2.13	2.17
High work complexity High income	2.21	2.06	2.05	2.10	1.97	1.92	2.08	2.15

4-point scale: high values = low mental health

All values within the positive end of the scale

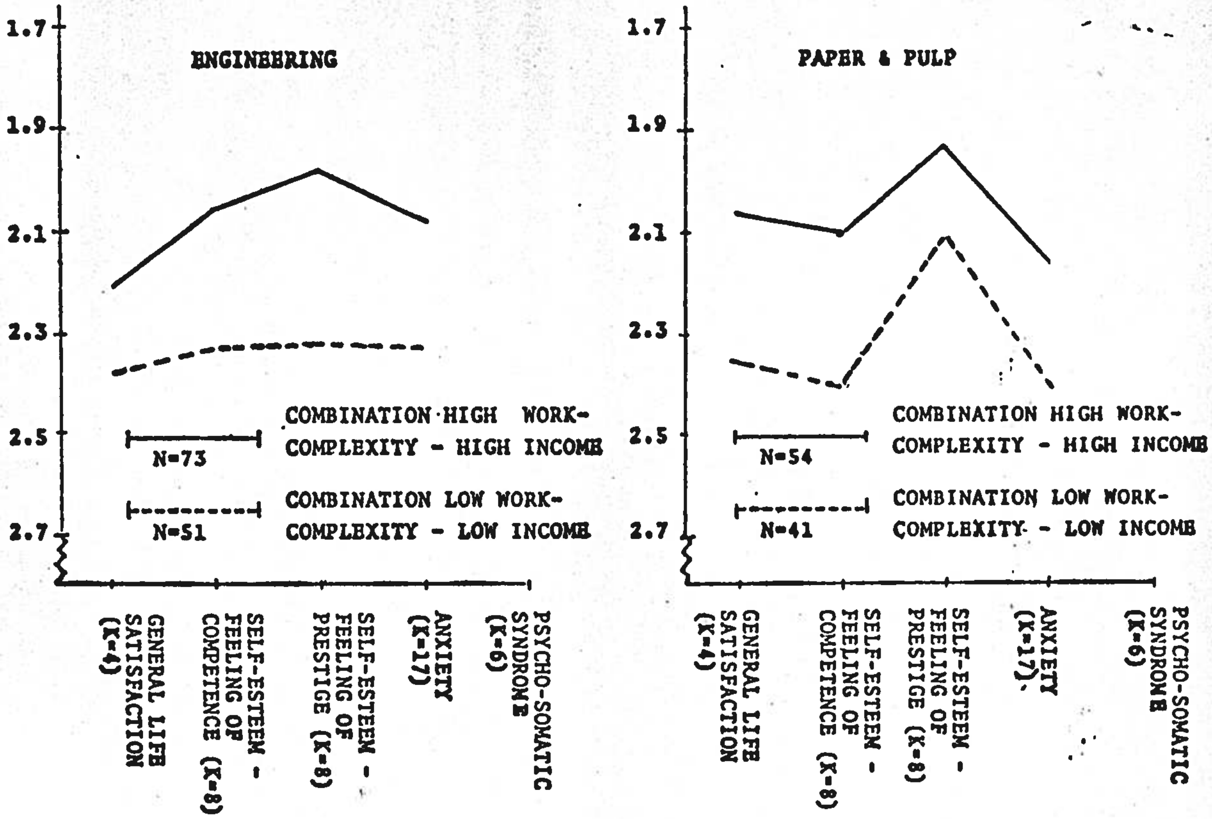


Fig. 16.9. Relation between work complexity—income and mental health.

tions. Accordingly, we have combined piece-rates with low income and low skill requirements and compared this group with the theoretically favourable combination of hourly rates, high income and high skill requirements. The diagram shows that persons paid by the piece in combination with low income and unskilled tasks exhibit much poorer mental health across all the variables we consider to be relevant criteria in this context.

Connexion between Work Alienation and Mental Health.

The variables pertaining to work alienation are here regarded as independent and the criteria of mental health as dependent, this in accordance with that part of our model which says that the degree of satisfaction of ego-relevant needs from work correlates positively with the individual's mental health. The work-alienation variables have been classified with the closest possible adherence to the five-point response alternatives that enter into the different questions. This gave us three classes in terms of point gradations:

I 1·0–2·5 = perception of monotonous work; high mental stress, low freedom and control

II 2·6–3·5 = in between

III 3·6–5·0 = perception of interesting work; low mental stress, high freedom and control

The mean of the different mental health variables has been estimated for each class, and the differences between means have been tested for significance in the usual manner.

The individuals who comprise each class will vary in number with this method according to the particular variable involved and the type of industry. Table 16.2 enumerates the individuals who enter into the different classes. The use of this classification gives us an average of about one-fifth who have expressed strong work alienation. However, curtailed freedom and constraints are strongly felt by only 10 per cent of the pulp and paper employees. Be that as it may, we believe that pronounced work alienation also characterizes the in-

TABLE 16.2

NUMBER OF PEOPLE IN GROUPS WITH DIFFERENT DEGREES OF WORK ALIENATION

	INTERESTING WORK				FREEDOM AND CONTROL IN WORK				MENTAL STRESS				SOCIAL INTERACTION			
	P & P		E		P & P		E		P & P		E		P & P		E	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
I	96	23	98	16	46	11	127	20	75	18	120	19	39	9	81	13
II	179	43	293	47	184	44	246	39	203	49	294	47	193	47	287	45
III	139	34	236	37	184	44	254	41	136	33	213	34	182	44	265	42

Interesting work: I = Perceives present work monotonous; II = In between; III = Perceives present work interesting

Freedom and control in work: I = Perceives low freedom and control in present work; II = In between; III = Perceives high freedom and control in present work

Mental stress: I = Perceives high mental stress in present work; II = In between; III = Perceives low mental stress in present work

Social interaction: I = Perceives social isolation in present work; II = In between; III = Perceives freedom for social interaction in present work

P & P=Paper and pulp; E=Engineering

between group since the class limit lies between 2·6 and 3·5 points. Expressed freedom from feelings of powerlessness and meaninglessness may be said to apply only to group III, i.e. for an average of one-third of the studied groups. Certain interindustry variations are observable as well as between the alienation variables, but these are relatively moderate. As we had occasion to note earlier, it is the differences between groups within each industry which concern us more. We shall later [p. 168] call attention to some interindustry differences, but not until we have first identified certain clearly delimited groups who can be said to typify the kind of production in question.

The connexion between different aspects of work alienation and mental health is shown in FIGURES 16.11 to 16.14 (*a* and *b*), where it is expressed as differences of means in the mental health variables between groups having different degrees of work alienation. For all aspects of work alienation, there are significant positive correlations in both industries as regards self-esteem and emotional rewards from life in general. The greater the freedom from alienation, the higher is one's self-esteem and the more pronounced is one's emotional satisfaction with life as a whole. Although a positive correlation also holds with reference to the clinically oriented variable, this is as a rule significant only for the population of the engineering industry. Another significant correlation, this one in the pulp and paper industry, is between mental stress and anxiety, i.e. the stronger the feeling of mental stress on the job, the more anxiety is expressed. These findings are interpreted to confirm our theory of a transplantation from ego-relevant satisfactions at work to more general feelings of self-esteem and life adjustment. We are well aware that other interpretations are admissible, but lack of space prevents us from considering them in this paper.

Connexion between Work Content—Work Alienation and Mental Health

Outlined on page 173 [FIGURE 16.15] is a model where the relation between work content and mental health is regarded with the perception of work as an intervening variable. In other words, we assume that the difference of ego-relevant satisfaction of needs from work affects the relation between work content and mental health in an important way. As we see it, these differences of needs satisfaction derived from the same type of work, are not a question of biological differences in the structure of needs or personality between different individuals, but rather a question of differences in aspirations and norms acquired by the individual during the course of his upbringing

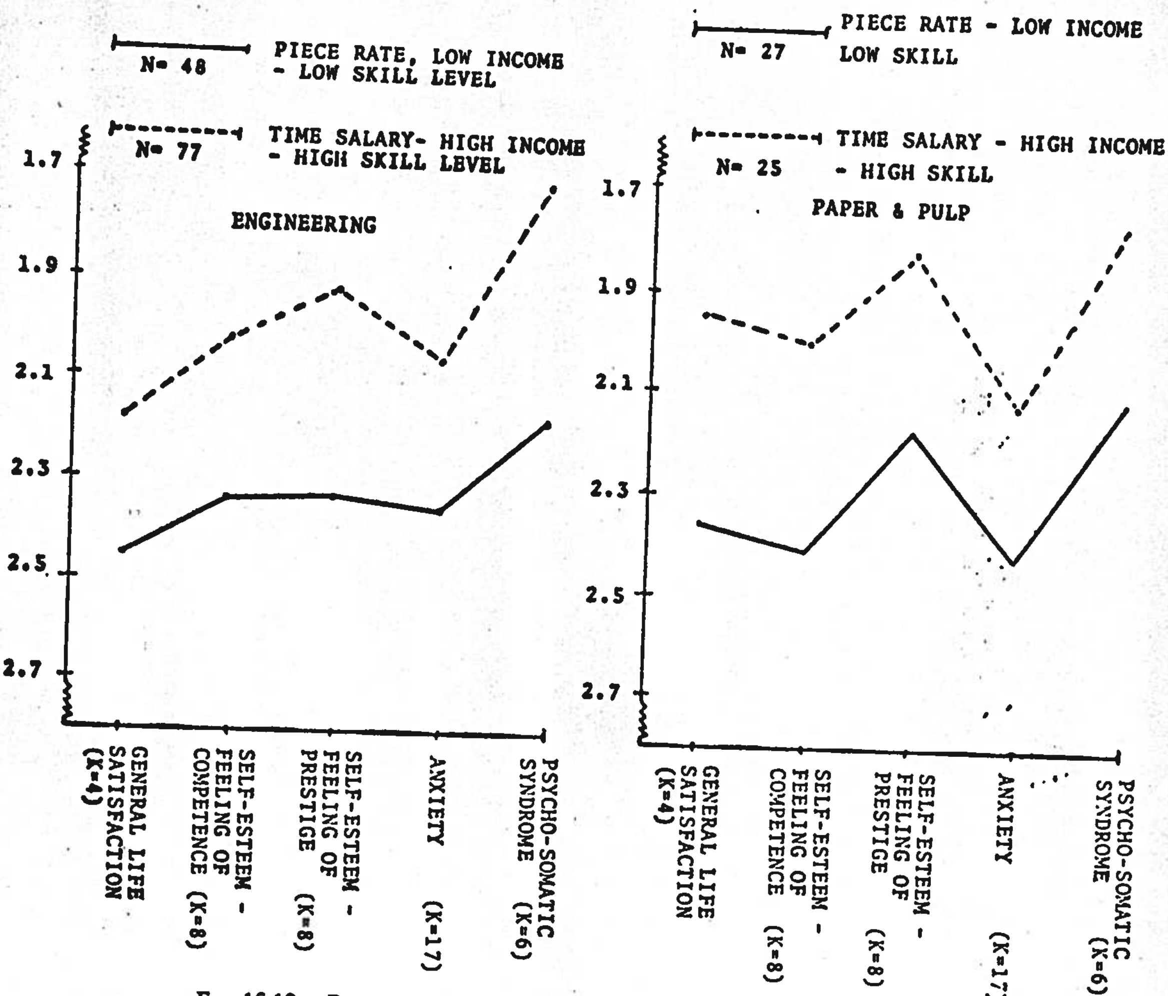


Fig. 16.10. Pay system, income and skill level in relation to mental health.

and/or diverse experiences of the job world. These differences of aspirations are bound up with such factors as age, social and economic background, sex, education and nationality. The group here under study is very homogeneous in terms of education: 82 per cent in pulp and paper and 93 per cent in engineering did not go beyond elementary school. The pulp and paper industry employs no foreign labour, while the population of the engineering industry includes 9 per cent of foreign origin, but these persons have been naturalized Swedes for many years. Both samples contain about 10 per cent of women, but they have been excluded from these analyses in order to eliminate the influences of sex-determined aspiration levels on the relations between work content and mental health that we wish to study here. Sexual differences of work perception and absenteeism are discussed in a separate study, where we have also obtained instruments to permit comparisons of men and women pursuing similar work (Gardell, Baneryd *et al.* 1968). The age effects have been kept under control by studying the connexions within each group separately.

The results so far produced are presented in Figures 16.16 and 16.17. What Figure 16.16 reveals *first of all* is that a larger proportion of individuals in the group performing tasks of low work complexity feel their work to be monotonous, while a larger proportion of the group performing tasks of high work complexity perceives its work to be interesting. This finding stands out with special clarity for the engineering industry. In pulp and paper the work is felt to be monotonous and interesting by roughly equal proportions. This fact must be continually borne in mind, and, as we have

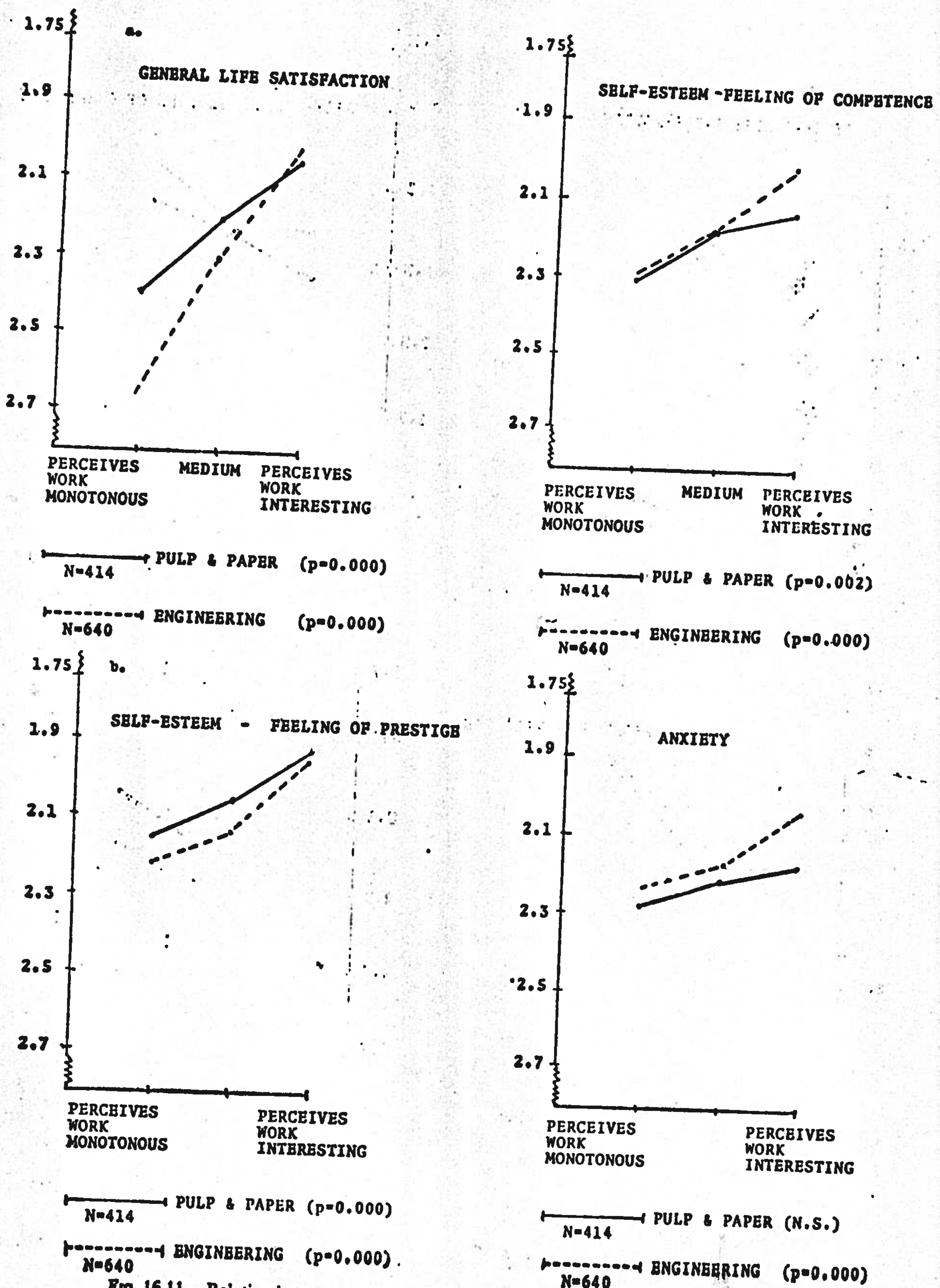


FIG. 16.11. Relation between work alienation (interesting work) and mental health.

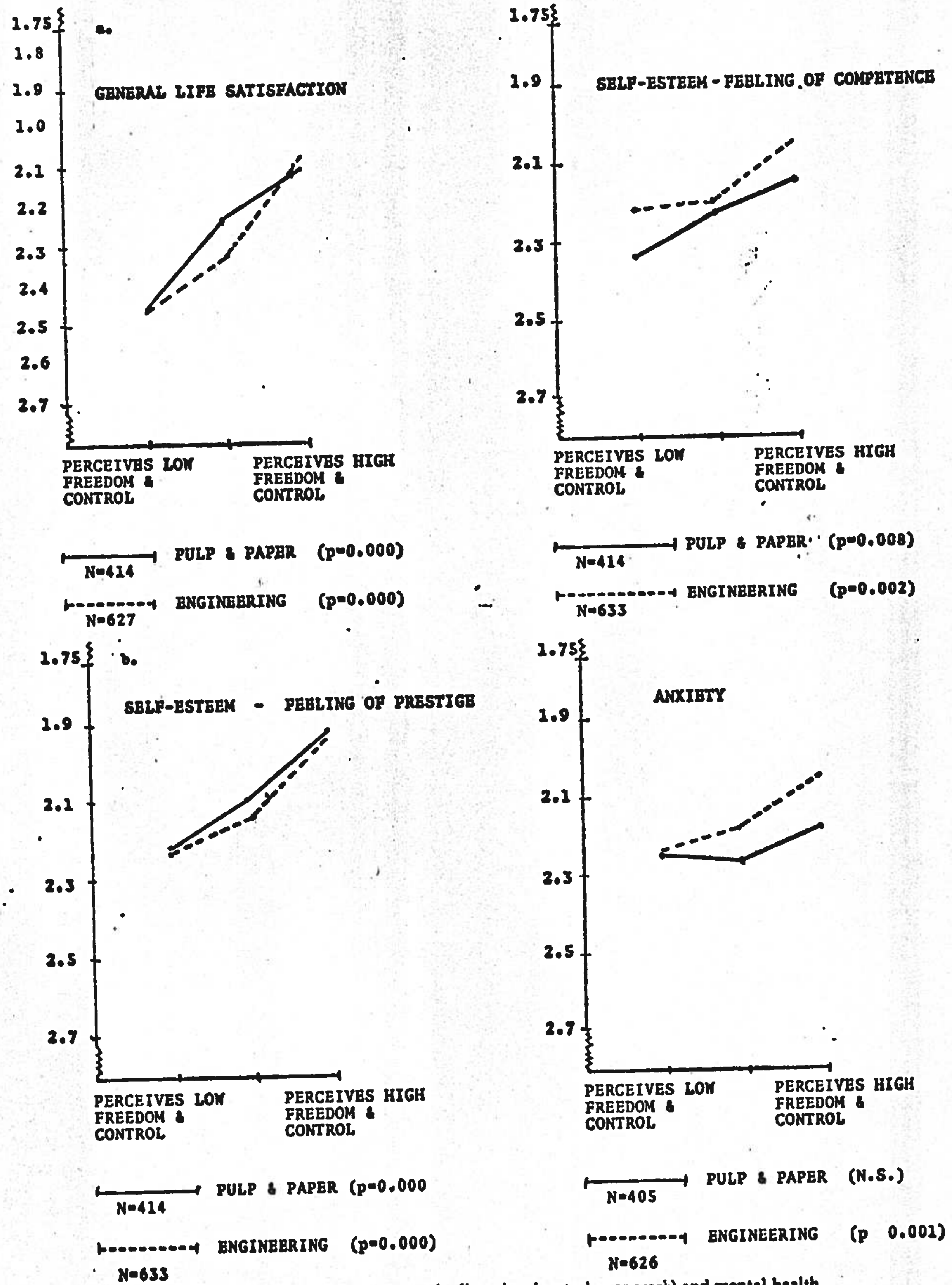


FIG. 16.12. Relation between work alienation (control over work) and mental health.

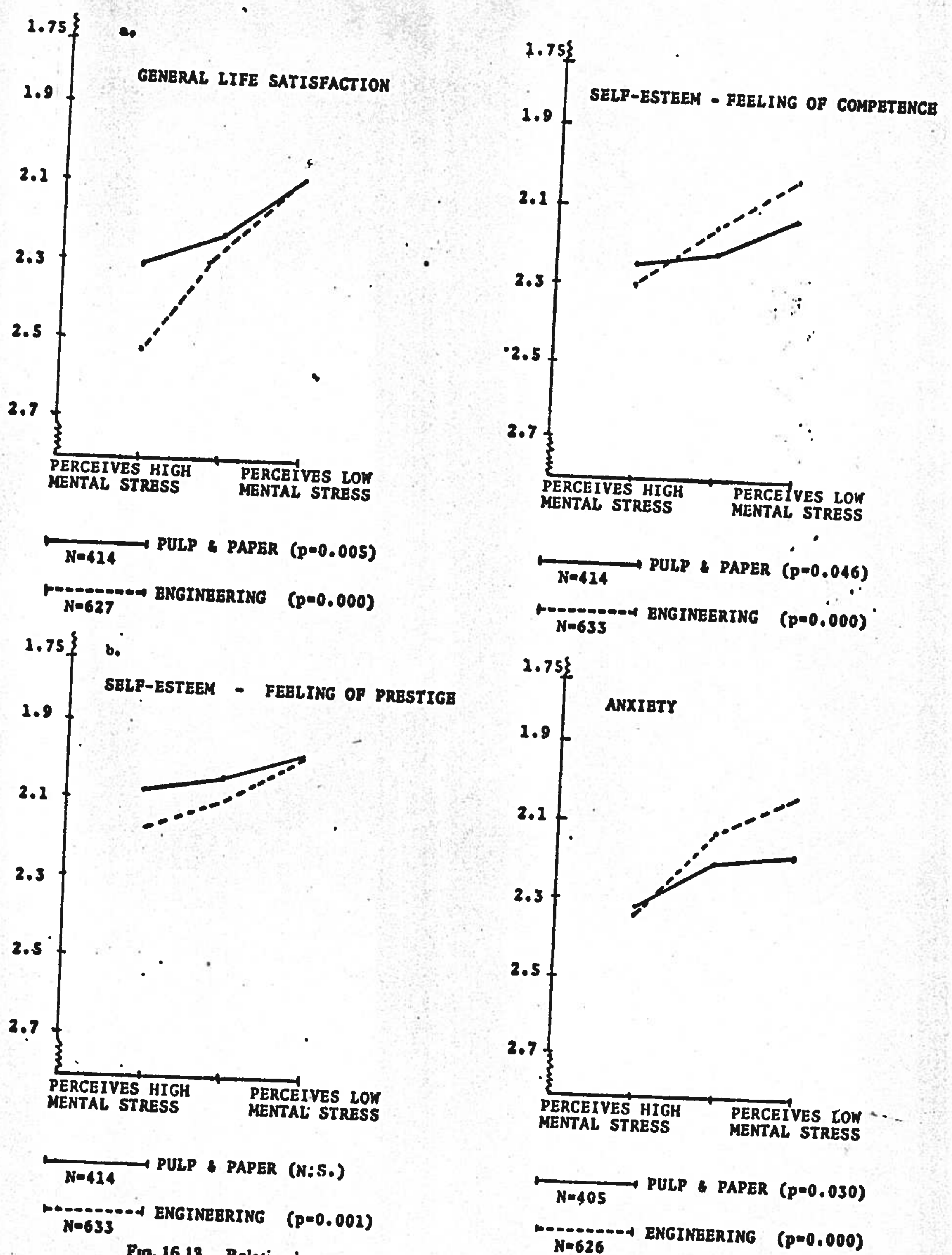


FIG. 16.13. Relation between work alienation (mental stress) and mental health.

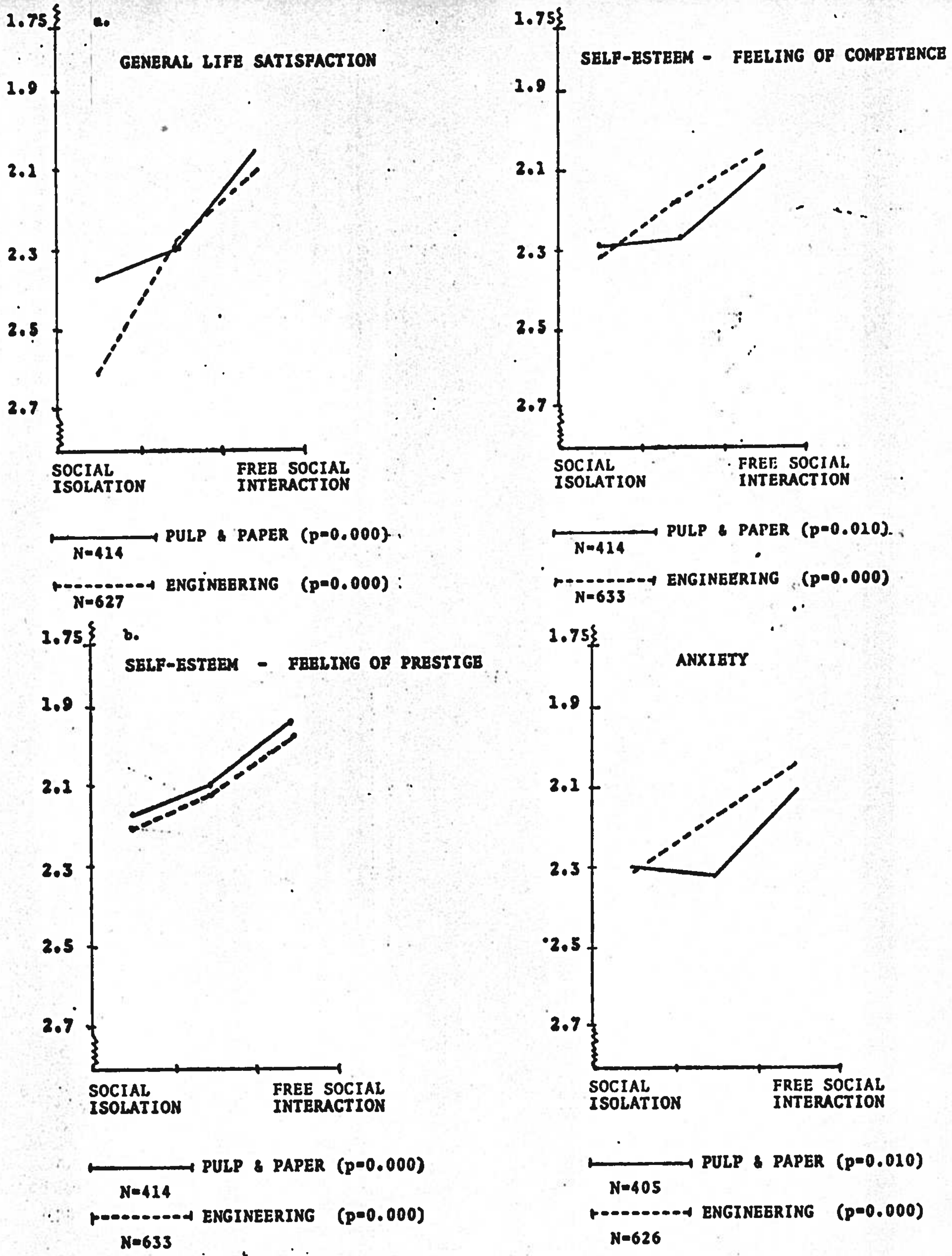


FIG. 16.14. Relation between work alienation (social interaction) and mental health.

already shown earlier, the relations between work complexity and work alienation are particularly distinct in the engineering industry.

Secondly, and this is important, the diagram shows that differences of work alienation for the same type of work content are accompanied by differences of mental health for all variables in both the engineering and pulp and paper industries. The differences are significant for all variables in the engineering industry but only for the variables of general life satisfaction and self-esteem–feeling of prestige in pulp and paper. This finding holds, irrespective of whether it is based on jobs of low or high work complexity, and it is equally valid for younger and older workers [Figure 16.17]. *Thirdly*, the diagram shows no differences in the mental health variables between individuals in jobs of varying complexity after allowance is made for the perception of ego-relevant needs satisfaction. From this the most reasonable conclusion to draw seems to be that the significance of work content for the individual's mental health is influenced by his level of aspirations and the satisfaction with work derived therefrom. If this level is low for some reason, it is manifested both in less pronounced work alienation and higher mental health.

The import of this finding—put in a perspective of practical policy–seems open to debate. In the first place, it must be remembered that a relatively small part of the total group engaged in unfree and unskilled jobs perceive their work to be interesting. Most people in these jobs feel their work to be uninteresting and non-involving, and they also hold a pronounced instrumental attitude to it [see Figure

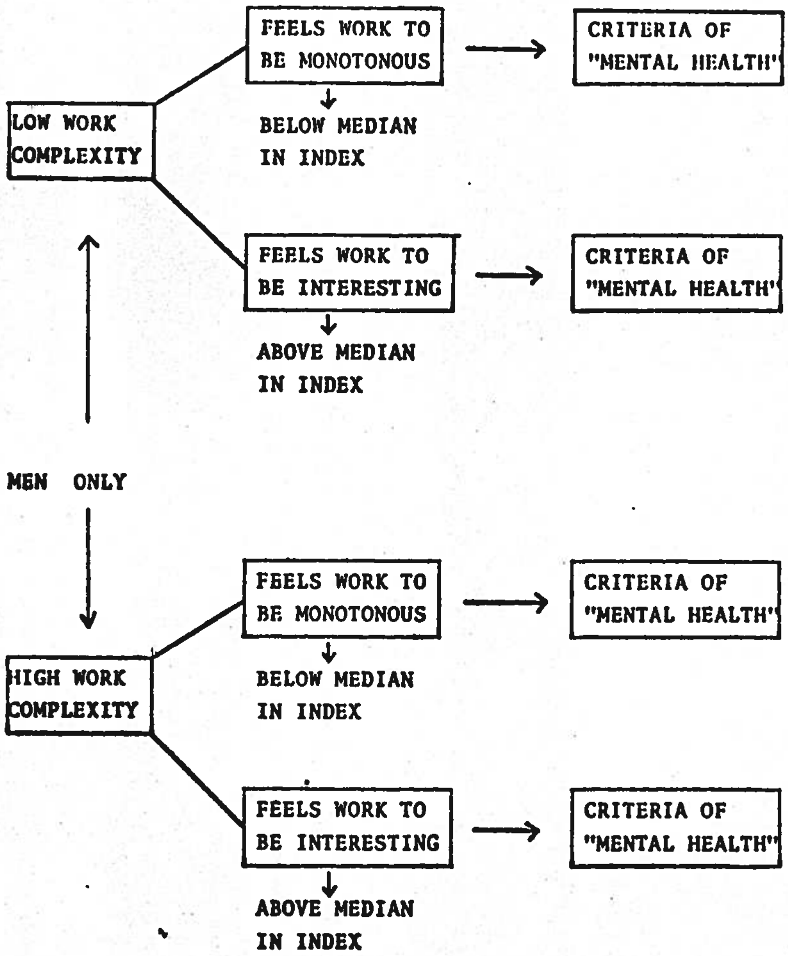


Fig. 16.15. Relation between work content and mental health with perception of work as an intervening variable.

16.2 and pp. 162 and 163]. As we demonstrated earlier, there is a direct connexion between mental health and the sociotechnical and economic conditions of work, which becomes especially conspicuous when we combine the freedom and qualification aspects of work with income and method of wage payment [FIGURES 16.9 and 16.10]. In the second place, it is extremely doubtful on grounds of democratic values, whether work satisfaction, self-esteem and general life satisfaction should be upheld for large groups by lowering their level of aspirations. To accept such an argument is to encourage a conservatism that does not challenge the fairness of prevailing notions in organization theory and rationalization philosophy. In its ultimate consequence that implies an acceptance in principle of the structure of society and the job world, regardless of how it is constituted. The values which underlie this study make us more inclined not to accept low aspirations and resigna-

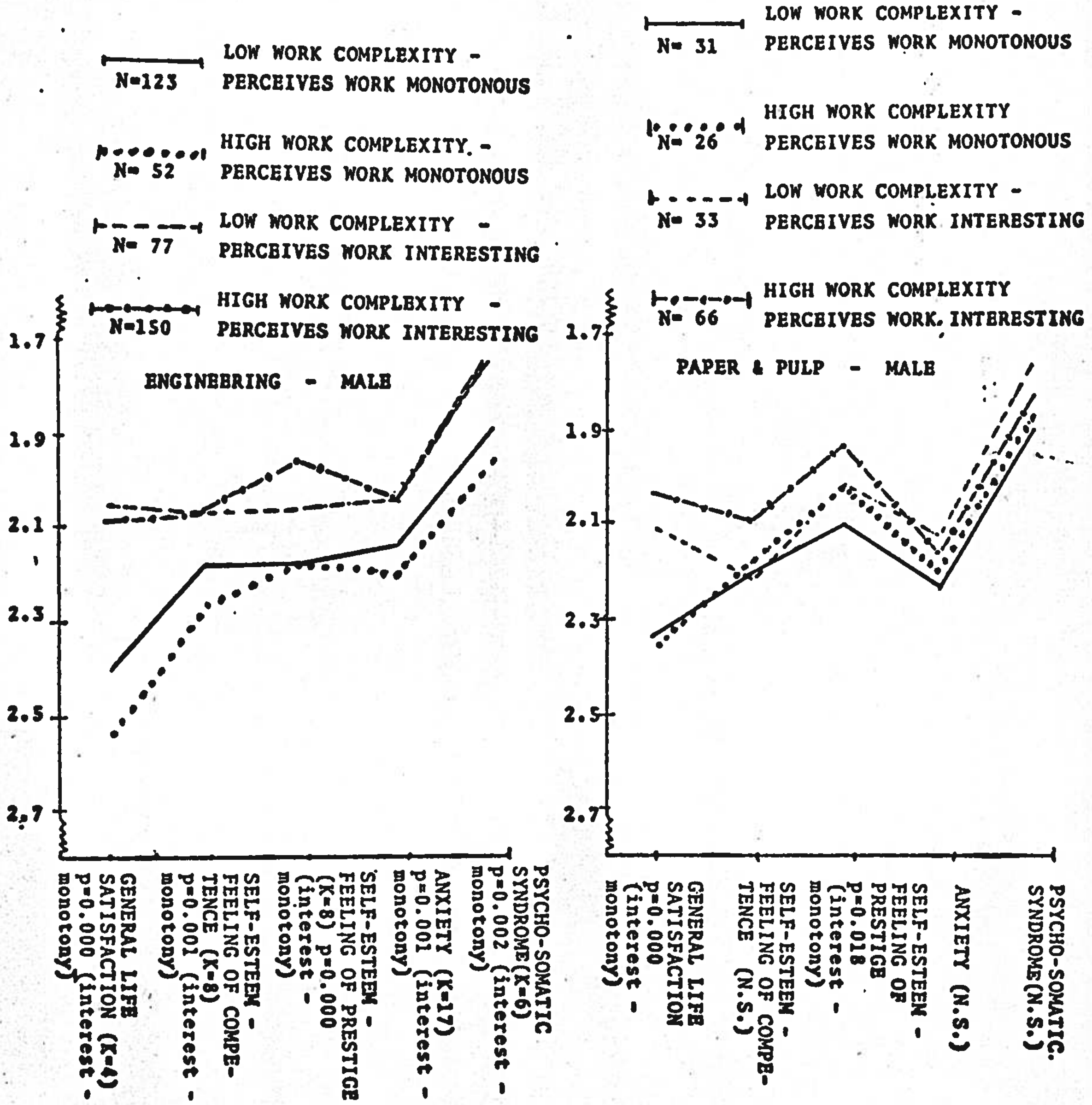


FIG. 16.16. **Relation between work complexity—work alienation and mental health.**

tion mechanisms as desirable, since these in a broader perspective retard a development towards deepened democracy and self-realization in the world of work. It is also probable that the level of aspirations, which now tolerates the unfree and unskilled jobs, will change in the direction of increased demands for freedom and influence in consequence of higher educational attainments, more permissive forms of upbringing and schooling, and so on. In Sweden, we can already discern clear signs in this direction.

Degree of Mechanization, Work Alienation and Mental Health

In an earlier work (Dahlström, Gardell *et al.* 1966) we discussed the psychological significance of mech-

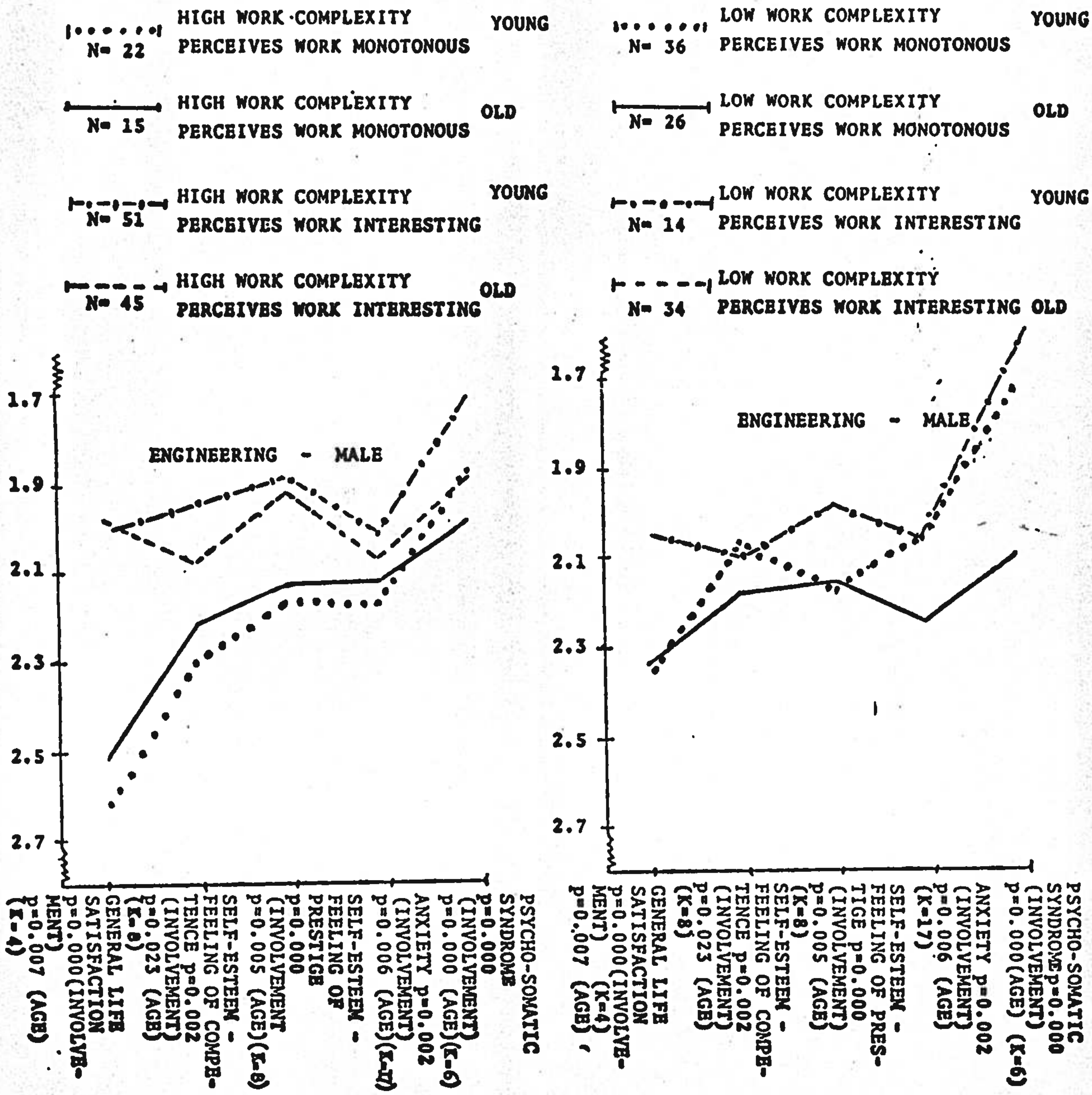


FIG. 16.17. Relation between work complexity—work involvement and mental health in different age-groups.

anization, assuming therein a U-shaped connexion between degree of mechanization and work alienation. The reason for this assumption is that both freedom and qualification aspects of highly mechanized work will be restored to values resembling those existing in crafted types of production, even though the tasks involved are otherwise of very different character; the knowledge content and manual skills are highly divergent, etc. On psychological grounds, we have assumed that these obvious differences between craft methods of production and highly automatic processes are of lesser importance; what is important instead is to have very similar determinants of free and skilled action. This is by way of saying that craft methods (low degree of mechanization) and the monitoring of automatic processes (high degree of mechanization) are pretty much of a piece in that both greatly diverge from work produced by semi-automatic methods where freedom and skilled action are severely circumscribed.

To test this assumption, we have drawn upon ratings of work content made by our technical experts, and upon data relating to the length of the operational cycle, to define three groups which we think essentially, albeit schematically, describe the development of mechanization. The first group, which we call crafts, consists of individuals performing a skilled trade that does not have any clear operational cycle. This group comprises 161 individuals taken from both the engineering and pulp and paper industries. Most of its members are tool-workers and maintenance men. The second group consists of individuals in jobs that the experts classified as machine-controlled manual work with an operational cycle lasting not more than one minute. This group is exclusively recruited from the engineering industry and subsumes a number of different trades. The third group consists of individuals whose work was classified as process monitoring or the operation of complicated mechanical systems. This group is mainly recruited from the pulp and paper industry, in particular workers in digester houses, bleaching plants and at paper-making machines.[2]

The mechanization scale thus defined has been compared with ratings of degree of mechanization based on a scale constructed by Bright (1958). Expressed as an association coefficient, the correlation between the scales is 0·62. Chi^2, based on a 3×3 table, is 270·1934. Degree of freedom $=4$ and $P=0{\cdot}0000$.

As will be seen from TABLE 16.3, the vocational training required of these groups varies greatly. The table shows that training requirements are

[2] The greater number come from Gruvöns Bruk, regarded as one of the most technically advanced paper-mills in Europe, with computer-controlled paper machines, etc.

TABLE 16.3

RELATION BETWEEN DEGREE OF MECHANIZATION AND TRAINING REQUIREMENTS

DEGREE OF MECHANIZATION	MORE THAN 2 YEARS		1/2 YEAR–2 YEARS		3 WEEKS–1/2 YEAR		3 DAYS–3 WEEKS		LESS THAN 3 DAYS	
I *Low*=crafts N=161	159	99%	2	1%	—	—	—	—	—	—
II *Medium*=machine-controlled repetitive work N=137	—	—	17	12%	47	34%	52	38%	21	15%
III *High*=process monitoring N=54.	10	19%	12	22%	31	57%	1	2%	—	—

TABLE 16.4

RELATION BETWEEN DEGREE OF MECHANIZATION AND WORK COMPLEXITY

DEGREE OF MECHANIZATION	WORK COMPLEXITY	SIGNIFICANCE
I *Low*=crafts	4.17	I- II p(t)=0.000
II *Medium*=machine-controlled repetitive work	1.72	II-III p(t)=0.000
III *High*=process monitoring	3.61	I-III p(t)=0.000

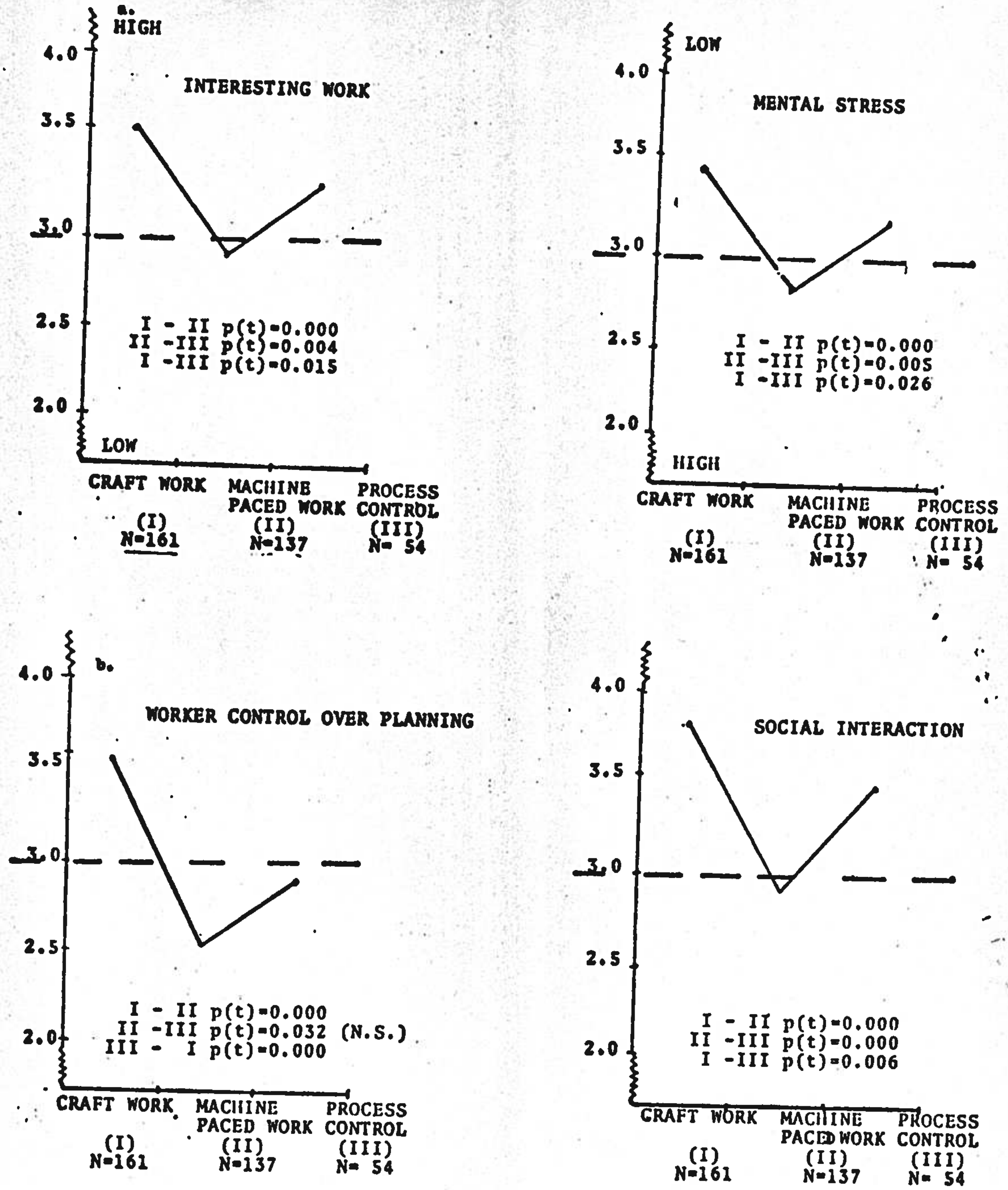


FIG. 16.18. Degree of mechanization and work alienation.

greatest for the crafts (low degree of mechanization) and least for the repetitive machine-controlled jobs (medium degree of mechanization). As a rule, the process monitors (high degree of mechanization) must meet a high training qualification, though not to the same extent as for the crafts.

It is essential for our theory that the freedom and qualification aspects of work are fairly equivalent for low and high degree of mechanization and that they rank high, i.e. favourably for ego-relevant satisfaction of needs. By contrast, we assume substantial curtailments in these respects

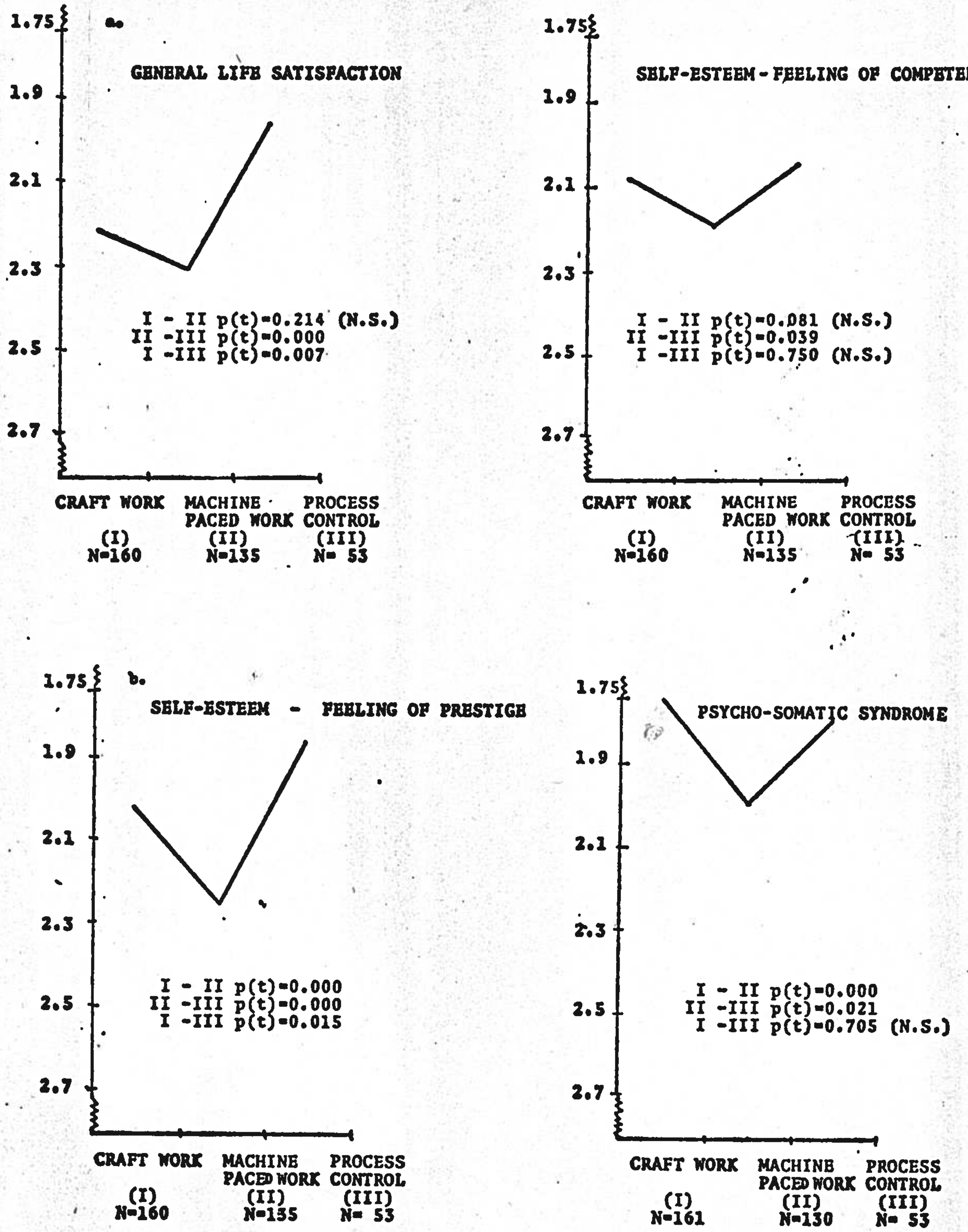


FIG. 16.19. Degree of mechanization and mental health.

for machine-controlled jobs which have a medium degree of mechanization. We have, therefore, related our schematic mechanization scale to the general structural measure, work complexity, with results that appear in TABLE 16.4. This table shows that free and skilled action is subject to strong limitations in machine-controlled repetitive jobs compared with other groups. In other words, the development from low to medium degree of mechanization greatly curtails freedom in respect of physical movement, variety of tasks, control over working pace and methods, and social interactions, and it also imposes severe limitations on the undertaking of skilled action, participation in decision-making processes and the like. A transition from medium to high degree of mechanization serves to restore some of these factors to values resembling those which hold for craft-based jobs. Certain important exceptions here have to do with control over work methods and work planning, which instead diminishes further with a high degree of mechanization.

An additional curtailment of freedom in connexion with medium degree of mechanization is that all of the jobs involved are paid by the piece. Hourly rates are in force for 83 per cent of the persons who enter into the crafts group, and for 100 per cent of those who perform monitoring work. The group engaged in machine-controlled repetitive jobs undergoes further strains in the form of high noise levels and uncomfortable operating positions. Noise levels exceeding 110 dB were measured for 56 per cent in this group as compared with 1 per cent and 6 per cent in the craft and monitoring groups respectively. For 81 per cent of the group, it was found that they carry out their work in a standing position all the time; this compares with 4 per cent of the craft-workers, and with none of the process monitors.

FIGURES 16.18 (*a* and *b*) and 16.19 (*a* and *b*) illustrate the degree of mechanization on the one hand, and work alienation and mental health on the other. These diagrams conclusively show that the differences of freedom, qualification requirements and physical stresses, which as we demonstrated earlier characterize the various degrees of mechanization, are also acompanied by substantial differences of both alienation and mental health. We accordingly find that the emphasis on more efficient operations (rationalization), as embodied by greater specialization, more forward planning and greater control of the individual's work by machinery, leads to increased work alienation and poorer mental health. In the case of automatic processes, for which it was noted that some freedom and qualification factors are restored, work alienation diminishes and the level of mental health is raised, though not to the same level as for low degrees of mechanization.

SUMMARY

Two psychologically important aspects of task organization and job content are identified in mass-production and process industries, namely:

1. Worker freedom and control.
2. Qualification level required.

A general measure of work structure, based on these dimensions, is constructed, and, together with income and pay system, related to different aspects of work alienation and mental health. Severe restrictions in worker freedom and control, and in qualifications required are found to be related to increased work alienation and lowered level of mental health. A U-shaped relationship with degree of mechanization is demonstrated regarding both freedom-qualification aspects of job content and work alienation mental health.

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The human work environment Swedish experiences, trends, and future problems

A contribution to the United Nations conference on the human environment

Royal Ministry for Foreign Affairs
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The human work environment
Swedish experiences, trends, and future problems

A contribution to the United Nations conference on the human environment

Kungl. Boktryckeriet P. A. Norstedt & Söner 710445
Stockholm 1971

In the Swedish debate and the discussions concerning the environment the human work environment has attracted considerable interest. Many problems of the general environment and those of human settlements are closely interrelated with the working environment.

Upon the request of the Swedish Preparatory Committee for the United Nations Conference a working party has prepared a survey of the environmental problems at the workplace, regarded from Swedish experiences.

The working party has consisted of Professor Sven Forssman (chairman), Dr. Erik Bolinder, Dr. Bertil Gardell, Professor Gideon Gerhardsson, and Dr. Rudolf Meidner. In addition, the following experts have assisted in drawing up the report: Dr. Magnus Hedberg, Mr. Inge Janérus, Dr. Gösta Lagermalm, Professor Nils Lundgren, and Mrs. Elisabeth Lagerlöf (secretary).

The Swedish Preparatory Committee hereby submits this paper to the preparatory work for the United Nations Conference on the Human Environment.

Stockholm, 13th of August 1971

Arne Engström

/ Göran Bäckstrand
/ Håkan Stenram

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Preface

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1 Background

1.1 Introduction

Developments in the external environment, as represented by rivers, lakes and seas, the air space above streets, expanses of plains and uplands, the soil in which food is cultivated and the ground beneath our feet, have attracted widespread attention and concern. However, "environment" embraces the totality of surroundings in which we live: during the day with work and rest, during the year with its rhythm of changing pursuits, and in the course of a lifetime with its different phases of growth and nurture, activity in work and ageing towards the end of the life cycle. In this respect the problems that affect the safety, health and well-being of man at the place where he works—the human work environment—is of great concern.

1.2 The work environment and technological advance

Anxieties over the work environment are by no means restricted to countries with a high economic standard of living. The surge of industrialization is headlong all over the world. Famine and poverty are being fought with methods of production that are largely transmitted from the already highly industrialized countries, but which must be applied in societies where the conditions differ in whole or in part from those where these methods were gradually evolved. Besides, this process is proceeding at a tempo which allows even less time for adjustment to the conditions under which individuals are supposed to live and work. The problems thus brought to the fore must be seen in relation to our knowledge that industrialization including the corresponding transformation of economy and urbanization, has, in many respects, been a painful process in those countries which now have a high GNP.

Of late many industrial countries have shown rapidly increased interest in problems of the work environment. Greater demands have been raised to abate the risk of accidents and to reduce the perils to health of the working population. At the same time there has been constantly growing awareness in many countries that the cost of production must include not only the cost of materials and straight wages, but also the price of not inflicting unnecessary damage or destruction on the external environ-

ment, as well as the price to be paid for protecting the physical and mental health of employees.
Today, moreover, it lies readier to hand to intervene technically in these processes than was earlier thought feasible. There are many reasons for this. An accelerated rate of technological advance exposes us not only to new perils in the form of faster and more powerful vehicles and allergies to new substances in our daily rounds. We are also being given devices that reduce or eliminate dangerous operations: fork trucks perform lifts that would otherwise cause many back injuries, new vacuum suction equipment eliminates the risk of silicosis for workers engaged in rock-drilling, etc. If we can design an aircraft cockpit so that the pilot can take in all instruments at a glance, the better to enable him to respond promptly and correctly to any upcoming situation without having to exert himself unduly or to end up in physiologically unsuitable postures, then many other problems of control, as in driving compartments and switch towers, are amenable to similar solutions.
The big, spectacular events also have their importance. If we can safely get the crew of a space capsule past the scorching barrier of reentry into the earth's atmosphere, then we may also be provided with opportunities for protecting the workers at smelting plants against high temperatures. This is not so much a question of technical spin-off effects as of the overwhelming conclusiveness that comes from a "showcase" demonstration. If technology can help us solve a very complicated space problem, the realization will dawn that a feasible answer is also forthcoming for more earth-bound problems.
However, the answers to these problems are less frequently self-evident, nor do they admit of solutions unless one is familiar with their special character. The first stage of solving a technical problem consists in defining the problem, delimiting it, quantifying its different components, dividing it up into various sub-problems, looking for solutions to these, and combining them into a favourable whole.
For this purpose great importance attaches to metrology or the science of measurement. A great deal has happened and is happening in this field. Moreover, further advances are in prospect as investigators need more refined instruments to describe the processes and situations they have selected for study.
Much ought to be achievable with the use of already known techniques for solving problems at workplaces. This is true, for instance, of a great many noise problems. In the longer run, what is even more important than protecting workers against noise is to arrange workplaces and to

design machines and other equipment that obviate exposure to harmful noise in the first place. The relevant operating variables here are choice of materials, engineering design, location of equipment and plant layout. Stepwise measures may be appropriate, as in providing workers with noise-control equipment, until results are forthcoming from the redesign of machinery and similar projects which necessarily take more time.
By the same token, existing technology can be made to improve conditions in one field after another. For example devices which exhaust poisonous or allergy-inducing solvents bring about improvement in some cases. In other cases it is better to replace one solvent with another which produces similar technical effects but does not have the same occupational drawbacks. A third approach is to replace the original procedure with a closed process where nobody comes into touch with the solvent.
These examples could be multiplied many times over. Inasmuch as technology has advanced, the number of technical combinations that suggest themselves for the solution of a given problem have increased even more sharply. The possible combinations comprise the basis for bringing out new products, for inventions or innovations. At the same time it forms the bases for permitting one and the same product to be made in different ways, not only means of completely new processes but also on the strength of major or minor modifications in existing processes.
Many operations and cycles involved in the manufacture of ordinary products emerged when the technical options were fewer, when not as many means were available or conceivable for achieving the same end. This is a plausible explanation for many of the problems that beset today's workplaces. Yet at the same time it signifies an opportunity to improve or solve many of the work-environment issues that now stand out as serious and exigent.
In its most sweeping application the mode herein described for modifying parts of the processes can lead to the adoption of quite different manufacturing methods for putting out the same products. However, it is still assumed that this has been done with the application of known technology.
None the less, these possibilities can be further extended if one introduces the potential inherent in new technical processes or elements. This may relate, for instance, to the use of a material having predetermined properties and which as such has been "tailor-made" for the particular task. It may relate to a new principle of mechanical moulding

or to a new technique of chemical separation. In that way the modification potential can be enlarged to embrace the bringing out of brand new processes or the launching of an alternative technology. Obviously, the new process must stand up to critical examination and evaluation from different angles, including that of the work environment. Be that as it may, it ought to be clear that questions of the work environment are every bit as deserving of professional consideration as (say) market questions when it comes to defining bench marks for the development of an alternative technology.

A valuable instrument in activities of this kind should be the utilization of special work-environment laboratories. Current work operations can be critically examined in such facilities, in some cases by building up essential segments of the operations, introducing modifications and then testing them. This can be done without making expensive interventions in the day-to-day course of production. Studies on a model scale can also offer valuable leads. The technique of employing analog and digital computers to simulate different processes offers other means of testing and evaluating combinations that would otherwise be completely unthinkable.

It should be emphasized that the technical measures must not be viewed in isolation. Social, psychological, economic and legal factors are essential ingredients of the work-environment complex. Thus in the absence of compelling reasons the demands of the individual, group, society and international organizations should not diverge by many powers of ten between different work sectors. This problem can be illustrated with reference to the unlike criteria that are imposed in nuclear engineering and traffic engineering. Without wishing to imply that safety standards in the nuclear engineering sector should be lessened, we question the rationale that for decades has accepted the high rate of casualties and risks on our roads and highways. In aviation the work of pilots must comply with high safety standards, and that is no doubt justified. But it may legitimately be asked why similar standards have not been required of the people who drive buses and trucks. In all probability equally valid comparisons could be drawn between sectors of the working community.

The exploitation of known technology or the development of new technology aimed at improving conditions of different workplaces is a task deserving of the highest priority. But it is a task that must be pursued systematically. It is all well and good to have new and better solutions emerge spontaneously, but that is not enough. The existing problems

are already too numerous and often overly complicated: in other words, we cannot afford merely to wait for the spontaneous solutions to turn up. Manufacturing firms, industries, safety authorities and even trade unions and employer organizations must systematically identify problem areas, define sub-problems and by commissioning experts to tackle them, explore for solutions. Public bodies entrusted with the responsibility for R & D programmes in technology, medicine and the behavioral sciences must support, initiate and coordinate research and educational projects that (1) lay a better general foundation for concrete solutions; and (2) open opportunities for new or alternative processes which permit equally good products to be made without inflicting deleterious effects either on the work environment or on the external environment.

1.3 Structural change and the urbanization process in Sweden. The changing structure of the economy

The rapid process of structural change in the Swedish economy can be best illustrated with reference to the distribution of gainfully employed persons among different sectors over a 25-year period.

Table 1. Distribution of the labour force by economic sectors, 1950—75, in per cent

	1950	1960	1965	1970	1975
Agriculture, forestry and fishing	20	17	12	9	6
Mining and manufacturing	32	30	31	30	27
Construction and power generation	9	9	10	10	10
Distributive trades, transportation and private services	29	31	31	31	32
Public services	10	12	15	20	24

Sources: The Long-term Surveys: *Svensk ekonomi 1966—1970,* SOU 1966: 1 and *Svensk ekonomi 1971—1975,* SOU 1970: 71

The most conspicious trends are the sharply declining proportion of the labour force engaged in agriculture and fishing—which is typical of the industrial countries—and the vigorously expanding service sector (employing more than 50 % of the labour force in 1970), especially the public services, where education, social welfare and care of the sick particularly require more personnel. However, even the apparently stable sectors are undergoing considerable changes as regards the structure of industries and firms. A declining proportion of total employment is mainly accounted for by the textile, apparel and leather products industries, at the same time that engineering (fabricated metal products, machinery and transport equipment) is enlarging its share of the manufacturing labour force.

The elapsed part of this period has witnessed major changes of corporate structure in the form of combines (mergers and long-term pooling arrangements), plant shutdowns and production cutbacks. From 1958 to 1969 the number of known combines rose from about 60 to nearly 400, most of them in the engineering industry. Large firms have increasingly resorted to collaboration, not least of international scope, in preference to other measures of rationalization or expansion. A growing proportion of the shutdowns seems to be taking place in firms that entered into mergers only a couple of years earlier.

Changes in the structure of manufacturing industry, as measured by the size of establisments, were not especially great in the period from 1950 to 1967: in spite of fewer manual workers employed by the smallest companies (those with no more than 10 workers) and a slight increase in the number employed in "big companies" (with more than 1000 workers), Sweden is still a country of small-scale enterprise. A clearer indicator of the dynamics involved in the process of structural change is the incidence of corporate exits and entries in specific industries. Figure 1 calls attention to the growing number of advance notices of plant shutdowns and production cutbacks that have been filed with the labour market authorities in the past decade. Figure 2 shows that the most adverse impacts have been visited upon the textile and apparel industries. However, even the largest industry, engineering, has felt the force of rationalizations, and the same holds true of lumber and wood products. It will be clearly seen from the diagram that (notices of) shutdowns turned sharply upwards after 1963 and that the number of employees affected have increased at the same rate. In other words, the necessary redeployment of displaced manpower has assumed proportions such as to give rise to considerable difficulties even when new job openings are available. A changing society imposes great demands in the way of mobility and adaptability. Many of the displaced are able to cope by dint of their own efforts and with the assistance of the Swedish Labour Market Board; for the most part, however, successful readjustment is confined to younger persons and the well-educated.

The problem is most serious for those groups who are already dis-

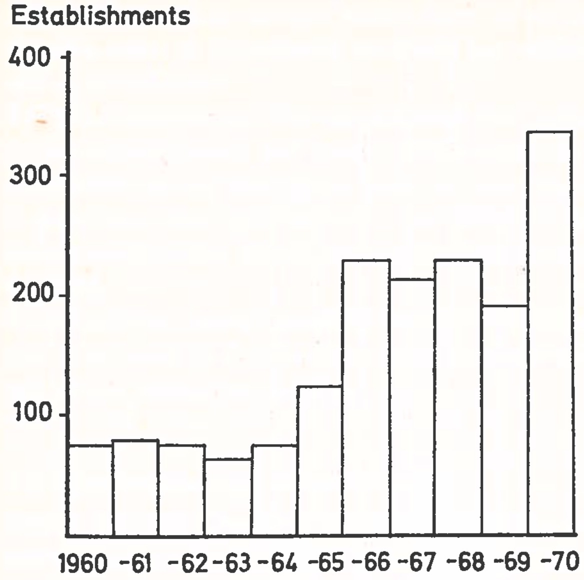

Figure 1
Advance notices of plant shutdowns, 1960—1970, by establishments
Source: National Labour Market Board

advantaged in some way: the elderly, the less-educated, women and the handicapped. Follow-up studies of plant/firm shutdowns and production cutbacks have shown that

(i) the majority of "redundant" personnel can admittedly be afforded new employment almost immediately, but that some of them transfer to new jobs only after experiencing a period of unemployment; that many feel they have changed for the worse as regards pay, physical or mental strain and/or work environment and job satisfaction in general;

(ii) some of the redundant enter retraining programmes or undertake relief work, while others enrol in public schemes of vocational rehabilitation and are reduced to sheltered employment;

(iii) some of the redundant remain unemployed and stop looking for work; they leave the labour force, i.e. are no longer counted as unemployed even though that is what they are in the real sense.

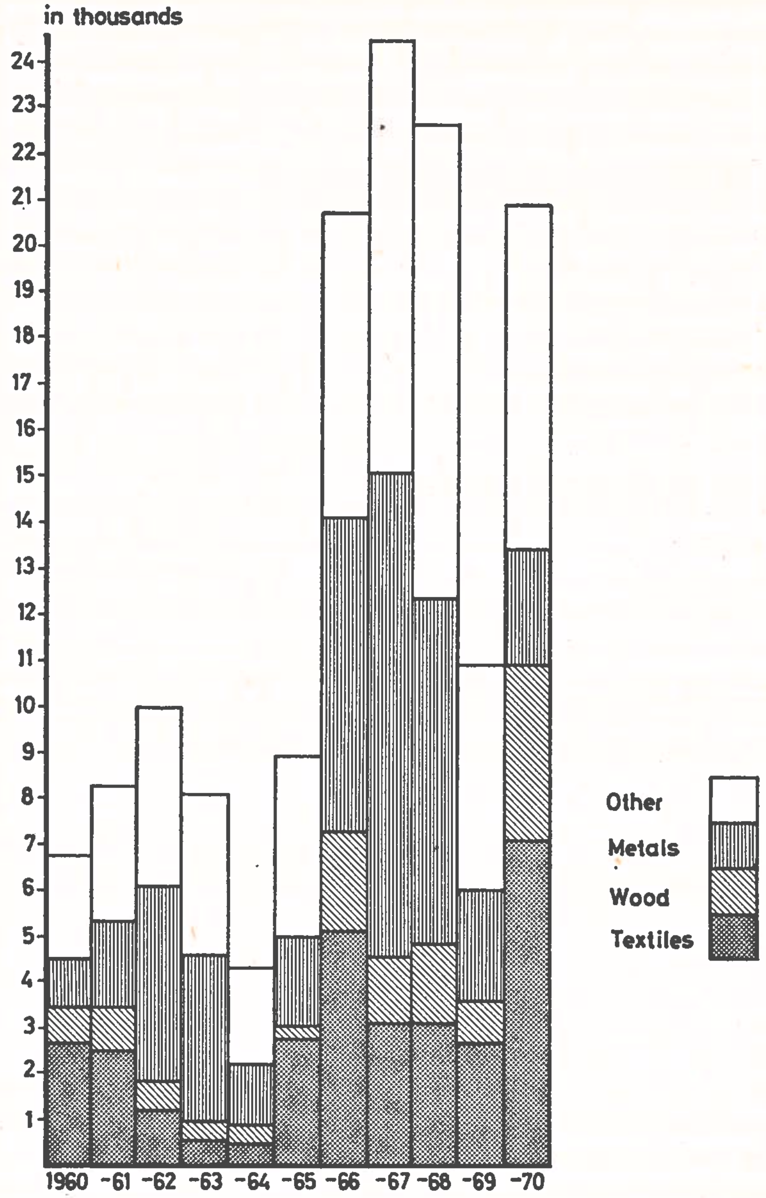

Figure 2
Number of employees affected by advance notices of plant shutdowns and production cutbacks, 1960—1970
Source: National Labour Market Board

In many cases these changes involve losses of welfare resulting from the abandonment of accustomed surroundings, difficulties of adjustment, and social isolation.

Yet plant shutdowns, with the demands for readjustment and the frequent unemployment they bring in their train, do not present the sole element of risk for the labour force, nor even the most important one. A great many more persons by far lose their jobs when companies reduce their payrolls, while yet another large number are the object of *in-plant* transfers.

As a matter of course, structural change in Swedish society has affected and is affected by the Swedish migration process and has given rise to population movements on a big scale.

1.4 Plant location and urbanization

During the past few decades there has been a mass exodus from the counties of Northern Sweden (Norrland) and other woodland tracts to the southern and middle parts of the country, with most of the concentration confined to two regions: the one coextensive with the lakes of Mälaren and Hjälmaren; the other in the southwest, extending roughly from Göteborg down to Malmö—Lund.

At the same time people are settling in the larger and more densely populated areas of the country as a whole.

The result of these population movements is to confront society with two problem complexes: on the one hand, there are the rural-to-urban drift and the problems of sparse settlement in Sweden's northern regions; on the other hand, there is the growth of metropolitan areas in southern and central Sweden. By international yardsticks the latter problems are of relatively modest scope. By contrast, the "outback" problems represent a cumulative process, which may be considered highly specific for Sweden owing to its intractable character.

One way of shedding light on these problems is the following: As of 1965, 15 % of the woodland-county population lived in urban settlements (as defined for census purposes), as against 45 % of the population in the rest of Sweden. At the same time the woodland counties accounted for 23 % of the national population but only 9 % of the people who lived in urban settlements with more than 30,000 inhabitants.

The outback or sparse-settlement problem is caused in large part by the fact that Sweden does not have any large clusters of population that can develop into so-called growth points.

To what factors may this trend be attributed? It derives in large part from the economic structure that formerly prevailed in the woodland counties, where people used to be entirely dependent on the logging industry and its offshoot lines of manufacture. These sectors have undergone considerable rationalization and concentration in recent decades. The result has been for the companies to concentrate their production in certain regionally defined areas, where they have been given access to a differentiated labour market, economies of scale and greater marketing potentials. At the same time increased prosperity has altered the pattern of consumer demand, a trend that has visited its most adverse impact on the agricultural sector.

Most of the migrants are young people between the ages of 25 and 34. The departure of these heavy consumers affects the consumption pattern in areas of in- and out-migration. In consequence the supply of services diminishes in sparsely settled areas while it enlarges in the regions of in-migration. Other changes arise as well. As more people leave an area they gradually remove the supporting base of more and more activities, such as schools, shops, retail establishments, dwellings, communications etc.

It is evident from the table that the regions, in terms of this size breakdown, greatly differ from one another with reference to net migration,

Table 2. Certain differences between regions in terms of the their size

Groups of A-regions ordered by population base in the component regions	Average domestic net migration 1961—1965	Average income per employee 1967	Number of vacancies in relation to number of unemployed avtumn 1965	Number employed per 100 head of population 1.11. 1965
29— 59,000	—7.0	SKr 19,275	1.04	41.4
60— 95,000	—4.0	" 19,379	1.15	41.4
96—132,000	—1.4	" 19,666	2.04	42.6
133—184,000	+0.4	" 20,570	1.92	43.8
Göteborg/Malmö/Lund/Helsingborg/Landskrona	+6.8	" 23,751	4.55	45.9
Stockholm/Södertälje	+6.9	" 26,681	6.67	47.6

Source: SOU 1970: 15, p. 7:25

average income, vacancies per unemployed, and rates of participation in the labour force. The large regions consistently have high net immigration, high average income, many vacancies per employed and high rates of participation. The latter finding should be interpreted to mean that a certain degree of underemployment actually obtains in regions of depopulation with a weak industrial base, which is bound to impede the placement of marginal labour. Conversely, the regions of expansion are so beset by labour shortages that the working community can even absorb people who do not meet the occupational definition of "able-bodied".

Tying in with the earlier discourse on the distribution of different population concentrations, we find that the woodland counties with their low population densities have high volumes of out-migration, low average income, few vacancies and low rates of participation in the labour force. That pretty well sums up both the causes and effects of out-migration. Since these regions have few jobs to offer, young people leave to obtain employment and make use of their education. Those who stay behind are older persons, poorly educated and with incomes at a low level. This being so, it later becomes very difficult to generate a process of economic growth, since both a stable population base and a reservoir of trained manpower are lacking.

In seeking to promote the growth of regional population and employment opportunities, the community at large is mainly concerned to achieve balanced expansion in selected regions based on promising nodal or growth points.

Other regions that do not offer long-term prospects of economic expansion are to be given opportunities to achieve a balanced concentration.

Up to now, however, it has not been possible to achieve the goal of a more balanced development, in other words to prevent the severe social and economic problems that have been generated in large parts of the country by the concurrent processes of urban growth and rural depopulation.

1.5 Changing value judgments

The changes in individual values that can be observed and that can be expected should be seen as concequences of the structural changes discussed earlier. These shifting value judgments cannot be viewed in isolation from changes in the human condition. Technological advance opens up opportunities for a higher standard of living, which in turn means that it takes less effort to satisfy the basic human needs of food, clothing and shelter. Thanks to collective arrangements for security, it becomes less imperative upon individuals to plan for future difficulties. This permits the adoption of freer attitudes to work situations and may result in demands on higher standards of safety and health at work. The policy of full employment creates—especially during boom periods—severe labour shortages, which widens the range of options available to individuals in the working community, as a result, supervisors are under greater pressure to adapt tasks and working conditions so as to meet individual wishes.

Over and above this liberty-creating process, the prolongation of compulsory schooling has given individuals (especially those in their younger years) increased resources, broadened interests and heightened aspirations and expectations as regards their work and living standard. The altered pattern of education acts in several different ways. First, the actual time spent in school has lengthened; second, the body of subject matter taught has been broadened; and third, the values imparted by the school have become less dogmatic. Further, the actual teaching situation, the role of teachers and the socializing function of the school have all changed. Lastly, prolonged schooling makes pupils older and more independent by the time they enter the job world.

Changes in the educational systems successively alter the determinants of the national life as new cohorts take over. By contrast the mass media impinge directly on larger segments of the population. The information that is daily communicated by feature articles, news services and the like can be compared with the education given in the school. Knowledge of conditions in other parts of the world, as well as of the philosophies and value judgments of other peoples, has increased phenomenally with the advent of television.

From this it follows that the opportunities of individuals—the young ones in particular—to assert themselves and their values have changed. That is sometimes interpreted to mean that their demands and expectations have grown, and sometimes that they have become less tolerant to the non-satisfaction of their wishes. These changes first manifested themselves among students who spend the longest time in education, but they are now also observable at industrial workplaces, especially as reflected by the mounting difficulties of recruiting young persons. Heightened aspirations, fired by demands for a better "quality of life" and greater self-fulfillment, are also addressed to the job world, even though work itself is being accorded less importance as compared with leisure,

family life, education etc. To an increasing extent the job world will be asked to offer more interesting tasks to perform, new systems of rewards and so forth.

Lengthening education, mounting self-esteem, the demand for individuality and the de-emphasis put on economic necessities: all these things also lead to demands for altered social relations. This is partly manifested in "anti" reactions to authorities, leadership, social institutions, previously accepted ground rules, standards and laws. Within the family circle the effect has been to widen the gap between generations.

Attempts to combine the need of cooperation with growing demands for individuality have taken many different forms. Examples consist of working teams, mass meetings, volunteer groups dedicated to such goals as community improvement, organized demonstrations and perhaps even wildcat strikes as well. A new and more widely accepted compromise between community and individuality has yet to be achieved.

In the job world the search for such a compromise is reflected by growing demands for a participative say in the shaping of work environments, in the performance of tasks and selection of supervisors, and a mounting insistence on the curtailments of rights of managers to "direct and assign the work".

1.6 The democratization process in Sweden

Labour and management face one another in Sweden as two strongly organized forces. Trade unions were formed at an early stage of Sweden's late industrial revolution, gained strength quickly and in 1898 established a central organization, the Confederation of Swedish Trade Unions (Landsorganisationen i Sverige, LO). The Swedish Employers Confederation (Svenska Arbetsgivareföreningen, SAF) was formed four years later. Disputes were bitter in those initial years, culminating in the general strike of 1909. Although this was the last time the organizations tried to break each other in open strike, they continued to regard conflict as the chief means of settling differences until the 1930's. In 1938 SAF and LO adopted their Basic Agreement (the "Saltsjöbaden Agreement"), which outlines a negotiating procedure to deal with disputes and prohibits a number of direct actions. However, this agreement says very little about other working conditions, which were left for the employer alone to decide. Here the trade unions took a defensive position: they reserved the right to react to obvious disamenities such as safety hazards, but did not lay claim to active participation in the shaping of

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work practices, technical equipment, organization and environment.
The first breakthrough in these roles assumed by the two organizations came around the time of World War II. In the controlled wartime and postwar economy all parties were interested in more efficient allocation of productive resources and in increased production, especially in manufacturing industry. Mechanization and rationalization altered the employee's workday. Tasks were simplified and greater weight was attached to quantity than to quality and skill of workmanship. This trend was accentuated by the proliferation of incentive pay schemes in various forms. The process of readjustment that was forced upon the majority of employees was perceived by many to be both painful and repugnant. It was at this juncture that a number of moulds were created to facilitate cooperation between the employers and trade unions.
Thus the operation of joint committees enabled employees to keep themselves informed about planned changes in technical equipment, environment and organization. The plans were discussed, and the employees could make available their experience and know-how so that any implemented change would also allow for their difficulties of adjustment. Practical experience of enterprise councils, which for the most part were vested only with advisory powers vis-a-vis corporate managements, indicated a low degree of employee involvement in the redesign of working conditions. This defensive posture has also characterized the behavior of employees on these bodies.
The agreement on joint committees did not signify any major shift of responsibility between the labour market parties in terms of the activities they pursued. As far as the employer was concerned, this form of cooperation was a necessary precondition if the technical-economic development was to lead to optimal increases in productivity. The trade unions concentrated for their part on the use and allocation of the now rapidly increasing production result. Real wages went up, working hours were shortened and the system of social security to deal with unemployment, illness and old age was expanded. The reforming ambitions were usually so intense that the trade unions themselves often spurred the drive to make industries and firms more efficient.
Bit by bit, the work of the labour market organizations was centralized. Negotiations on pay and conditions of employment were moved up to the national level. The contents of collective agreements were enlarged so as to leave only insignificant bargaining issues to be settled at the local level. Most of the negotiations conducted by the parties in the individual firm came to be concerned with applying the provisions of the centrally

drafted agreements. In these negotiations both sides were put under the obligation to keep the industrial peace.
The consequences of structural and technical rationalization, and of the rising material standard described earlier, face the labour market organizations with the task of devising new arrangements to resolve their differences. More and more of the expectations that members put into their trade union have to do with in-plant factors that must be tackled by the local chapters. It will then be up to the central organizations to provide facilities that will enable the local organizations to take decisions right on the spot.

The foregoing involves problems of the *work environment,* where health risks are increasing rapidly in a number of areas.
It involves *labour market problems* which arise when tasks are standardized and performance demands pushed to the point where large groups of older and partially disabled employees risk being eliminated from the labour market.
It involves the *diminished job satisfaction* associated with increasingly repetitive and constrained tasks and with monotonous monitoring and control functions.
It involves the employee's *growing aspirations* to independence, to participation in planning, decision-making and the assumption of responsibility in his own work and the upgrading of his skills.
It involves a desire for a *change of relations* inside the firms in the same direction as that taken by the democratization of the larger society outside.

To promote these objectives the trade unions will naturally want to develop the cooperation on advisory bodies towards an increasingly greater say in the performance of management and supervisory functions. The parties must jointly explore new approaches to the operation of rationalization programmes and the design of the work organization. One way that suggests itself here is to restore segments of planning, decision-making and control of performance to the production workers in group form and thereby impart a more varied content and greater challenge to their jobs. This would also fall in line with the democratization of on-the-job relations that is being impelled by developments in the larger society.

1.7 Summary

Hardly any of the features of technological advance, structural change and urbanization that have been briefly described above are peculiar to Sweden. They closely coincide with familar tendencies in many of the world's highly industrialized societies. It cannot be justifiably asserted that new technical methods are applied more quickly or on a greater scale in Sweden then anywhere else, that firms are concentrating here into larger entities with exceptional speed or that the urbanization process leads to the formation of agglomerated settlements which can be called extremely large by international comparison. What is typical to Sweden is the lofty ambition of its welfare-economics objective, which not only has the quantitative aspect of striving towards a high employment level but also qualitative aspects: to give people a wider range of choice in the tasks they perform, to create good work environments, and to prevent the social and economic strains that follow in the wake of structural change.

Mention has already been made of how improved education has served to intensify demands in terms of job satisfaction and industrial democracy. Generally speaking, there is growing awarness of conflicts between profit-oriented efficiency goals and social welfare goals and on the enterprise level the problem may be how much of available resources should be used for increasing production (and salary) and how much for improving work environment. These conflicts are exacerbated by the fact that Swedish industry's dependence on foreign trade requires it to become more competitive, at the same time that the modern industrial environment tends to subject people to greater mental and—to some extent—physical stresses. The remarks made in the sections that follow are to be interpreted as attempts by the Welfare State to solve this conflict situation: preventive measures in the field of industrial safety, improved programmes of occupational health services, efforts to adapt the machine to man and to humanize the work organization with the aid of ergonomics—this whole complex of measures seeks to augment the goal of employment policy defined by ILO ("full, productive and freely chosen employment for all") with a qualitative dimension. According to the Swedish viewpoint, it is not enough that everyone should have work, that people can freely choose between jobs and that work can be productive: it should also be performed in an environment that meets reasonable requirements of physical and mental well-being.

2 The present work environment in Sweden as seen from hygienic, ergonomic and sociopsychological aspects

2.1 Introduction

Perceptions of health have come a long way during the past fifty years. This change is in no way specific for Sweden but has followed a similar pattern in other industrial countries as well.

Many years ago the term "health" mainly referred to the abscence of provable illness. In order to restore health lost through illness, medical care was therefore organized at the workplace, especially in largescale manufacturing industry. At first, however, this medical activity was mainly confined to treating employees who had sustained accidental injury or suddenly fallen ill on the job. But in due course the activity took on a prophylatic orientation, designed to prevent accidents and ill health on the strength of various preventive medical and engineering programmes and to monitor the state of employee health through different forms of directive health check-ups, which were meant to supervise the health and work adjustment of the employees. During this period labour science research began to gather momentum, both internationally and nationally, and the relationships between different types of work-environmental risks and their connection with health and work adjustment in a broader sense came to be increasingly appreciated.

Growing regard was paid to the general definition of health given by the World Health Organization in 1946. WHO defines health as "physical, mental and social well-being" and not as the mere abscence of illness. Towards the end of the 1940's it began to be emphasized in Sweden that problems of mental health were also of great importance at work.

In 1954 the Swedish industry established the model based on a preliminary agreement between the organizations of employers and workers that was to govern the design of their occupational health and medical services. It was given a medical and engineering function, and its mode of operation in the more strictly preventive sphere was to look after the organization of work in terms of accident prevention, industrial hygiene, ergonomics, job placement and adjustment.

But as the 1960's commenced, the negative consequences of different interacting factors in the work environment as a result of the industrialization process came to be more and more conspicuous. Organi-

zations of employers and especially of employees both called upon the larger society to take steps towards achieving a better-balanced development, one that would pay greater deference to human needs.
The government commission of inquiry into occupational health presented its report in 1967. According to the commission, in-plant programmes ought to aim at preventing occupational risks, promoting health and capacity for work, and contributing to work satisfaction, security and efficiency. The commission was thus applying WHO's broad definition of health, supplemented with an observation that the job should be adapted to the individual, according to WHO's definition of occupational health.
In the late 1960's the different competents of WHO's definition underwent a further shift of emphasis. Originally, the main concern of internal occupational health was with physical health. During the 1950's and 1960's the mental components of health attracted increasing attention at the workplaces. These components continue to grow in importance, at the same time that more people are beginning to appreciate the significance of social factors in the job world such as industrial democracy, participation in decision-making processes at the workplace, and matters relating to work satisfaction. These factors will presumably take on more and more importance during the 1970's.

2.2 Industrial safety: present status and development tendencies

2.2.1 General tendencies

From the very outset of the first Industrial Revolution the term "industrial safety" was made to subsume those measures which were intended to protect the employees against both accidents and ill health. The accidents dominated for a relatively long time. Preventive measures were not closely integrated with the production process. Since knowledge of the factors that caused ill health was limited, preventive measures had little efficacy.
As in other countries attempts were made in Sweden to write certain minimum requirements into law. The initial approaches to industrial safety legislation are embodied in different ordinances from the 17th and 18th centuries. What might be called Sweden's first Labour Welfare Act was adopted in 1889, and in 1890 the first factory inspectors started making their rounds. The law of 1889 laid down a number of regulations on safety at the workplace and stipulated criteria for ventilation, heating, illumination, air pollutants and good hygiene. To accomodate these environmental and climatic factors, a new concept was gradually introduced: occupational hygiene or industrial hygiene.
Major revisions and enlargements of the legislation were undertaken in 1912, 1938 and 1949. A central administrative agency, the National Board of Industrial Safety (Arbetarskyddsstyrelsen), was constituted in 1949. During the 1960's certain amendments were made in the Labour Welfare Act, and its derivative ordinances as well as several commissions of inquiry have dealt with the agency's organization and duties. The Act is now applicable to every kind of work except that in the home. An official inquiry authorized to draft a completely new law on work environment commenced in 1970. This will probably very much broden the sphere with reference both to contents and measures.
Industrial safety would appear to be the first major issue on which Swedish employers and employees have sought cooperative arrangements. Important milestones are the rules adopted in 1942 for works safety organization and the introduction of local safety stewards. Under the latter innovation the employees were enjoined to elect one of their number to represent them and plead their interests in matters of industrial safety. The institution of safety stewardship thus created by the labour market parties, together with the practice that evolved for cooperation at the local level, was elevated to a statutory provision when the Act was revised in 1949.
In a firm it is up to the management to organize safety work in the large, lay down the division of responsibilities, allocate funds and to provide the basics for a good system of industrial safety.
It also rests with management to formulate safety rules, arrange suitable training and information, and to control and follow up the measures that are taken.
The line supervision plans and directs the local safety programme, improves working methods and equipment, performs controls and inspections, and investigates in detail accidents that have occurred. The employees' own representatives, especially the safety stewards, are not only supposed to be familiar with the occupational risks and make these known to their workmates, but also take part in investigations and inspections at the workplace and suggest improvements, promote cooperation and help to maintain a vivid consciousness of safety. As a rule, safety stewards are designated by the local trade unions. The task of training safety stewards rests in principle with the employee organizations, while its counterpart for industrial safety engineers and foremen rests with the employer. Even so, the principal responsibility for in-plant

safety is vested in the employer under law, and it is a responsibility that cannot be delegated.

For the purpose of bringing about sound and safe conditions at the workplace, the Act specifically calls upon an employer and the people in his employ to pursue an appropriately organized safety programme under the employer's direction and in cooperation.

It follows that industrial safety in Sweden is regulated both under law and on the basis of voluntary agreements reached between the labour market parties. In connection with the 1942 agreement provision was also made for a joint labour-management body called the Industrial Safety Council (Arbetarskyddsnämnden). The Council now has a staff of 11 persons and carries on extensive programmes of training, information etc.

The course of events inside firms has moved towards a more solid integration of industrial safety with the engineering work that goes on at every workplace. It devolves upon the technical safety service to plan, organize and control the measures that can be taken to prevent accidents. This service acts as the firm's body of expertise on safety matters and must be adapted to the firm's type and size. In principle it is activating and decentralizing, in other words it imposes a heavy responsibility on the individual departments, especially the line supervisors and foremen.

The technical safety service takes part in the planning of structural alterations and new plants, and also examines blueprints and proposals. It recommends technical improvements and new safety devices in both existing and new plants. With the passage of time these tasks have become increasingly sophisticated and now often presuppose a great deal of independent efforts based on elimination techniques.

The technical safety service keeps up with changes in legislation and other developments in safety engineering. By virtue of contacts with authorities, organizations, specialists and other firms, the service can inject new impulses and ideas into its own firm.

Internally, the safety service functions as a joint body which takes part in measures for influencing attitudes and activating safety consciousness. Training, information and propaganda, addressed not only to the employees but also to outside recipients, among them homes and schools, have proved to be important aids in this work.

2.2.2 *Technical safety on the job*

Of the 3.9 million or so persons who are gainfully employed in Sweden,

more than 136,000 fall victim each year to occupational injuries—as defined by the official statistics, with the limitations that this implies. About 2000 of these cases are classified as occupational diseases while the rest are on-the-job accidents. More than about 1800 people are impaired for life, and work-related accidents take an annual toll of about 400 lives, of which about 300 are on-th-job accidents. In order to follow the genesis and severity of occupational injuries, and to take preventive measures on the strength thereof, the *rate of occupational injuries* is evaluated. This is used to refer to the number of injuries per million man-hours, the number of days absent per individual and year on account of injury, and the number of days absent per injury. For preventive purposes it is also important to establish the incidence of injuries in different occupations, different etiological factors, type of injury and parts of the body affected.

Several industries and a large number of firms maintain their own statistical records of occupational injuries. A system for inquiring into and reporting on such injuries, where the factors mentioned above can be analyzed, has been devised by the Industrial Safety Council and adopted by a number of industries. This system makes a good data base for the official statistics, and the results are complied on an annual basis. The National Social Insurance Board tabulates the cases that are reported either to it directly or to the local benefit societies. Because these statistics suffer from a long time lag between the occurrence and notification of injuries, they are now being overhauled.

2.2.3 *Preventive measures against occupational injuries*

Accidents are usually caused by several factors in combination. Especially since the end of World War II, various studies have sought to map out this complicated interaction. A commonly used classification of these factors has three main heads: technical, environmental and human. In the interests of better prevention it is particularly important to be able to identify which factor or factors is the precipitating cause.

Accidents may be put in various categories ranging from "close calls" and trifles to casualties and fatalities. A Swedish investigation has shown that if prompt results are sought that can be made to underpin action programmes to reduce the number of accidents, the best place to start is with the near accidents. It has been demonstrated in investigations from forest work that there are about 700 of these for every actual accident. Other investigations, mostly from the Swedish iron and steel industry, have shown that new hires, inexperienced or inadequately instructed

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persons run the gravest risk of meeting with accidents. The risk is often aggravated by transfers to other jobs or small changes in the working method. A great role is also played by the quality of technical equipment and the work environment. Poor discipline at the workplace, curtailed freedom of movement and a shortage of good tools are some of the most common causes of accidents.

Once the technical and environmental factors have been well pinpointed, it becomes relatively easy to deal with them. Hence systematic and detailed analyses of the situation are fundamental to modern industrial safety with its technical and environmental orientation. The results of such analyses are used to support the planning, execution and control of adequate measures.

The human factors pose a more formidable problem. People at a workplace have different physical and mental resources, and the interplay between the demands imposed by the job and individual capacity for work is often a significant cause of accident risks. Social scientists have therefore tried to find out how the human factors operate on the accident process. For this purpose they are concerned not only to describe the causes of accidents but also to define the characteristics of safe working conditions.

The approaches now being used to research the human factors include the following:

(i) studies of hiring practices and suitable placement of new hires;
(ii) painstaking induction of new hires;
(iii) training and instruction;
(iv) detailed instructions and thorough review of special risks;
(v) continuous information and propaganda.

2.3 Industrial hygiene

2.3.1 General tendencies

The usual reference under this head is to measures designed to prevent direct diseases or discomfort from the effects of physical factors such as noise or heat, chemical factors such as dust, gases and fumes, and biological factors such as fungi, moulds and viruses.

Industrial hygiene occupies the border area between medicine and engineering, and as such incorporates elements of both disciplines. The first hygienic efforts of a medical nature had to do with diagnosing and describing the mechanism of different diseases caused by environmental factors. Medical diagnosis has also had great importance for insurance

assessments of occupational injuries. The engineering efforts have embraced methods of identifying exposure as well as methods of eliminating harmful exposure.

The deleterious effects of lead, mercury, phosphorus, benzene and stone dust were among the risks that received early attention.

Developments since the turn of the century are characterized by constantly increasing international cooperation and a growing volume of interdisciplinary research, where doctors, chemists, engineers and other specialists have tackled problems of industrial hygiene from different angles.

The findings of research have permitted a better specification of measures of different kinds and their justification. This in turn has fostered more universal appreciation of the importance of industrial hygiene. Within the engineering portion of occupational health, the three major segments are technical safety, industrial hygiene and ergonomics.

2.3.2 Technical measures

It is characteristic of advancing techonology that the new manufacturing processes can give rise to health risks where they are least suspected. More often than not, an increase or change of production intensifies the hygienic problems. A case in point is the increased risk of silicosis in crushing plants. Factors which may be tolerated when taken separately can produce synergistic effects in interaction that greatly compound the risks. For various reasons the hygienic engineer must undergo specialist training and have access to specialized equipment that is relatively massive.

The human organism has a certain degree of built-in tolerance to most chemical agents. It is not until the tolerable dose is exceeded that ailments or injuries arise.

To permit assessment of the potential risk for injuries or discomfort, different environmental factors must be recorded in objectively measurable magnitudes. Little by little, various analytical methods have been designed that are sufficiently fast and convenient of operation to lend themselves to on-the-job applications. For instance, it has been possible to relate the measurements to different benchmarks, of which some are called hygienic threshold values. These indicate the requirements stipulated by the authorities. The American specification of hygienic threshold limit values has been used in Sweden since the early 1940's. A corresponding Swedish list is of more recent origin, though this builds in the main of American empirical data.

The crucial technical measures of industrial hygiene have to be inserted at the planning stage. Subject to budget constraints, better solutions can be attained in many cases if, say, measures to combat noise, a hygienic estimate of the ventilation requirement, a review of climatic factors or an assessment for working methods are performed at this stage. The follow-up of ill-health or discomfort factors can be delegated to no more than a limited extent. They differ in that respect from the accident-preventing measures, and often require access to certain instruments or laboratory equipment.
Measures of industrial hygiene are now broken down into the following steps:

(i) A list of potential risks, dangerous substances etc. is prepared and kept up to date. With this list as a guide, arrangement is made for systematic observation of close calls, early indications of deleterious effects, complaints etc.
(ii) In suspicious cases the cause in question is identified by objective measurements. More often than not the real cause is other than the one suspected out at the workplace. Investigations of this kind must therefore be made by personnel who are conversant with industrial-hygiene assessments.
(iii) Exposure is determined with reference to time and concentration for the substance or agent under study. Where necessary, these measurements are augmented by biological tests such as urine assays, blood assays and diagnoses of hearing.
(iv) In partnership with the doctor, the exposure is related to hygienic benchmarks or limit values. If personal predisposition of some kind is suspected, e.g. individual hypersensitivity, the diagnosis is made by the doctor. In certain cases the deleterious effect may be due to an individual suspectibility, which makes the hygienic benchmarks inapplicable. It may then be necessary to transfer the employee to another job.
(v) Adequate technical measures are usually prepared in collaboration with other engineers inside the firm, for instance from different departments such as planning, production and operations.
(vi) The effect of any one measure is controlled and a follow-up programme worked out.

In some industries, such as the manufacture of chemicals, the products are inherently toxious or otherwise hazardous when mishandled. Risks

of this kind must be investigated, and appropriate safety measures must be devised not only for the manufacture of such products but also for their distribution and end uses. For instance, it may be necessary to specify the main ingredients of a product on the informative label as a guide to the user: this will be the case for certain paints and solvents. On the basis of the information given to him the user can then organize his own surveillance of the health risks, prepare instructions etc.
In addition to keeping track of the hygienic status, in which are also included different sanitary matters such as conditions in staff rooms, lavatories, locker rooms and the like, it is also necessary to check up on different technical devices for operating efficiency: filters, fans, lighting fixtures etc. Here again suitable measurements must be performed at definite intervals. To a growing extent it has become necessary to plan and control the discharge of industrial emissions outside the factory area; while these usually involve air and water pollutants, consideration must also be given to noise and other nuisances to the immediate environs. The methodology of industrial hygiene largely lends itself to such investigations. However, other criteria must be used than those which are applicable inside the factory area. A programme of industrial hygiene must be systematically charted to permit the earliest possible costing of different preventive alternatives and to gauge their likely effects.
Cost-benefit analyses are necessary for this purpose. If the hygienic expertise is available within the firm, the implementation of a programme will not be counted among the financially burdensome projects. Outside experts may be brought in as needed.

2.3.3 Medical measures

As already mentioned, the industrial-hygiene research of an earlier day focused on the diagnosis and treatment of occupational diseases, in addition to which it provided a data base for the prevention of those diseases on the strength of measures in environmental engineering. Today, the medical measures are more concerned with improving the physical and mental health of employees in general. Technological advances and the current industrial trend towards greater mechanization and automation have given medicine new tasks, tasks which have to do with the adaptation of work to man in a broader sense. The principal objects of study in the past were those factors which caused relatively well defined injuries, e.g. intoxications, specific infections and eczema. Nowadays the objects are more likely to be a combination of different stress factors. The key word here is "combination", because adverse impacts on health do not result from any one of these factors acting alone. In many cases the deleterious effect does not become discernible until after many years of exposure, which may make it very difficult to establish the causal connection between exposure on the job and the effect under study. Vast problems for the future are posed by the teratogenic, mutagenic and carcinogenic risks. A great deal of attention has been paid to the effects on health of heavy labour performed in high temperatures, to the strains imposed by shift-working, and to questions that involve highly mechanized and automated production. These matters also entail questions of an intellectual and psychological nature, but as yet relatively little research has been done on them. The general state of the population's health is of great importance, since factors of stress at the workplace visit their more adverse impacts upon persons afflicted with various physiological and psychological handicaps.

Diseases and accidents directly attributable to work now form but a minor portion of health problems at workplaces. Questions relating to general work adjustment, mental health problems and the significance of mental disorders both for the individual and the plant have been accorded greater weight.

Considerable interest has been devoted to the problems of elderly labour, working women and the partially disabled, the latter also involving the provision of employment opportunities and different issues of rehabilitation. The cooperation between employers and employees in these matters has increased.

2.3.4 Development trends

During the 1960's growing importance was attached to industrial hygiene in relation to measures of environmental protection and control. Up to a certain point technological advance, increased consumption and work environmental improvement move in tandem. It is almost as though a better environment does not have to be planned, since it is thrown into the bargain anyway when production is modified. But after a given point the interacting negative effects penetrate with powerful force. In order to cope with them resources have to be deployed on an enormous scale, yet the desired goal eludes our reach and we have to make the best of it. Since the implementation of environmental measures lags so far behind, the initial costs are huge and the half-baked measures numerous. This problem has taken on major relevance for Sweden. Experience shows that it takes about ten years to arrive at an important new technical solution, one forceful enough to work major changes in society.

This inertia must be reckoned with in the preventive planning.

In the preventive work the demands made by society set reference points for some of the measures that must be taken. In the industrial activity of tomorrow firms will often be compelled to anticipate coming demands on their own, this because they probably will often be the first to come up with the problems. Even now, for instance, the manufacturer must certify the qualities of his products in compliance with the present legislation on toxic substancies. Demands that were formerly confined to the prevention of direct injuries have now been extended to prevent unnecessary wear and tear and to create optimal working conditions, where work satisfaction will enter in as one of the central issues. This development imposes a particularly heavy responsibility on the engineers.

The technical measures taken to date have been concerned to stay beneath the upper limits of different threshold limit values. They have greatly locked in the rate of technological advance—put it in the freezer, so to speak—at the permissible level. Once the stipulated limit value is allowed for with a margin to spare, the requirements are thereby held satisfied, and other inducements for reducing the percentages even more have usually been lacking. New gains from technology do not come unless the quest for new solutions is pushed ahead by the most powerful impelling forces. Here there has been no pressure or competitive squeeze of the kind that would get things moving, safety measures have been relegated to the background, and the technical innovations are conspicuous by their absence. In many cases nobody has even taken the trouble to find out about the great limitations that attach to the hygienic threshold limit values. These values are often based on experiences of relatively high exposures to specific substances or agents for brief periods—as it happens, many of the values are derived from animal experiments. We know more about acute effects than about chronic effects. Little is known about the synergistics effects of different substances or agents in interaction, but we know that they do occur.

More recently, support has been found for the opinion that reducing the total quantity of pollutants to which one is exposed over a lifetime could greatly reduce the morbidities and deaths from several chronic diseases. If the lifetime load imposed by polluted air in highly exposed areas were to be cut in half, diseases of the respiratory tract would decline sharply, to mention just one example. Air pollutants with that effect are to be found both in the workplace and outdoors. The best promise of achieving substantial reductions is to tackle pollution where the percentages are highest, that is at the places where people work.

It has been pointed out of late that the risk for chronic injuries is determined more nowadays by the minimum levels associated with prolonged exposure during a lifetime of work and during leisure time than by the magnitude of peak values, for instance in situations of smog in the big cities. From this it follows that attempts must be made at workplaces to keep the minimum levels as close to zero as possible. Further, a good case can be argued for bringing down the existing percentages at workplaces if people spend their spare time in polluted air. At all events maintaining the cleanest possible air at workplaces is strongly warranted on health grounds. To stay barely inside the threshold limit values set up for specific substances is no longer enough. This means that the limit-value principle should be regarded as one way of specifying minimum requirements during a first phase of industrialization, but that another principle must be adhered to in the next phase, namely the best-technique principle. That applies both to the external and the work environment. The best-technique principle implies searching in every situation for the best available production-engineering solutions even if the initial costs work out higher. It further implies that every kind of technical development work must promote the advent of new technical solutions which satisfy more stringent environmental criteria than the limit values in force up to now.
A close interplay obtains between the environment of work and the external environment—between microclimate and macroclimate. It is the strain imposed on man round the clock from all sources that is counted. From now on, therefore, every effort must be made to demolish the present contrived barriers between work environment and the surrounding environment. The crucial questions to ask are these: How shall we go about fashioning the best technical counter-weapons in the shortest possible time? and, What orders of priority shall we assign to them?
The different industries engaged in the production of goods and energy are now spending about SKr 5000 million per annum on plants and buildings. These same industries are also investing about SKr 6500 million per annum in machinery. A programme to improve the work environment in line with the present of aspirations would incur extra annual outlays in excess of SKr 1000 million.
Hence the massive effort of work environment cannot be implemented without affecting on the one hand the wage levels, i.e. the way of allocating wage costs into wages, social and health services, preventive measures against occupational hazards etc. and on the other hand the

ability to compete. This makes it important to have international rules concerning occupational health. International rules (conventions, recommendations, agreements) on aspects of health upon work environment may contribute to reduce these difficulties and will be of general value to protect and promote the health of man at work. However, it is not possible to abstain from national efforts while waiting for agreements for this purpose. The provision of greatly enlarged scope for technical research and development holds the key to desired improvements of the work environment at substantially reduced costs.

2.4 Ergonomic problems

2.4.1 What is ergonomics?

The word "ergonomics" is derived from the Greek ERGON (work) and NOMOS (law). It was coined in 1949 by the British psychologist, K. F. H. Murrell, as a composite name for aspects of man at work taken from the fields of anatomy, physiology and experimental psychology. Although the original definition will be retained in this report, it should be noted that the purview of ergonomics has been gradually enlarged for certain purposes. A case in point is systems ergonomics, a field which seeks to develop methods for a broad analysis of the interaction between man, machine and environment. Another common extension of the term involves its use as a pedagogical concept in the training of engineers and other "technical planners". In both these instances ergonomics, in addition to drawing upon the fundamental disciplines mentioned above, has come to embrace data from other areas, especially industrial and environmental hygiene, differential, educational and social psychology, cybernetics and technological work science.
Regardless of whether the subject matter of ergonomics is defined in the original narrower sense or more broadly, its practical application relates to two main areas:

- The adjustment of man to work and the work environment with the aid of vocational counselling, education and training, suitable job placement, follow-up of work adjustment and different measures of habilitation and rehabilitation.
- Technical and organizational adjustment of work and the work environment to human needs, capabilities and limitations.

While both these applications are obviously important, it may be observed that the focus of practical concern has gradually shifted towards the latter. Hence ergonomics is often defined nowadays as a technology based on human-biological and behavioral-science data. One explanation for this shift is that the human work situation, in consequence of technological advance, tends to become more complex than in the past, which makes it all the more imperative to give thoroughgoing consideration to man's working capabilities already at the planning stage. As an example of what the term, ergonomics, signifies for many initiates in Scandinavia, we quote the following excerpt from the statutes of the Nordic Ergonomic Society, which was formed a few years ago:

> "The Society's objectives are to disseminate more profound knowledge of the interaction between man and the environment in which he lives and works, and also to foster applications of such knowledge to the design of that environment, with consideration given to human needs and capabilities, safety and health."

The practical goals that are envisioned in the larger society from application of all the knowledge which has been more or less pinned with the "ergonomics" label may largely be subsumed under the following heads:

(i) Protection against accident risks.
(ii) Promotion of employee health, partly from the prevention of occupational diseases and partly out of regard for the work-related role of other illnesses.
(iii) Prevention of fatigue and discomfort.
(iv) Attainment of psychologically acceptable working conditions.
(v) Adequate utilization of the human work effort.
(vi) Design of suitable jobs for all segments of the population.

As a matter of course, the degrees of urgency attached to these practical goals will remain irrespective of whether a certain part of the future factual base and its use will be called "ergonomics" or not.

2.4.2 Physiological problems of work

A powerful tradition of fundamental research on physiological problems of work has long flourished in Scandinavia. This must be seen as background to the early interest that was also taken in applied industrial physiology, as well as to the subsequent pursuit of physiological studies of occupational work on a fairly large scale. It should also be noted that these applied studies have lent themselves to integration at many points with fundamental research.

The exploratory investigations of the physiological work load in different sectors of the economy that have been going on in Sweden since the early 1940's afford certain opportunities for assessing the development. As to the energy demands of work, it can be established that a great many heavy jobs are still left. For instance, this is true of logging, where operations performed with power saws are every bit as arduous as the earlier use of handsaws, axes and bark spuds. Other jobs that still require much physical exertion are to be found in construction, stevedoring, manual loading and materials handling (as in the manufacture of steel, pulp and food products) and in the work of warehouses and shipping departments. At the same time, it has of course been found that mechanization often eliminates heavy operations. This has been observed, for instance, in the recurrent studies of steel mills that have been made in the past twenty years, as well as in mining and the fully mechanized logging that is now being developed. However, a typical result of many studies is this: although the aggregate work load in the course of a working has admittedly diminished, momentary peak exertions are still necessary—a demand that older personnel find especially hard to meet.

Other physiological studies have had to do with the heat load. Here again the rationalization process appears to have left the conditions unchanged in some cases if it has not actually made them more arduous, a fact that has been observed in certain machine shop tasks and in the metallurgical industry. In other cases mechanization has helped to reduce the heat problems; this was one of the findings from the steel-mill studies referred to above. That cold is also deserving of attention in contemporary occupations has become apparent from studies of the food processing industry and in connection with physically light mechanized jobs performed outdoors.

One problem that has undoubtedly taken on greater importance in many places is the physical load imposed by having to work in cramped or abnormal postures as well as by rapid, repetitive operations which have to be done by hand. These questions will be further discussed under the next heading. Suffice it to mention here that this kind of work, apart from its topical effect on muscles, back and limbs, also may subject the heart to considerable strain. This may come from prolonged standing, from static muscular exertion, from work which engages the small muscles and from work with the arms held in elevated position—in short, in connection with the performance of many tasks that are common both in factories and offices.

Another fact that should be noted is that the physiological load both in energy-demanding work and in troublesome work postures and motions will greatly depend on the extent to which the performer can vary his task and set his own pace. The opportunities for exercising such options are still good in, say, manual woodswork and many construction jobs, and work of this kind would indeed appear to be sometimes better suited to elderly people than jobs which require less energy but are more constrained. Although the psychological problems related to monotonous and controlled assembly-line production are often emphasized, it should also be noted that the physical load may be unexpectedly high owing to constraint and standardized work speed in connection with, e.g. line jobs and manual machine-tending.

Increasing mechanization has brought with it another problem: the poor stamina that results when light work is combined with low physical activity away from the workplace. A matter of longterm sociomedical concern is the likelihood that lack of exercise contributes to degenerative diseases, especially of the cardiovascular system, with its implication that ongoing mechanization may entail risks of greater morbidity of this kind. It follows that great importance is attached to the effective pursuit of physical training.

The foregoing exposition traces developments up to the present day, and with that as the starting point we can speculate on the future significance of industrial physiology problems as follows:

(i) Continuing mechanization will obviously shift more of the load on to machines, which among other things will lower a now common barrier to employment, especially of older persons. However, machine work often creates other kinds of barriers, which means that research will have to pay greater attention to such things as working postures, perceptual abilities and physical factors of environment.

(ii) The tendency towards deteriorated physical condition in consequence of lighter jobs presents a medical problem that is likely to become more and more common.

(iii) Some tasks or operations are hard to mechanize and may be expected to persist, at least in part. As a result they will probably continue to remain important barriers to the employment of middle-aged and elderly persons. Further, momentary peak exertions of the type here indicated have the drawback that they often give poorer training than more massive physical labour, for which reason some of them may come to be performed with inadequate working capacity.

(iv) Constrained work on assembly lines may impose a heavy physiological load even if the job's energy demands are moderate. The cause may lie peripherally in the muscles, in that the performer cannot rest when his body needs it most. It may also be bound up with the greater strain imposed on the blood circulation by prolonged standing or some other unvarying posture. The practical significance of these conditions has yet to be fully investigated.

(v) Many environmental factors, such as heat, carbon monoxide and high altitude, increase the physiological load from a given quantum output of energy, a datum that must of course be taken into account in the future technical planning.

2.4.3 Problems of a functional, anatomic nature

According to a questionnaire which the Swedish Confederation of Trade Unions (LO) recently circulated to its members, problems associated with health risks at the workplace were reported by more than 80 % of the respondents. By far the most common problem, to which more than 50 % of the respondents attested, had to do with strains of a mechanical nature. This problem is also illustrated by the official statistics on occupational diseases in Sweden, where between one-third and one-half of all the annually recorded cases fall under the head of mechanical strain. To shed further light on this problem, it can be mentioned that the number of applicants for government programmes of occupational welfare on account of motor handicaps rose by 153 % between 1960 and 1968.

These problems intertwine at many points with the physiological load mechanisms that were discussed in the previous section, e.g. the circulatory strain of prolonged standing and, for that matter, sitting postures as well. However, here we come upon a number of sub-problems that deserve illumination from two other angles, namely muscular physiology and anthropometry.

As regards athropometric measures of relevance for design of the workplace, Sweden is in the fortunate position of being able to draw directly upon much of the comprehensive statistical evidence from the United States, the greater part of which has been obtained from measurements of military personnel. Although measures of this type have been chiefly used in residential planning, it is not until recent years that they have been more widely made to underpin the design of machinery.

Under the head of back problems, investigations have shown that about three-fourths of all people sooner or later contract back ailments of one kind or another. No clear-cut distinctions are observable in this respect between light and heavy occupations. Even so, a bad back and a heavy job naturally entail practical problems of a quite different order by comparison with a light job. Yet many light jobs also have their problems owing to rigid postures. An important aspect of ergonomics is to make work easier on the back by simplifying lifts of burdens and improving postures at the workplace.

The design of motion patterns based on guidelines from muscular physiology will assume constantly growing importance for future work layouts. One important thing in this connection is to estimate the additive effects on muscular activity imparted, for instance, by mechanical vibrations.

All these matters that have to do with suitable postures and opportunities for adequate motion patterns may be expected to carry over into the future. Not only that, but they may well intensify because the rationalization process, unfortunately, often results in more stationary workplaces with their concomitant risks of constrained postures as well as monotonous and "programmed" motion patterns.

2.4.4 Psychological problems

The mechanization and automation of work processes has been accompanied by a growing interest in man's mental capabilities. Data taken from experimental psychology have laid the foundation for man—machine psychology and systems ergonomics. Many of the problems analyzed in this category have been of an informational character, the object being to shape an environment that facilitates the exchange of information between man and machine. Its principal applications for the present have been in traffic engineering and the military sector. An industrial application did not begin to acquire appreciable extent until more recently, in that practical actions have up to now been mainly based on relatively simple rules of thumb. These problems may be expected to take on considerably increased importance for the future.

Another significant area of experimental psychology has to do with the feelings of exertion and comfort induced by different occupational and environmental factors. These matters have long been analyzed with reference to specific environmental variables, in particular temperature conditions, for which investigators have designed comfort indices of the effective-temperature type, etc. A great deal of experimentation

remains to be done in this field, where the object in respect of different variables is to standardize the tolerance limits for human comfort that should underlie the planning of workplaces. These tolerance limits usually lie in the "subclinical" field and are often much narrower and moreover harder to define than the tolerance limits that must be applied on medical grounds.

A third important area relates to stress research, which is concerned with the biological defence mechanisms that are triggered off by and are common to a great many stressors of a physical and mental nature. One focus of current research is to find out what practical significance reactions can have, for instance as cause of diseases of different kinds, a field that still remains unclear at many points.

If problems of the work environment are tackled from an overly narrow ergonomic angle, it will obviously be found that man often does not react in the expected manner. Man forms part of a social system that also affects his perception of the work environment and his ways of acting. Ergonomics must therefore be fitted into a holistic approach to the study of environmental problems at the workplace.

2.5 Sociological and psychological aspects of the work environment

2.5.1 General remarks

In recent years continually growing importance has been attached in Sweden to psychological and sociological aspects of the work environment, which may now be said to form an integral part of those measures of practical policy that are taken to improve industrial safety and the human condition in the industrial setting. It may be assumed that this is mainly bound up with increased aspirations in consequence of a higher standard of living, better education and a labour market which, generally speaking, has long been characterized by a shortage of labour. Increased knowledge on the strength of psychological and sociological research has probably also contributed to this development, for instance from analyses of the connections between production engineering and work satisfaction.

2.5.2 Value-based premises

The fact that dissatisfaction with and alienation from work are now widely regarded in Sweden as important social phenomena may be linked to at least four different value areas. *First,* under an *economic* set of motives, work satisfaction and work involvement are supposed to be conducive to higher performance levels and/or lower labour turnover and absenteeism. Although research has not been able to provide conclusive findings in this matter, a large number of investigations show that labour turnover and absenteeism tend to increase with greater alienation, especially if a shortage of manpower prevails on the labour market at the same time. In Sweden there is now a widespread tendency for young people to shun factory employment, apparently not so much because of the renumeration offered but because the industrial environment looks unacceptable to them on physical and social grounds. The manning problem is especially difficult for large, highly rationalized firms with a high proportion of repetitive and constrained jobs. It is obvious that this greatly induces the firms to interest themselves in environmental issues.

Second, there is an *ideological motive* which stresses the intrinsic value of work satisfaction. Democratically governed societies have generally accepted values to the effect that an individual has the right to a meaningful and interesting job, the right to influence his own working situation, the right to freedom from arbitrary behavior, physical and mental attrition etc. The individual's reaction to work therefore becomes essential for its own sake, irrespective of whether any direct connection can be demonstrated with productivity or some other economic measure. In other words, the incidence of work satisfaction or alienation can be seen as manifesting how well the machinery of production is able to accomodate certain real human needs. Norms of this kind appear to be widely diffused, especially among younger and better-educated groups.

Third, there is a motive which emanates from the value area of *health*. This builds upon notions of a relationship between health and alienation. The starting point here is an assumption that self-esteem is strongly rooted in work for most people in Western societies. Work and its connection with education and income constitutes the major stratification variable in these societies. Status at the workplace generally determines status in the larger society. Due to the influences exerted by the Protestant ethic and other culturally conditioned factors, it is probable that most people look upon work as a socially necessary and hence positively sanctioned act. These factors, moreover, make it likely that most people perceive work to be one of the most important life areas. Given this background, it seems reasonable to assume that the potentials of work for satisfying ego-related needs bear not only upon work satisfaction but also upon general life adjustment or mental health. Working conditions

that afford limited opportunities for influence, perceived meaningfulness and self-realization tend not only to reduce work satisfaction but also to instill feelings of inferior ability and prestige in the larger society and to diminish general life satisfaction. It also seems reasonable to assume that impaired self-esteem correlates with the increase of certain physical ailments. Investigations carried out in various countries, among them the United States and Sweden, indicate that certain general relationships of this kind may exist.

Fourth, the latter-day Scandinavian discussion of how jobs are organized has been linked with the *issue of industrial democracy*. This approach entails certain notions that the realization of broader influence for employees at the workplace presupposes a greater degree of self-determination and responsibility in the daily work round. Unless these preconditions are met, reforms of the economic/political structure will not assume any real significance for the ability of individuals to influence decisions, and as such will not affect their work satisfaction, either. Conversely, it is assumed that greater self-determination and responsibility at the workplace will create a more active orientation to work and thereby intensify demands for influence over decisions, including those which have to do with the general management of the firm. These notions have very much permeated the current experiments with deepened industrial democracy that are now under way in Sweden in both the private and public sectors.

The Swedish debate on social changes in the work environment dwells for the most part on two main aspects, namely the way in which the system of authority is designed and the fragmented, constrained nature of work. The first of these aspects is dealt with elsewhere in this report and we confine ourselves here to making only a couple of observations: *first*, that ways and means of strengthening representative democracy in firms are being intently discussed in Sweden at the present time, especially in terms of how the changeover from joint consultation to employee power, is to be effected; and *second*, that demands have been raised insisting on greater influence for the trade unions over the social and physical environment, inclusive of production engineering, personnel policy, occupational health programmes and the like.

This means that an important segment of the questions which bear upon democracy in the firms can also be assigned to problems of industrial safety and work environment in the broad sense. Deepend industrial democracy and better industrial safety both aim to bring about a more human work environment.

2.5.3 Research on productivity and work satisfaction

As will have emerged from the foregoing discussion, it is widely felt in Sweden—on various grounds—that the individual's reactions to work and the work environment represents a value of cardinal importance for the larger society. With that as a starting point, it becomes an important problem to find out whether mechanization and rationalization—which aim at more efficient and profitable forms of production—are achieved under certain conditions at the expense of work satisfaction and result in low assessments of work as a source of needs satisfaction.

A great deal of research has sought to clarify the significance of work content and job design for individual satisfaction from and involvement in work. Most of the investigations under this head proceed from an assumption about a set of needs common to all people in our civilization. These needs may be classified as follows:

(i) Needs related to the individual's *physical existence*, such as adequate income and safety of life and limb.

(ii) Needs related to the individual's *security*, such as security of employment, freedom of choice on the labour market, and freedom from arbitrary conduct.

(iii) Needs related to the individual's *self-esteem and prestige*. In this category we include the need of a job that is adequately related to the individual's physical and mental resources, the need of variation and diversity at the workplace, the need of work that is meaningful, the need of influence and control over one's own work situation, the need of social interaction and valuative participation in the working unit as a social system, the need of opportunities for self-fulfillment from work.

The satisfaction of these needs through work will largely determine how the individual evaluates it. Of particular importance for a positive nexus to the job is that the needs which are related to the individual's self-esteem will be met at the workplace. When these needs are blocked, the result will be to generate one or more of many alternative reactions. The individual may react aggressively, resist change, leading to wildcat strikes in the extreme case; or he may react by quitting his job, asking for a transfer, absenting himself frequently or falling ill. From the individual viewpoint these behaviors are both rational and legitimate, and may be seen as different ways of defending himself against a system whose conditions he cannot accept. One of the most common reactions,

however, entails a more passive form of adjustment, one that downgrades the job as a source of needs satisfaction. Work is regarded as no more than an instrument for the creation of resources capable of satisfying needs away from the workplace, as by different forms of consumption. This instrumental attitude is widespread in present-day industrial society and partly has to do with the way in which we have built up our workplaces. Swedish investigations suggest that, on an average, about two-thirds of today's industrial workers embrace an attitude of this kind. Moreover, this psychological attitude to work becomes more pronounced the more repetitive, unskilled and constrained a job is.

Establishing a positive nexus to work seems to depend in particular on catering for those needs which are related to the individual's self-esteem. Two aspects of work organization and content seems to describe the essential prerequisites for ego-relevant satisfaction of needs from work: *first*, the degree of freedom enjoyed by the individual in regard to determining for himself the planning of tasks, working methods, the pace to follow, the taking of contacts, the performance of work according to various alternatives, the improvement of his performance and the further development of any personal aptitudes he may have; and *second*, the qualification requirements that any one task on the individual's creative talent, i.e. on his proficiency, initiative, independence and contact ability so that the task will be satisfactorily performed.

The greater the opportunity that is given at work (up to a certain limit) for free and skilled action, the better will be the prospects in hand for satisfaction of ego-relevant needs.

To judge from the development that the industrial system has taken so far, the following characteristic features may be ascribed to it.

A guiding principle has been to distinguish between the performance of work operations on the one hand and their planning and control on the other. The latter tasks are entrusted to highly-skilled workers whose conditions of employment are such that their loyality can be more or less taken for granted. Further, successive endeavours have been made to break down the operations into the smallest feasible number of components and to keep training and learning time as short as possible for the labour force. The coordination and control of all these sub-functions have been delegated to supervisory personnel at different levels, which has led to the pyramidal structure of organization with a single control authority at the top. Rigorous rules and administrative procedures which regulate order and discipline have also been deemed necessary. Incentive wage schemes have been used to link the individual's interest in good earnings with the firm's interest in good performance, and have thus induced him to loyally accept the objectives of the economic system.

Added to the foregoing is the fact that technological advance and the development of work practices have proceeded in parallel with a trend towards larger and larger plants or units of production. This increased bureaucratization has conferred certain advantages, for instance as regards security of employment, better job assignment (fewer "square pegs in round holes"), more objective assessment of work performance and greater opportunities for occupational and social advancement. However, the large, bureaucratically ruled enterprise also brings with it greater demands for advance planning and formal channels of communication, greater separation of different functions etc. In consequence the individual forms a less comprehensive view of the firm as a social system and enjoys less influence over his own job and its design.

The implications of this type of work organization and job design have come in for a good deal of attention in recent years. Swedish research shows that, on an average, people who perform repetitive and constrained tasks derive less satisfaction from their work and feel it to be more stressful and coercive compared to workers in more complex and skilled jobs. These differences cannot be explained by differences of age, sex or income, but subjective feelings of poorer work satisfaction appear to be more widespread among young persons with a good educational background if these are placed in repetitive and unskilled jobs.

Research has also shown that these feelings correlate with an instrumental attitude to work, i.e. the individual focuses exclusively on the earnings from work. Feelings of poorer work satisfaction also seems to correlate with a higher rate of absences, lower self-confidence, a lower general life satisfaction and with psychosomatic disorders. In addition, certain research findings suggest that fragmented and constrained work and the alienative attitude to it can be defeating of efforts to interest broader groups in involving themselves in the firm's decision-making processes.

2.5.4 Current development tendencies

Experiences of this kind make it legitimate to address serious criticism to present-day production technology. Future endeavours must concentrate on enlarging the individual's scope for exercising personal control and giving him more opportunities to make use of his skills. A

course of events in that direction would seem to be particularly necessary having regard to the higher educational attainments of the population. As mentioned earlier, recruitment problems are especially severe for the large, highly rationalized industries which operate in expanding segments of the labour market. Most adversely affected are the plants which are characterized by repetitive, machine-controlled jobs and/ or otherwise inferior work environments with their concomitants of noise, strenuous working postures and the like. It should also be pointed out that many of these jobs are paid at piece rates. For the time being firms are able to cope with their recruitment problems by resorting to foreign labour or to women. Certain tendencies are also observable for firms with hard-to-fill jobs to locate in parts of Sweden where labour is in better supply. While such a policy is understandable from the viewpoint of corporate managements, it needs to be stressed that solutions along these lines cannot be considered satisfactory when a broader perspective is applied, partly because they run counter to longer-ranging solutions of environmental problems in the job world, and partly because they run counter to the political quest for greater equality in the job world and in the larger society.

It is reasonable to assume that the longer-ranging solutions will have to aim at work environments which look satisfactory to the labour force as a whole. Among other things, this means that jobs must be organized to provide scope for a higher degree of self-determination and better potentials for turning all the facets of human ability to useful account. This kind of thinking comes into conflict with time-honoured principles of work organization and for some firms may well imply lowered productivity and difficulties of continuing production inside the country's borders. However, a number of firms have embarked on large-scale programmes of experimentation involving broader definitions of job responsibilities, delegation of decision-making powers, alternatives to assembly-line methods of production, etc. Similar efforts are being made under the auspices of the Development Council for Cooperation Questions, a body jointly sponsored by employer and employee interests, and the Industrial Democracy Delegation, which is run by the government. Ambitious experiments are also being pursued to have straight piece rates to a greater extent replaced by alternatives in the form of mixed rates or a straight hourly rate; the trade unions have also put forth demands for the adoption of monthly salaries.

While it is still much too early to pronounce definite judgment on the experiences that have been gained, a great deal of evidence suggests

Table 3. Connections between degree of mechanization and work content

Mean values, 5-point scale. High values = favourable prospects for satisfaction of ego-relevant needs from work.

Psychologically relevant job characteristics. Ratings made by technical experts in collaboration with company executives and trade union officials	Degree of mechanization		
	Low n = 161 Craft production	Medium n = 137 Machine-controlled, repetitive	High n = 54 Process monitoring
Freedom of physical movement	3.85	1.70	3.52
Variety of tasks	4.83	1.47	3.96
Attentiveness required	2.95	2.97	2.35
Self-determination and personal control over work performance			
— working methods	3.36	1.10	1.96
— sequence of operations	3.53	1.01	1.94
— pace of work	4.35	2.04	1.52
General influence over work-related decisions	3.22	1.28	3.09
Freedom of social interaction			
— may take contacts provided this does not disrupt work	4.80	1.77	3.39
— opportunities for initiating contacts	4.86	2.42	3.63
Economic responsibility			
— tools, equipment, machinery	2.68	1.39	3.52
— materials and products	3.51	1.75	3.32
— course of work	2.26	1.88	3.88
Vocational training required			
— enough to grasp production relationships	4.20	1.48	3.50
— enough to cope with present position	4.99	2.44	3.57
— enough to come up to normal earnings (for a trained new hire)	4.46	2.61	1.30

Source: Gardell, B. (1971)
Production Engineering and Work Satisfaction
Swedish Council for Personnel Administration, Stockholm

that the measures taken have in any event led to greater work satisfaction—and in many cases to increased productivity and lower absenteeism as well. None the less, it is also obvious that gains in work satisfaction and health will only be achievable in many cases at the price of losses in productivity. The question of whether or not such a development can be considered acceptable will probably become a central issue of collective bargaining and public policy during the 1970's.

Another main line of development towards more favourable work environments may be inherent in greater automation, both in the form of a growing proportion of process industries and in the form of increased investments which aim at having machines take over the repetitive tasks that are now performed by human labour. Certain investigations suggest that freedom aspects as well as the qualification requirements connected with high degrees of mechanization may be restored to values resembling those which inure to craft methods of production, even though the tasks involved are otherwise of very different character. From the psychological aspect the obvious differences between craft methods and the kind of work performed in highly automated processes are of minor importance, whereas the similarities in terms of self-determination and qualification requirements are strikingly great. This may be illustrated with the table below, which sets out the values for a list of psychologically relevant job characteristics. In repetitive tasks that are controlled by machines, i.e. the jobs which are least satisfactory in the eyes of labour, the constraints on freedom and qualifications are considerable; in the monitoring of processes, by contrast, the tasks again become less confining, monotonous and socially isolating and demand a greater measure of education and responsibility. In a great many studies it has also been shown that these jobs are much more greatly esteemed by the workers concerned, even though their performance involves shift work and some monotony and stress are felt on account of under-stimulation.

It should be stressed, however, that increased automation does not necessarily bring improved work environments and more interesting tasks in its train. In a great many cases increased automation has led to more constrained and monotonous work. If this trend is to be checked, we must at the same time formulate *social goals* for advancing technology, in other words consciously exploit the technical potentials for bringing about greater influence over the performance of work and greater responsibility for the workers concerned.

3 The welfare concept as seen by industry, the society and the individual

3.1 Introduction

GNP is considered as an adequate analysis of production capacity. However it has not been designed to evaluate health and social welfare and can thus not be used as a measure of society's aggregate welfare. Once the standard of private consumption has reached a higher level, greater emphasis is put on demands to protect the natural environment and to improve the work environment. There is growing awareness that economic growth (the increase in GNP), unless it is deliberately controlled, often conflicts with these environmental values. A measure of the society's welfare must be sensitive to changes in values. Since the strength of environmental preferences is hard to evalute in monetary terms and since a given GNP can be attained with or without paying regard to changing values, GNP can never be more than a partial measure of welfare. However, these are weaknesses that attach to every measure of welfare. Inasmuch as welfare is a concept with many dimensions, we cannot expect all its aspects to be reflected in a single measure. With regard to the above mentioned aspects of health and welfare and the need for a welfare measure, we must study the construction of GNP more closely.

If we disregard short-term fluctuations in the utilization of resources, GNP may be called a kind of index that measures the capacity of the national economy to produce different goods and services. The determination of GNP implies weighing together the produced quantities of goods and services with their relative prices as weights. If the assumptions of theories of competition formulated by the economists are met, the system of weights (the relative prices) reflects, on the margin, the value of productive resources in alternative uses. If these extremely stringent conditions are fulfilled, the production mix will agree with the prevailing preferences of society. However, this "theory of harmony" is beset with crucial shortcomings, which are also bound to appear in the GNP measure. Apart from the strictly technical problems of measurement which arise, the measure is unable to shed light on problems of income-distribution. This is serious, since the distribution of incomes directly affects the demand structure and thus the production mix. The structure of preferences also affects the composition of GNP, but

competition theory does not try to explain how preferences originate. But what is more serious for the treatment of environmental factors is that only preferences concerning goods and services priced in the market directly influence the composition of GNP.

When changes in production technique are to be made at a workplace, it is often easy to calculate changes in the capacity of capital equipment. How the employee will be affected by the new environment, usually is given little thought. The welfare changes that arise concern the decision-maker only if they result, by way of changes in productivity, in altered quantities and prices of the goods produced. Unfortunately, the interval within which environmental deterioration results in welfare losses, without adversely affecting the production result, is often rather large. When negative effects on physical and mental health become apparent, it is almost always difficult to attribute them with certainty to a specific environmental change. Only a limited portion of the medical costs needs to be charged to the production process that has caused them.

These indirect negative consequences of production decisions are just as difficult to calculate when they bear upon the natural environment. GNP is not affected by environmental deteriorations except as they change the costs of producers or the preferences of consumers. The consumer's ability to express this environmental preferences is usually limited to political manifestations. Stronger environmental preferences are bound to induce the politicians to assign lower priority to economic growth (increase in GNP).

The case for including investments in GNP may be argued by saying that they point to production capacity not only in the present but also in the future. For the rest it can be said that the price system gives information in only a very restricted sense about expectations of and preferences for the future. If environmental preferences are further strengthened in the future, the GNP-based planning now being done to come to grips with anticipated bottleneck sectors of production will have to consider one way or another also the aspects of human environment in planning the society's future welfare. There is in Sweden as in many other countries a great interest in cost-benefit studies, evaluating the effects of medical, technical and social preventive measures. General methods covering the whole field of health and welfare are difficult to find and many cost-benefit studies will have to be limited to special problems of health and welfare.

3.2 Economic prerequisites of industry

The increased output and productivity of industry have been achieved by means of ongoing rationalization, based primarily on innovations in the technical sphere and in administrative techniques. To technological advance may be attributed the advent of new materials, new manufacturing processes, new designs, improvements in communications, and mechanization of the decision process through the use of computers and other automatic aids. Classifiable under the head of administrative techniques are measures of the kind that create economies of scale from mergers, greater flexibility in the firms, and so on.

Pari passu with this rationalization process, the employees conditions of work in individual firms have undergone changes with reference to the organization of work, job qualifications and the work environment.

These changes have had positive as well as negative effects for the people concerned. Among the *positive* effects, the greater opportunities for higher standards of living enjoyed not only by the privately employed labour force, but also by the larger society, deserve particular mention. In the first phases of this rationalization process the employee organizations have been mainly concerned to improve their positions with a view to sharing in the production increases. They have successively focused on standard improvements of an economic and social nature as well as on various aspects relating to greater security.

A number of other positive effects have also flowed from the development insofar as mechanization has absorbed many types of arduous, dirty or hazardous work formerly performed by human muscle. It has been possible to eliminate many hazardous environments, especially with reference to accidents and acute risks, to the extent that technology has helped to remove people from direct participation in the handling of goods, the processing of dangerous materials etc. Because of mechanization in general and automation in particular, human inputs in several sectors, especially the processing industry, have been transferable from direct participation in the process to monitoring and controlling functions. The exploitation of technical know-how in construction work has made it possible to build more hygienic and pleasant workplaces.

Among the *negative* effects, it may be mentioned that problems of occupational hygiene have mounted in pace with a constantly growing volume of chemical products whose consequences in this respect have been difficult to foresee. Mechanization has also brought in its train, pari passu with increased production effect, aggravated problems with risks of this kind, such as increased quantities of dust, higher noise levels

etc. The emphasis on profitability, as defined on efficiency and economic grounds, in the introduction of new processes and new materials has often meant that aspects of occupational hygiene are overly neglected. A case in point here is asbestos, which from the technico-economic viewpoint has proved to be a highly useful material in a number of technical products, but whose grave hygienic consequences for the labour force came to be realized much too late. Mention may also be made of the so-called jet scorching in the stone industry, where a new technique for breaking stone has achieved major gains of efficiency but at the same time brought with it two undesirable by-products: very high noise levels and considerable dust problems with concomitant risk of silicosis. These examples could be multipled many times over.

Rationalization in the form of batch production in mechanized processes has built upon an organization of methods according to the principle, "A job is best performed if it is performed after a predetermined method in a predetermined way at a predetermined time". This principle very much applies to a widely diffused type of work organization where people are tied to short-cycle tasks in assembly-line work, machine operation, inspections etc. Moreover, the present tendency is moving towards a high degree of task specialization which compels the individual to adapt physically to the design of a machine or the layout of a process. Even though we have more and more come to appricate the merits of the science called ergonomics, it must be established that vast problems have piled up over the years due to process layout and machine design, with far too little regard paid to man's physical and mental capabilities. The result has been a sharp rise in the incidence of stress-caused ailments of one kind or another.

As new types of work organization have taken shape, the problem complex has shifted its pivotal emphasis towards psychological and sociopsychological problems which have to do with lack of freedom, control, isolation tendencies, communications and so on. While these problems have been described at greater length earlier in this paper, they should be emphasized in the present context because of their greater visibility and their close connection with health aspects.

The rationalization process has led to demands for greater flexibility. People have been compelled to accept readjustments both in the individual firm and in the labour market generally. In the large firms enterprizes production tends to become more and more uniform, in the direction of what is called "standard performance" in job analysis. Due to methods planning, wage payment plans and the like, employment problems arise for sections of the labour force whose capabilities are limited in one way or another. This complex of problems visits its most severe impact upon elderly workers, for whom less and less accommodation can be found within the framework of structural change in the industry. Wherever firms are rationalizing or unprofitable firms are going out of business, one finds that these disadvantaged members of the labour force are hit the hardest.

Obviously, the industrial community itself has become increasingly alerted to the negative consequences of this development. Collectively bargained agreements between the labour market parties have gradually evolved a number of programmes that embody guarantees to cater for the employees in their needs of security, health and work adjustment. As far back as the 1940's the foundation was laid for a cooperative effort aimed at improved conditions of industrial safety and personnel planning. Corporate managements have increasingly co-opted staffs of experts to deal with employee welfare and occupational health. To a great extent, however, these measures have been cast in a remedial and rectifying mould, this in order to conform to a technology and a work organization that are already hard and fixed in a great many respects. Not until a relatively late phase comes the realization that these functions must be built into the corporate decision processes in such a way as to make a really effective contribution towards influencing the more basic determinants of the production process itself.

It was during the 1960's that the work environment first became a topic of really widespread debate both in the job world and in the larger society. In the past few years the trade unions have undertaken a number of studies to find out how people perceive the environmental situation at the places where they work. The findings of these investigations indicate the existence of a pervasive anxiety as regards both the physical and mental risks to health under present-day working conditions. From the purely microeconomic aspect, it is quite obvious that the firms incur heavy costs due to such negative consequences of the rationalization process. A tendency towards higher rates of labour turnover is observable, which is especially pronounced for firms with a high degree of specialization and batch production. Indeed, for some firm these rates are now running above 100 %.

Illness-caused absences in all branches of industry present another formidable problem. The fact that absence rates average about 10 % in manufacturing industry alone makes it necessary to overman the labour force commensurately.

Swedish firms, especially those located in industrial centres, have to cope with great recruitment difficulties. To a great extent they must try to import foreign labour, at the same time that they find it more difficult to assign suitable work to the older and partially disabled workers who are already employed with them.

Even though the industry has become more attentive to these negative consequences of the rationalization process, it has been difficult to analyze them with the available tools of business economics. The same applies to the society at large, whose instruments for measuring welfare increments and welfare losses cannot readily accommodate social and environmental consequences of this kind. None the less, the industry and the society have largely achieved consensus as to the more economico-technical goals of industry, that is to say, increases in production contribute to increments in social welfare. This may well explain the division of responsibility that has arisen between the two sectors according to the negative output that has unquestionably formed one element of the private rationalization process.

3.3 The society's social objectives

Pari passu with the rationalization process in industry (here understood to refer to all branches of economic activity), the society has built up different systems of social security to provide its citizens with security and greater equality to deal with life's vicissitudes. The postwar period has been especially productive in this respect with its provision for health insurance, occupational injuries insurance, compulsory retirement pensions and so on. The purview of government labour market policy has been more and more enlarged. One of its objectives is to assume responsibility for those who for various reasons connected with health and social disabilities are unable to cope on their own with their situation in the job world. This objective has become more and more difficult to realize as policy aspirations have soared to higher levels.

The social costs in the aforementioned sectors have continually risen, at the same time that administrative agencies have had to struggle more and more with lagging resources in virtually all sectors. This is particularly true of the health and medical services, where the need of care has been mounting constantly. According to national accounts the overall costs rose by about 40 % in volume between 1965 and 1969 (see figure 3).

Under the head of social insurance, the past 20 years have witnessed

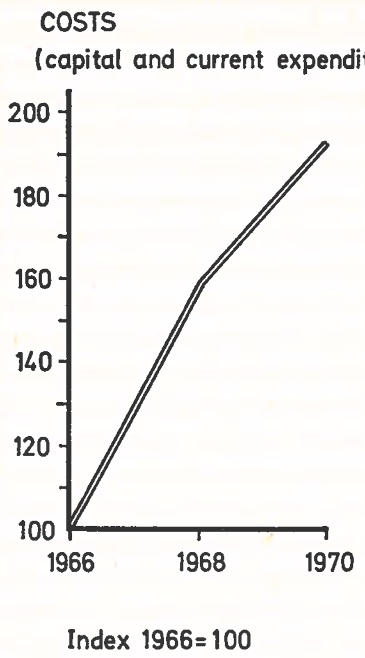

Figure 3
Capital and current expenditures in the medical services according to RUPRO 69 (the 1969 rolling-forecast survey)

several rounds of improvements in the compensation payable for illness-caused disability.

Over a period of ten years the level of compensation for health insurance scheme was raised from about 65 % to about 80 % 1966. Moreover there is a possibility by means of collective voluntary insurance, which is rather common, to increase this level of compensation to about 90 %.

Parallel with this trend there has been a steep rise in illness-caused absences from work, especially in manufacturing, where the average rate went up from about 5 % in 1960 to about 10 % in 1970. Many factors may contribute to this increase, which is difficult to analyze in detail.

A main objective of labour market policy all along has been to safeguard full employment. Under this head the National Labour Market Board has drawn upon a broad arsenal of instruments, of which the following may be mentioned: employment exchange; a regional develop-

ment policy to provide new job openings in communities with a weak economic base; occupational welfare schemes in the form of relief work, job training, retraining courses and sheltered employment in public workplaces; searching-out programmes to prepare for job openings; and inducements to private employers to provide semi-sheltered employment in firms.

Compared with other countries Sweden has been able to maintain a high employment level throughout the postwar period, with unemployment rates that have stayed within the range of 0.5—2 %. On the other hand it has become growingly apparent, especially during the past ten years, that these low rates have been maintainable only on the strength of ever-increasing public inputs as reflected by government programmes of assistance to the private sector.

The consequences of rationalization and structural change in industry have had most of their adverse impacts on elderly workers and those whose physical and mental endowments fall short of meeting the demands imposed by the contemporary work situations.

Thus the society has had to assume a mounting responsibility for measures of labour market policy addressed to these groups. However, the increased welfare services have also contributed to that larger groups than before have been recorded within the labour force, especially older persons and handicapped. This must be considered when figures of unemployment from different years are being compared.

It is possible to discern a trend in labour market policy from an earlier preoccupation with mediating between job-seekers and prospective employers, with its concomitant of temporary supportive measures, towards a policy that is more integrated with the business community. Lastly, the society has entered a phase where it must more or less reluctantly accept a situation of also having to assume the role of "meal ticket"; sometimes this means resorting to employers in an activity sector where production is not a primary but a secondary goal, this in order to satisfy the main criterion of giving jobs to that segment of the labour force which cannot find employment in any other way.

Most of the labour demanded by employers in 1970 was for people in the younger-age and vocationally trained categories. The demand figures ranged from 65,000 to 80,000 vacancies. At the same time about 85,000 persons were registred in occupational welfare schemes. As of the end of 1969, about 40,000 were receiving support from labour market policy in one form or another. If we compare the recession year of 1967 with the boom year of 1969, we find that Sweden had more unemployed than vacancies in the autumn of 1967 but only about 50,000 persons who were engaged in retraining, relief work or sheltered activity. Two years later there were twice as many vacancies, but right in the middle of the boom there were 65,000 persons at the receiving end of labour market policy, and of these a growing proportion consisted of people afflicted with handicaps of different kinds.

The proportion of older persons among the unemployed is higher than before. During the second quarter of 1970 an average 42 % of the unemployed registered with the employment agencies were 60 years of age or older as against 26 % in the corresponding period of 1968. Industry has substantially met its need of labour by bringing women into the job world or by importing foreign labour.

3.4 An integrated view of welfare

The grounds on which present measures of welfare are based are now coming in for more critical appraisal both within the industry and the society at large. More and more glimpses can be caught in the public debate of a widening gap between the welfare assessments that are made in the larger society and those that are made by the individual. In the final analysis, much of what the public sector does to improve welfare seems to boil down to no better than remedial measures that have to be taken to offset negative output from the private sector, and this aspect is being increasingly questioned. Constantly new demands for increased medical resources ultimately stem, perhaps, in large part from consequences of a work environment that is physically and mentally strenuous. Rising social insurance costs are probably related to medical, psychological and sociological consequences of the work environment and working conditions. Perhaps the constantly increasing demands for measures of therapy and rehabilitation to help the elderly and partially disabled, as well as the demands for public employment of individuals who cannot obtain jobs in industry, ultimately stem from rationalization endeavours that could be channelled into different courses if other values were postulated for them. One has to bear in mind also the influence of the expanded aim of social insurance upon its costs.

The focus of efforts is beginning to shift more and more from the remedial to the preventive. Above all, preventive efforts inside the industry in the form of environmental improvement, new forms of work organization and the technical design of jobs can help to lower costs and demands for resources in the larger society. In our society new

approaches of this kind will lead to increasingly greater integration between the respective inputs made by the private and public sectors. This new philosophy should confer on man the opportunity to work in an environment that satisfies his needs of physical and mental well-being.

4 Development tendencies in the field of work environment

4.1 Introduction

The term "environment" has a very broad definitional compass. People speak of the external environment, social environment, work environment and so on. The efforts in these different areas readily tend to fragment. In many cases the responsibility for these efforts is vested in completely separate administrative entities. Legislation in the different areas is based in different premises, the traditional methods of tackling the problems vary, etc.

In regard to the work environment two lines of development may be distinguished. On the one hand, the very concept of work environment has been broadened so as to keep pace with the course of events. At first problems of the work environment centered mainly around risk factors such as accidents and occupational diseases. With time, the concept was extended towards the adjustment of the productive apparatus to man's physical capabilities. In the terminal stages of this development problems of mental adjustment to work have also become increasingly exigent. Today, the term "work environment" is made to embrace the broad totality of aspects relating to human health and adjustment at the workplace.

On the other hand, it has become more and more difficult to draw the line between work environment and external environment. This holds in great measure for the hygienic aspect, where it has become increasingly imperative to view configurations of exposure in the work environment in relation to the total configuration. It also very much holds for the mental aspects of the work environment, where more and more attention is being paid to the significance of work and working conditions for the rewards from and commitments to the overall life situation.

Tendencies are now detectible in Sweden that appear to be moving towards a higher degree of integration in the environmental sphere. We are beginning to discuss the feasibility of introducing uniformity in legislation on environmental protection. We are trying to overhaul administrative procedures in different sectors of the total environment. The first steps to coordinate the education of experts on external environment and work environment are being taken. On the other hand,

the decision-making systems for the improvement of the external environment and for the improvement of the working environment have to be different.

4.2 The future national welfare index must better reflect environmental preferences

As pointed out earlier in this report, certain shortcomings attach to the use of GNP as a measure of the national welfare. It is characteristic of the changing values that have taken place in our country, especially during the past ten years, that ever increasing demands have been put on a work environment which guarantees health, employment security and work satisfaction to the individual.

Our problem today is that we cannot insert such factors into assessments of the national welfare. The present economic data base for welfare calculations is under critical examination both in Sweden and abroad. Different methods of weighting environmental and social factors are being tried out. But in spite of the mounting fire of criticism aimed at the current GNP concept, it has been anything but easy to find new and more inclusive yardsticks for this purpose. When a general assessment of the national welfare is not possible, studies of evaluation may be limited to special problems.

4.3 Problems of the work environment must be solved already at the planning stage

The industrial rationalization process has long been preponderantly controlled by economic-technical objectives. To a great extent the environmentally conditioned inputs have been inserted at a stage where the technological and organizational assumptions are already given. Although the occupational health services built up by the business community have admittedly been able to contribute substantially to the elimination of negative environmental factors, an inordinately high proportion of these efforts has been of a remedial character.

A typical feature of the latter-year development has been the growing quest to incorporate considerations of the work environment already at the planning stage. It is now possible to identify a quest within more and more sectors to accord an equal footing in the fundamental decision to matters that involve the physical, mental and social environment.

If a firm opts to impart such a direction to its corporate policy, it must be prepared to underwrite greatly increased investments costs.

4.4 Education and information are required for decision-makers

In a society where the environmental aspects assume ever-growing weight, the educational system must satisfy more exacting criteria. This applies not only to the education of experts on environment, but with even greater force in the form of supplementary knowledge to prospective decision-makers at all levels. In recent years a growing body of public opinion has favoured the adoption of courses on environment at different levels of education. Thus certain curricula of the upper secondary school have been offering instruction in ergonomics for the past couple of years. At the university level there used to be no environmental education in the undergraduate curriculum either for physicians or engineers. Provision for labour-science subjects will be made in the undergraduate curriculum of a new institute of technology that is now being planned. Medical education is strengthening the labour-science components in the undergraduate subjects of hygiene and social medicine. The liberal arts faculties are seeking to introduce courses in "environmentalism" which would lead to both first and advanced degree.

4.5 Development of occupational health services

Sweden has a long-standing tradition of occupational health services based upon employer-employee cooperation.

Problems of the work environment have taken on more and more facets. Managements and employee representatives are therefore compelled to evaluate increasingly complicated problems. Not only does this require a much broader framework of knowledge and experience for those responsible, but it also stresses the need for expertise on which to base decisions.

In the course of equipping the occupational health services of firms to deal with these greater challenges, two problems have dominated for the most part. First of all, neither managements nor unions have provided adequately for the training of labour welfare representatives. Second, there have not been enough resources to finance the additional manning of these services with medical and engineering experts.

The organized employers and employees have both invested huge resources in education. Agreements on educational and training programmes have been reached in the collective bargaining process. The public sector has also contributed by providing greater capacity.

Techno-medical preventive programmes have long formed an integral part of the Swedish occupational health services, though it must be

pointed out that their purview has been chiefly restricted to the larger firms. A cardinal goal is to expand occupational health to embrace all workplaces in the country. In 1967 the labour market parties agreed on guidelines for occupational helath, whose programme is largely based on the preliminary agreement of 1954 and on the 1959 recommendations issued by the International Labour Organization.

Since 1967 the rate of expansion based on this voluntary agreement has greatly accelerated. During the past few years this has chiefly involved small and medium-sized firms, which have pointly sponsored the formation of occupational health centres. About fifty such centres are now in operation.

The larger society looks upon occupational health as supplementary to the public health and medical services. Joint public-private bodies are being organized to plan the future expansion. Society ought to assume special resonsibility for the small and scattered firms that cannot solve their occupational health problems by merging with other firms.

For the moment the expansion of occupational health services is being retarded by the shortage of engineering and medical personnel. More engineers than doctors are needed in a ratio of about two to one. There are not enough trained engineers and doctors to fill all the available posts. From now on, however, the provision of greater resources ought to open up new opportunities for improved occupational health. A realistic assessment of the supply of doctors should be used to formulate guidelines for the allocation of doctors to this field. Moreover, other trained personnel are also in shortage, but society has made resources available for a vigorous enlargement of education in this sector.

If we look at the costs of administering occupational health services, their gradual expansion up to 1980 would require expenditures on the order of SKr 600 million in that year, figured at current prices, as compared with an estimated SKr 300 million in 1970.

4.6 Better means are needed to look after the individual

Sweden has a very high level of aspirations for the work environment. It is not enough for everyone to have a job, to be able to choose between different tasks and to obtain economic rewards from work, but the job should also be performed in an environment which meets reasonable demands of physical and mental well-being.

As will have emerged from the earlier exposition, this high level is hard to implement. That holds not least for the older labour force, for whom it is becoming more and more difficult to realize even the first criterion, namely thas everyone shall have a job. This problem has been most recently recognized in the draft of a new law intended to improve the employment opportunities of older persons. Among other things, the proposed law calls for serving longer terms of notice on older employees. In addition, society offers inducements to employers in the form of allowances to workplaces that are specially designed for older persons. Just as important as giving the individual a safe, secure job is to enable him to derive satisfaction from the work he does. In present-day Sweden we have reached the point where we uphold the individual's legitimate right to influence the conditions around him and his work. This influence may lie on different planes. First, the individual employee may exercise influence over his own work; and second, he may exercise influence over collective decisions. The latter decisions may be taken both indirectly, e.g. through a trade union, and directly by the individual himself.

At present there are three different activities in Sweden which tie in with these types of cooperation. First, a great deal of work goes into devising cooperative systems in firms. The reference here is to a new agreement on joint enterprise councils and to proposals for broadened employee participation in management. Second, programmes of personnel administration have been undertaken, at least in the larger firms, which to some extent amount to experiments in employee "development". The new agreement on enterprise councils identifies personnel and educational matters as particularly urgent for mutual consultation. Third, a pilot programme based on sociotechnical approaches is under way which seeks to broaden employee self-determination on the job, e.g. in the form om autonomous groups.

Most of the experiments and research in this area are sponsored by the Development Council for Cooperation Questions, jointly formed by the Swedish Employers Confederation (SAF), the Swedish Confederation of Trade Unions (LO) and the Swedish Central Organization of Salaried Employees (TCO), and the government-run Industrial Democracy Delegation. The Development Council has mainly pursued its work at "floor level", i.e. it draws upon sociotechnical techniques to change conditions on the factory floor. More recently, the Development Council has also begun to tackle problems of personnel administration, rationalization and board representation. By contrast, the Industrial Democracy Delegation has been concerned from the outset not only with sociotechnical approaches but also with cooperative systems. A number of experiments have also been initiated by private firms.

4.7. Legislation and inspection

Society must enact laws to lay down the demands that should be imposed on the work environment and to arrange for inspection and supervision to ensure compliance with statutory requirements. Developments in the field of work environment are moving swiftly. It is therefore necessary to revise the law constantly to keep pace with changes and new knowledge as they unfold. The present Labour Welfare Act in Sweden dates from 1949 and various amendments have been written into it since then. A government commission of inquiry appointed in 1970 has been asked to submit the draft of a new Labour Welfare Act. The terms of reference given to the 1970 committee say that it should be feasible to afford the employee with effective protection of his physical and mental health at every stage of production. For this purpose the law will insist on an interaction between preventive technical, medical and psychological factors. These should be addressed both to working conditions and the individual and serve the twofold aim of correcting deficiencies in the work environment and safeguarding health. The law should encourage measures that seek to adapt jobs to the mental and physical capabilities of employees and on the whole build up a work environment that permits the employees to feel satisfaction and derive pleasure from their work. It would also be desirable to consolidate this law with legislation that relates to the external environment.

Society must ensure compliance with the legal stipulations out at the individual workplaces, above all the small plants and establishments. This makes it necessary to have efficient inspection and counselling services. Our administrative agencies in this field are the National Board of Industrial Safety and the Industrial Safety Inspectorate. The broader the purview of work-environment problems and the more complex they have become, the greater have been the demands put on these authorities. The old type of inspection activity, which was mainly of a technical character, has gradually evolved towards a more interdisciplinary effort, involving elements of engineering, occupational hygiene and medicine, which emphasizes giving advice to firms in their planning and development work. Pari passu with the build-up of local resources for environmental control within the business community, the Industrial Safety Inspectorate is in a better position to ask for reports on hygienic test results, ergonomic programmes etc. These opportunities will become all the greater as regards minimum hygienic standards, demands for environmental performance in machine design, planning of construction projects and so on. Increasing use is being made of programmes tailored to specific industries, which are spelled out in the form of so-called directives after mutual discussions between civil authority and parties at interest in the industry concerned. These directives are then made to underlie programmes of environmental rehabilitation in each industry, where the Inspectorate visits the firms and programs the local activities with referenece to fixed deadlines for measures.

4.8 Society must put up resources for R & D and education

New knowledge is constantly required to keep pace with the course of events. There is always risk that negative consequences will be noticed and action taken against them when things are too late. Society must therefore build up facilities for labour science research with sufficient dimensions to keep truly abreast of advancing technology. In Sweden we have sought to amalgamate the labour sciences in a National Institute for Occupational Health, which is called upon to act as a central organ of research, development and education on matters of the work environment. The Institute is also supposed to function as a coordinator and initiator of R & D in relation to the labour science research that goes on at universities and to other institutional research in this field.

Close and effective ties must be forged between the industry, the administrative agencies entrusted with matters of the work environment and research institutions if we are going to be able to establish a cross-fertilization of ideas and, above all, to translate research findings into practical action programmes with the greatest possible speed.

Furthermore, the problems that have particular urgency for the industry and the society at large at any one time must lend themselves to prompt initiation of research efforts in the forms of applied research programmes. The interval between research and practical application is occupied by a development stage, the responsibility for which should, it is felt, also be vested in society. This has to do with the development of technical solutions in machine design, air conditioning, pollution abatement etc.

Decision was taken in 1971 to levy a payroll tax whose proceeds will be put into a fund for labour protection research, education and information. The integration between the business and scientific communities is important, and towards this end the contact will be strengthened in various ways, especially by arranging respesentation on research councils for government, business organizations and research institutions.

4.9 International cooperation

To a great extent, Swedish advances in the work environment field have been promoted by an international exchange of experiences. As regards research and documentation, regular contacts between Swedish institutions such as the National Institute of Occupational Health and similar institutions abroad have been of great value. The study of practical solutions to work environment problems in different countries has given very good results. Sweden has been able to pick out those foreign solutions which have best lent themselves to practical application, having regard to specific Swedish conditions, traditions and administrative procedures, at the same time that Swedish experiences have proved valuable in supplementing the actions taken by other countries.

Although much of this cross-fertilization has been on an informal basis, regular provision has also been made for research seminars on the strength of bilateral agreements, such as that concluded between Sweden on the one hand and Yugoslavia and Czechoslovakia—Finland on the other.

Organized international cooperation has also been arranged. The Nordic Council recently formed a special task force for cooperation on occupational health between the Scandinavian countries, which has begun its activities in 1971. OECD also seems to be an organization where items on the working environment should be brought up. The international congresses that are organized every third year by the Permanent Commission and International Association on Occupational Health have provided valuable opportunities for mediating experiences and contacts between researchers and practitioners. Under the head of research and education, WHO has hosted international seminars and rendered other contributions. In a series of reports the joint ILO-WHO expert committee for occupational health has taken stands on various matters of principle and recommended different solutions, which have been of great value for the development in Sweden. As regards practical solutions, say in in-plant occupational health services or rehabilitation, it is often advantageous to discuss these at international level in a three-party organization. ILO's recommendations on occupational health services have therefore contributed a great deal to Swedish progress.

An enlargement of this valuable international cooperation would be desirable for Sweden, especially within the framework of ILO or WHO.

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PROPOSITIONS PRESENTEES PAR UNE COMMISSION D'ENQUETE SUR LE MILIEU DE TRAVAIL

par Karl-Ingvar Rundqvist, assesseur au Secrétariat juridique du Ministère des Affaires sociales et de la Santé publique

En Suède, les débats publics sur les conditions de la vie de travail ont été, ces dernières années, plus vifs que jamais. Les questions afférentes au milieu de travail ont été au centre des discussions. L'intérêt s'est porté pour une large part sur les répercussions qu'a eues et a toujours sur la santé, la sécurité et la joie au travail, la rapidité de l'évolution technique et économique dans la collectivité suédoise. A différentes occasions, il a été souligné que la législation en vigueur en matière de protection des travailleurs qui, pour l'essentiel, remonte à 1949, ne répond plus aux exigences actuelles.

Sur cette toile de fond, et après des exposés présentés par le Parlement ainsi que par la Confédération générale du Travail de Suède (LO), le gouvernement suédois a chargé en 1970 une commission de procéder à une révision générale de la législation sur la protection des travailleurs ainsi que sur l'organisation du secteur de cette protection. La tâche des enquêteurs est, en considérant, dans une optique axée sur les impératifs des temps présents, les objectifs et les méthodes pour la protection des travailleurs, de présenter des propositions concrètes sur la façon dont la législation sur la protection des travailleurs et les organes de cette protection doivent être refondus pour constituer des instruments efficaces en vue de l'obtention de bons milieux de travail. L'enquête où en particulier sont représentées les organisation centrales du marché du travail, a pris le nom d'enquête sur le milieu de travail.

L'enquête a décidé de donner la priorité à certaines questions à traiter dans un rapport partiel qui a été présenté au Ministre des Affaires sociales et de la Santé publique à la mi-décembre 1972. Dans les propositions de ce rapport, l'accent a été placé sur les questions relatives à l'activité locale de protection sur les lieux de travail, comme aussi sur celles afférentes à l'organisation de la surveillance officielle.

Coopération - influence accrue des travailleurs

La législation suédoise sur la protection des travailleurs prévoit que c´est la collectivité et ses organes - la Direction nationale d´hygiène et de sécurité du travail, au niveau central, et l´Inspection générale du travail, au niveau régional, qui répondent en dernier lieu de la protection de la vie de travail. Selon les statuts légaux, la responsabilité de la protection des travailleurs sur le lieu du travail incombe principalement à l´employeur, les travailleurs devant y contribuer dans une certaine mesure. Peu à peu s´est développé en matière de protection des travailleurs sur le marché du travail un système de coopération entre employeurs et travailleurs, ce qui se reflète également dans la législation. Dans l´esprit de l´enquête sur le milieu de travail, il importe de continuer à développer le système de coopération entre les parties du marché du travail. Un engagement accru de la part des travailleurs dans les efforts en vue de la sécurité du travail augmente, selon l´enquête, l´influence de ceux-ci sur le milieu de travail. L´enquête constate que les statuts légaux de la protection des travailleurs ne répondent pas aux exigences qui, actuellement, doivent être formulées en ce qui regarde la participation des travailleurs à la forme à donner au milieu de travail. C´est pourquoi l´enquête présente des propositions quant à une extension des statuts légaux à cet égard. A ce sujet, ces propositions portent avant tout sur les voies de la coopération des travailleurs dans les activités de protection qu´exercent les délégués à la sécurité des travailleurs et les comités de protection au sein des entreprises, des administrations, etc.

Les délégués à la sécurité des travailleurs

L´institution en Suède des délégués à la sécurité des travailleurs remonte au commencement de ce siècle. A l´origine, ces délégués ne se rencontraient que sur certains lieux de travail dans l´industrie. Ces délégués étaient, à l´occasion des visites de l´inspecteur du travail sur ces lieux, chargés d´exposer les points de vue des travailleurs sur ce qui, à l´époque, était considéré comme questions de protection. Actuellement, des délégués à la sécurité des travailleurs doivent généralement se trouver sur les lieux de travail occupant au moins cinq travailleurs. Certaines possibilités sont données à l´organisation syndicale des travailleurs de placer sur le lieu de travail des délégués à la sécurité des travailleurs qui ne sont pas eux-mêmes des travailleurs sur le lieu de travail. Ultérieurement, les tâches des délégués à la sécurité des travailleurs se sont aussi étendues. C´est ainsi que maintenant, ces délégués ont à attirer l´attention de l´employeur ou de l´Inspection générale du travail sur les lacunes en matière de protection des travailleurs comme aussi à essayer de promouvoir la participation des autres travailleurs dans les activités du domaine de la protection des travailleurs. L´évolution a donné lieu à une législation ainsi qu´à des accords entre les parties du marché du travail en vue de la coopération locale pour la protection du travail. L´enquête a toutefois constaté que la réglementation devait être complétée sur des points importants.

L´enquête propose que les attributions des délégués à la sécurité des travailleurs soient étendues. Ceux-ci auront également à participer à la conception des locaux de travail, des aménagements et des méthodes de travail. C'est ainsi, par ex., que s'il y a lieu de craindre des risques sanitaires dus à la présence de gaz dans un local de travail, ces délégués pourront exiger que l'employeur fasse contrôler les conditions de sécurité. Les délégués à la sécurité des travailleurs seront, en outre, admis à prendre connaissance de tous les documents et informations d'importance pour l'exercice de leurs activités.

Une clause légale est proposée selon laquelle le délégué à la sécurité des travailleurs pourra disposer pendant ses heures de travail du temps nécessaire à l'accomplissement de ses tâches. Le temps réservé aux travaux courants de ce délégué: participation aux rondes de contrôle de la sécurité, etc., serait, en premier lieu, fixé par accord. Si les parties ne peuvent s'entendre sur le temps requis pour l'accomplissement des tâches courantes, cette question sera résolue par l'Inspection du travail. Dans les situations critiques, le délégué à la sécurité des travailleurs pourra lui-même déterminer le temps qu'il lui faudra pour sa contribution à la sécurité.

Attributions

Il est proposé que dans certaines situations, le délégué à la sécurité des travailleurs interrompe le travail. En cas de danger immédiate et grave pour la vie ou la santé des travailleurs du fait de conditions de protection défectueuses, s'il ne peut y être remédié sur-le-champ par recours à l'employeur, le délégué à la sécurité des travailleurs pourra intervenir en interrompant le travail, dans l'attente que l'Inspection du travail prenne position. Ce délégué sera aussi habilité à interrompre le travail si l'employeur refuse de se conformer aux interdictions formulées par l'organe de surveillance contre des travaux déterminés ou contre l'utilisation de certains locaux, de certaines machines, etc. En vue de combattre l'emploi abusif du droit d'interrompre le travail, sont proposées certaines dispositions sur la responsabilité en matière de dommages-intérêts.

En corrélation avec la modification de la situation des délégués à la sécurité des travailleurs, l'enquête estime nécessaire d'accroître leurs possibilités de formation. Employeurs et travailleurs répondront en commun de ce que le délégué à la sécurité des travailleurs recevra la formation nécessaire. Il est proposé de rattacher une délégation de formation où seront représentées les deux parties à la Direction nationale d'hygiène et de sécurité du travail, organe central de surveillance. Il incombera en particulier à cette délégation de donner les directives pour l'activité afférente à la formation. L'enquête estime que les frais relatifs à la formation des délégués à la sécurité des travailleurs doivent être à la charge des employeurs. Une forme de perception collective des frais de formation est proposée.

Afin d'appuyer et de stimuler davantage les activités de sécurité sur les lieux de travail où l'organisation de cette sécurité est défectueuse, il est proposé que le système actuel avec délégués choisis en dehors de la sphère des travailleurs soit développé. De tels délégués devront pouvoir être désignés sur les lieux de travail où n'existent pas de comité de protection. Il est préconisé que les frais relatifs à l'activité de ces délégués soient supportés par l'employeur.

Les comités de protection des travailleurs

Un comité de protection des travailleurs doit exister sur les lieux de travail occupant au moins 50 travailleurs. Au sein de ce comité se débattent entre les représentants des employeurs et ceux des travailleurs, les questions relatives à la sécurité des travailleurs. De l´avis de l´enquête, ce comité devra occuper une position centrale dans l´activité locale de protection. Aux termes de la proposition, des comités de protection devront toujours être établis lorsque les employeurs ou les travailleurs le demanderont. Dans ces comités seront traitées, entre autres, les questions de planification de locaux de travail, nouveaux ou modifiés, ainsi que d´aménagements et de méthodes de travail. Les questions concernant le service médical d´entreprise devront également être traitées dans ce comité, afin de tirer parti des possiblités données aux travailleurs d´exercer une influence dans le développement et le fonctionnement du service médical d´entreprise. Dans l´éventualité où les parties n´arriveront pas à s´accorder sur la teneur des décisions du comité de protection, la question sera automatiquement portée devant l´Inspection du travail, si un membre du comité le requiert.

Afin que la force voulue soit assurée à la position du comité de protection, celui-ci devra comprendre une personne appartenant à la direction de l´entreprise ou occupant une situation comparable ainsi qu´un membre du comité directeur de l´organisation locale des travailleurs. En outre, cela va de soi, le délégué à la sécurité des travailleurs fera partie du comité.

L´organisation officielle de surveillance

L´enquête souligne que les propositions relatives à l´activité de protection sur les lieux de travail sont étroitement liées à celles qu´elle présente quant à une organisation officielle renforcée de la surveillance de la protection des travailleurs. Les modifications proposées pour ce qui regarde cette surveillance s´appliquent aussi dans une très large mesure à l´Inspection générale de travail qui a à répondre de l´appui à apporter à la sécurité des travailleurs dans les entreprises et à la surveillance de cette sécurité, entre autres, par des conseils, le contrôle des plans et des visites effectuées sur les lieux de travail.

L´enquête estime que l´Inspection générale du travail, telle qu´elle est comprise actuellement, à savoir une inspection générale et un nombre d´inspections spéciales, doit être en principe abandonnée. Il est donc proposé que les différentes inspections spéciales qui se pratiquent dans les mines, les travaux forestiers, le trafic terrestre et le trafic aérien soient ordonnées dans l´inspection générale laquelle, à cette occasion, sera renforcée et pourvue des spécialistes nécessaires. Simultanément, l´enquête propose, en particulier, afin de créer des possibilités accrues d´étroits contacts entre l´Inspection du travail et les lieux de travail, de porter de 11 à 18 le nombre des circonscriptions de l´Inspection générale du travail. Dans chaque circonscription sera établie une commission comprenant des représentants des parties du marché du travail et dont le président sera le fonctionnaire en chef de la circonscription, le directeur de l´Inspection générale du travail. Cette commission sera l´organe auquel il appartiendra de décider sur les questions d´orientation et de coordination des activités afférentes à la sécurité des travailleurs dans la circonscription. C´est elle également qui prendra les décisions en matière de prescriptions et d´interdictions conformément à la législation sur la protection des travailleurs.

Comme jusqu´ici, les lieux de travail de moindre importance continueront à faire l´objet d´une certaine surveillance avec la participation des communes, sous la direction de l´Inspection du travail. Cette surveillance sera normalement exercée par un inspecteur de l´hygiène possédant la formation nécessaire en matière de sécurité des travailleurs.

Est présentée une proposition de renforcement considérable et d´extension de la Direction nationale d´hygiène et de sécurité du travail. Depuis le 1er juillet 1972, date à laquelle un institut de médecine du travail, jusqu´alors indépendant, a été rattaché à la Direction nationale d´hygiène et de sécurité du travail, celle-ci comprend un service de médecine du travail. Actuellement, il est proposé, entre autres, qu´un service de médecine du travail soit établi dans la ville d´Umeå, en Suède septentrionale.

Autres propositions

Par les modifications proposées, l´enquête a voulu dans une mesure appréciable créer la possibilité de présenter dans un rapport ultérieur des propositions de nouveaux statuts matériels pour la protection des travailleurs. Le fait que fonctionnera déjà une organisation nouvelle et bien développée pour la protection locale des travailleurs ainsi que pour la surveillance au niveau central et au niveau régional lorsque seront appliqués les statuts légaux définitifs - lesquels seront vraisemblablement repris dans une nouvelle loi sur le milieu de travail - a été estimé offrir un avantage considérable.

Il convient toutefois de souligner que le rapport partiel présenté maintenant comporte aussi d´autres propositions à d´importants égards. Se fondant sur la nécessité de prendre des mesures de protection déjà au tout premier stade, l´enquête a proposé différentes nouveautés en ce qui regarde l´examen préalable des locaux de travail et des installations en faisant partie. Généralement, cet examen du point de vue du milieu de travail sera effectué à l´occasion de celui du projet de construction auquel procèdent les autorités du Bâtiment. Il devra être contrôlé que la possibilité d´exposer ses points de vue à la phase de la planification a été donnée à la partie constituée par les travailleurs. L´enquête a aussi présenté des propositions d´amélioration des règles de sécurité et de coordination concernant les lieux de travail communs pour les travailleurs de plusieurs employeurs. Par ailleurs, sont proposées des prescriptions pour la protection des travailleurs sur les lieux de travail dont ne disposent pas leurs employeurs propres. Sont importantes également différentes propositions visant à rendre plus efficaces les moyens de sanction dont doivent disposer les autorités de surveillance.

L´enquête propose que les modification légales nécessaires entrent en vigueur le 1er janvier 1974. Il est prévu que l´extension et le renforcement de l´organisation officielle s'effectueront pour la majeure partie au cours d'une période de deux ans à partir du 1er Juillet 1973. Les propositions de l'enquête ont été soumises à un nombre de services publics et de collectivités invités à en faire connaître leur avis. Le gouvernement escompte pouvoir présenter des propositions sur la base du rapport de l'enquête à la session de 1973 du Riksdag.

THE SWEDISH WORK ENVIRONMENT FUND

ASF 3/72

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NATIONAL PLANNING OF OCCUPATIONAL HEALTH RESEARCH IN SWEDEN

by

Professor Sven Forssman

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Introduction

In order to improve the work environment and the health of workers Parliament decided in 1971 to establish a Work Environment Fund in Sweden by increasing the compulsory fee paid by employers for insurance against occupational injuries and diseases. The contributions will amount to over 20 million Swedish crowns (approx. $ 4 million). The Fund will be used for research, education and information.

As a basis for the research planning of the fund the Minister of Health and Social Affairs requested in 1971 that a special study be carried out. I was asked in July 1971 to conduct the study with the assistance of an expert on toxicology and occupational medicine and one on ergonomics, physiology, psychology and sociology. The report was presented in April 1972.

The aim of this study was to gather information from all concerned - technologists, industrial planners, employers' and trade union organizations, research institutes as well as faculties of medicine, social sciences and engineering as to what occupational health problems could be foreseen in the next five to ten years, and what research projects should be planned accordingly, in the light of expected changes of technology, industry, labour market and society. From the information thus obtained the study group made a classification according to different systems, putting different projects together in groups. Finally some principles of priority were established and eleven research areas of special priority laid down.

In carrying out this study I took the opportunity when at international congresses and conferences to discuss future occupational research with experts from many countries.

Information collected in Sweden

A main task of the study group was to obtain information on the expected development in technology, industry and other fields of employment, to collect information on development of the employment market, changes in the distribution of the population from urban to rural areas and of the demographic development in Sweden, as well as expected changes in public health.

Information was collected from six groups of experts, institutes, organizations and authorities, as follows:

1. Authorities and organizations active in planning industrial development, employment, labour market, public health and social services, occupational health and safety, and social environment.

2. Employers' and labour union organizations. The Swedish Employers' Confederation furnished information also from its branch organizations, for instance the iron and steel industry, chemical industry, textile industry, mining etc. Through the Federation of Labour Unions similar material was obtained from its branch unions, such as the metal workers' union, the miners' union, and the textile workers' union. Interesting information was also obtained from the Swedish Central Organization of Salaried Employees. The Union of Employees in Public and Civil Services also provided information as well as the National Farmers' Union and the Swedish Cooperative Union and the Commercial Employers' Association.

3. Authorities and organizations directly concerned with the control and improvement of work environment, occupational health and safety, like the Swedish Industrial Safety Board and the Factory Inspectorate, the associations of industrial physicians, of occupational health nurses and of safety and industrial hygiene engineers, the occupational health service organization for building and construction workers.

4. Authorities, organizations and institutions with general experience in research and research planning but not directly engaged in occupational health, among which were the university faculties of engineering, medicine, natural sciences and social sciences, and the academy of engineering sciences.

5. Research councils or other organizations giving financial support to research in different fields, embracing the Medical Research Council, the Swedish Natural Science Research Council, the Swedish Council for Social Science Research, the Swedish Council for Forestry and Agricultural Research, the Swedish Board for Technical Development, the Swedish Council for Building Research and the Bank for Sweden Tercentenary Fund etc.

6. Institutes and organizations active in research in the occupational health and safety field, such as the National Institute of Occupational Health and university institutions, as well as the institutes of hygiene and public health, the institutes of psychology, sociology and social medicine, the clinical physiological university laboratories, and the regional occupational medical clinics. The considerable experience of research on occupational health collected through the years in the National Institute of Occupational Health was in this respect of greatest importance.

Estimated need for future research in Sweden

The suggested projects and the estimated needs for research were classified in five large groups:

1. Work science methodology

   Emphasis was laid on the need for further development of the methods in occupational health services, and the need to evaluate regular health examinations in relation to health hazards and work load, studying especially the health problems of the very small industries.

2. Work health factors of environment

   Health hazards from exposure to chemical substances were considered to be of increasing importance. The great number of new chemicals being introduced in industry will call for toxicological studies and epidemiological research, especially concerning combined effects of several toxic substances and the effect of long term exposure. There will be a great need for developing new engineering methods for the elimination of air pollution of toxic substances in industry.

Concerning dust a major point must be further research on the effect of exposure from asbestos dust and organic dust such as wood, cotton, dust in food industry and other sources. Another urgent question is the further development of engineering methods for dust suppression.

Noise will be an important health problem in the future unless noise prevention is applied at the planning and construction stage of new factories, machines and working processes. There will be a need to study the effects from noise apart from deafness and there must be further research on engineering methods of noise prevention.

A similar need for further research has been mentioned in respect of vibration and research on the effect of vibrations, especially the low frequency vibrations and the prevention of exposure to vibrations.

Climatic factors, especially the effect of cold climates and draught has been emphasized. According to recent studies of job attitudes in Sweden one of the most common complaints of the workers is complaints about draught and cold climates. Another requirement is research on physical and psychological effects of climate.

The psycho-social climate has attracted increasing interest during the last 5-10 years in Sweden with special reference to such factors as job organization, monotony, understimulation or underload. There is an increasing demand, especially among younger workers, for a meaningful occupation with job satisfaction and a possibility for the individual to influence his own work environment. It will be essential to undertake research on the effects of these psycho-social factors as well as experiments to find new ways of organizing jobs in order to improve job satisfaction. Mention was also made of such psycho-social factors as the effects of urbanization, especially when individuals were moved from urban to rural areas, where they leave not only their homes but also their professions and are retrained for new jobs in new industrial cities. The problem of the adjustment of migrant workers from other countries was also brought up in this context.

Ergonomics will be an important factor of future work environment. This will entail research on the effect of work environment factors for back pain. Another foreground question here will be research in machine ergonomics especially as regards noise, vibration, the design of instrument panels in transport machines for instance and the design of robots to take over heavy and unpleasant work from man. Also the development of technical aids to facilitate the work of handicapped people will be of importance as well as the development of research in ergonomics for handicapped.

Research in accident prevention will be of great importance especially as concerns the human as well as technological factors contributing to an accident with injury. There will be a great need for basic research as well as applied research on accident problems in different types of industry such as the wood industry and mines.

3. Working processes

The necessity of research on occupational health and safety in working processes has been emphasized and certain processes were mentioned, welding for example. Cleaning of factories and offices has to a certain extent been mechanized, for instance the cleaning of floors and windows, but this work still entails considerable heavy physical work and health hazards which should be reduced through research.

4. Occupations or industrial branches

There is a great need of interdisciplinary studies on health problems including occupational hazards as well as the psycho-social climate. In particular occupations within hospital and other fields of medical care have been suggested as subjects for survey. This work may include heavy physical work loads, especially from lifting and carrying and many aspects of ergonomics may be applied. Certain occupational hazards from infections should be considered. The new work organization in hospitals has changed the psycho-social climate and there may be a need to study job attitudes and job satisfaction in relation to the organization of work.

It has also been mentioned that it would be useful to carry out an occupational health study relating to school teachers.

The work and work environment of the farmers has changed considerably during the last decades. Farming has been mechanized, pesticides and other toxic substances have been introduced, larger units of farming have been created which will change the organization of the job.

Food industry has also been recommended for occupational health surveys especially emphasizing stress and noise.

The work environment of the small industries should be studied. Very little research has been carried out in this field, especially in regard to preventive measures and how occupational health services should be organized in order to meet the special problems of the small industries.

5. Working time

The length and distribution of the working time involves many health aspects, especially in connection with shift work. There is now a trend all over the world to increase the amount of shift work, mainly for financial but also for technological reasons. Shift work may influence the physical, mental and social well-being of the worker and it is important to evolve methods for diagnosis of deviations from normal health while still at an early stage. Recommendations on how shift work should be organized in order to reduce the negative health effects as far as possible should be based on physiological, psychological and sociological studies.

6. Groups of personnel

Certain large groups of personnel may have common problems or difficulties in adjusting to work and work environment. The aging worker has reduced functions of the body, especially in respect of their maximum capacity. From the practical point of view reduced capacity to work at high speed, to take in information and lowered perception are important. It is important to design new working processes and new machines that will fit the requirements of the aging workers.

In certain occupations such as forestry, where mechanisation is being introduced, it is important to study the aging workers' possibilities of carrying out his duties under the new working conditions.

Individuals with diseases of the heart, blood vessels and respiratory organs may have reduced heart and lung functions and reduced resistance to certain factors of the work environment such as cold, irritant gases and dust. Further research in these fields has been proposed.

It is also important to study the physical and mental health of those who have been unemployed for a long time and have difficulties in reentering the labour market due to some physical or mental handicap, the aim in this case being to study the factors of this negative selection as well as the possible stress effects of unemployment.

International experiences

A comparison of the information collected in Sweden with experiences from other countries concerning the future need of research shows that the major problems and the priorities are rather similar in different countries.

Within occupational health occupational diseases have lost their dominating position, although the health hazards of new working processes and from the use of new chemicals must be studied already at the planning stage of the working process. Methods to study the mechanism of action and to establish the diagnosis at an early stage must be improved, as well as methods for establishing maximum allowable concentrations. In addition to the traditional toxicological methods other ways must be found to study the effects of toxic substances. The effect on higher nervous functions have been studied especially in Eastern European countries but the Permanent Commission has established a subcommittee on this field. In the future the research on toxic effects on the enzymatic system will be expanded. Methods on studying cancerogenic, teratogenic and mutagenic effects must be developed.

The great number of new chemicals introduced in industry every year will call for a close international cooperation for instance through ILO, WHO and the Permanent Commission since it will be difficult even for a large country with great resources to carry out sufficient research to establish maximum allowable concentrations for all new substances introduced or discovered.

Concerning silicosis there is a great need for further research on industrial hygiene engineering methods to improve dust control. Exposure to vegetable dusts, such as dust from cotton, hemp, flax, different kinds of dust from food industry, tobacco, will probably be of increasing importance. There is a great need for developing practical methods for field use in order to measure dust concentration and particle size in air.

In the field of toxic substances many studies have been devoted to the effect of exposure to one substance. At work there is usually exposure to several substances at the same time. Future research should concentrate on the combined effects of long-term exposure to low concentrations, comparing exposed groups and control groups. The effect of multiple stress must be studied, since exposure to toxic substances may be combined with stress factors at work. The great possibilities of using the experiences from occupational health services to collect a large body of material over long periods must be considered. Methods should be developed to collect material according to a uniform system in order to allow a comparison of results from different countries. It may be that the exposed group in one country may be too small and research must therefore be based on international cooperation.

The effect of occupational hazards or the physical and mental work load upon such vulnerable groups as the aging workers and the handicapped must be studied in the future.

Many non-occupational diseases, like ischaemic heart disease or diseases of joints, bones and muscles, may be influenced also by factors at work. Future research must devote considerable effort to studying the influence of health factors of the work environment upon the occurrence of non-occupational diseases.

Mental health problems have during the last decades been studied to an increasing extent but more research will be needed. Attitudes towards work concerning anxiety, alienation, job satisfaction must be studied in relation to physical and mental health factors at work.

Research has in the past devoted much time and effort to peak loads especially where heavy physical work, heat exposure, work at high speed etc are entailed. With increasing mechanization and automation the effect of "underload" must be studied where the effects of reduced physical activity combined with reduced mental stimulation should be especially considered.

The trend in future research must be that man should as far as possible be studied from all different aspects concerning his physical, mental and social well-being, which will mean more team work, especially with the basic team of physicians, engineers, nurses, physiologists, psychologists and sociologists.

Priorities

With the changing concept of occupational health and with a wide approach emphasizing also the psycho-social climate at work and with the enormous amount of problems to be studied in relation to technical development, mechanization and automation as well as industrialization and urbanization it is important to establish research priorities on the national and international level. When a research project is planned the background should be described, a program worked out but at the same time the follow-up and the practical application of the results should be foreseen. A research project should not be considered as finished until its results have been put into practice and applied at the work place.

Sweden, like every other country, has to establish priorities taking regard to the limited resources for research. The following aspects on research priorities were considered by this survey; the expected technological and industrial development and the corresponding planning, the expected change in structure of industry as to size, economic sectors, as well, as expected changes in the labour market, the industrialization and urbanization. These aspects were emphasized by several experts within the organizations of industry, national employment service and the federation of labour unions and the employers' federation.

As regards health factors at work the survey should consider the degree of seriousness of the occupational disease or injury, the incidence or morbidity and the number of people exposed.

Concerning health factors at work which influence non-occupational diseases the survey should consider if the disease may cause disability and death, as for instance ischaemic heart disease and if the morbidity is high among the working population.

In order to establish priorities of research in health problems of certain occupations or professions the survey considered factors such as high accident frequency, high general morbidity, high sickness absence and high labour turnover. A rapid change of production processes may cause problems of job adjustment. The workers' subjective evaluation of his work, especially if there is a strong negative attitude to the work with job dissatisfaction, alienation, absence and labour turnover may call for occupational health research.

Considering these aspects on priorities the survey selected the following eleven fields as especially important for new or expanded research in the near future: Industrial toxicology; industrial hygiene engineering eliminating air contamination at work; noise, effects and prevention; climate, especially low temperature and air movement; organization and motivation of work; back diseases; occupational injuries; interdisciplinary health surveys of industrial groups; working time, length and distribution during day and week, especially shift work; sickness absence and labour turnover; the aging worker.

The same fields seem to be of interest or importance also in many other countries.

The Swedish Work Environment Fund was established 1. January 1972 in order to support research, education and information. Concerning this survey on occupational health research the Board of the Fund has recently selected the following four areas out of the eleven areas of priorities mentioned above:

Research into the problems of working hours, including the length and distribution of working hours, shift and night work etc.

Research intended to reduce the frequency and severity of occupational accidents.

Broad cross-discipline investigations of working environment conditions within various branches of industry.

Research on deleterious chemical substances in working environments.

Working groups have now been established for each of the selected research areas in order to describe what research has already been done, what is now going on where, and what is needed of further research. The groups should present a survey and then evaluate, study, report and follow-up new research projects.

Summary

A national fund for research, education and information on occupational health and safety of 4 million US dollars/year was established 1972 in Sweden. Based on a study on the future need for research eleven top priority fields were selected for research during the next few years: Industrial toxicology; industrial hygiene engineering eliminating air contamination at work; noise, effects and prevention; climate, especially low temperature and air movement; organization and motivation of work; back diseases; occupational injuries; interdisciplinary health surveys of industrial groups; working time, length and distribution during day and week, especially shift work; sickness absence and labour turnover; the aging worker.

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AN ELECTROPHYSIOLOGICAL STUDY IN PRENATAL SHEEP

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INTRODUCTION

The development of functions of sensory systems was originally analysed from the appearance and changes of the reflexes which could be elicited by afferent stimulations (for reviews, see *e.g.* Windle 1941, Carmichael 1951, 1954, Gottlieb 1971). Several basic developmental concepts were postulated such as the functional precocity of somesthesia, particularly the trigeminal afferent inflow, compared to audition and vision.

The introduction and use of electrophysiological techniques, notably the evoked potential method, made it possible to obtain further information about the functional development of the sensory systems. The investigations on somatosensory evoked cortical responses in newborn dogs, cats, rabbits and rats (Scherrer and Oeconomos 1954, Grossman 1955, Marty 1962, Delhaye-Bouchaud 1964, Thairu 1971, Verley and Rokyta 1972) give conclusive evidence that the afferent connections from the skin receptors to the cortical projection areas are already present at birth in these animals. Recent studies on the visual system during postnatal development have provided data on the involvement of different subcortical and cortical structures in the generation of various components of the evoked cortical response (Rose 1968 a,b, 1971, Rose and Lindsley 1968). Comparable investigations have not been made on the maturation of somatosensory cortical responses. However, the relative functional importance of the afferent pathways directed towards the somesthetic cortex of postnatal animals can be deduced from findings on electrocortical activities in primary and nonprimary projection areas evoked by electrical stimulation of ventrobasal and intralaminar thalamic nuclei and reticular structures (Purpura 1961 a,b, 1962, Scheibel 1962, Scheibel and Scheibel 1964, 1971, Verley, Siou and Garma 1966, Verley 1967 a, Verley and Siou 1967). In addition, responses have been described in subcortical relay stations evoked by peripheral tactile stimulation (Verley 1967 b).

The importance of the number and speed of the neuronal signals for the functional differences between the neonatal and the mature afferent systems has recently been discussed (Scherrer, Verley and Garma 1968, 1970). Interest has also been paid to the ability of the immature sensory cortex to code information concerning different qualities of the peripheral stimuli. Thus, there are data available on the postnatal development of receptive field characteristics in the visual cortex (Hubel and Wiesel 1963, Wiesel and Hubel 1963, Barlow and Pettigrew 1971) and of somatotopic organization in the somesthetic cortex (Rubel 1971). The results indicate that the functional organization of the cells within the somesthetic cortex, which serve the processing of afferent information, is fairly well organized at birth in postnatal cats. No investigation has been directed towards the problem of the building-up of this functional organization during the early stages of ontogeny.

Several studies on mammals employing natural and electrical stimulation of different peripheral receptors have demonstrated qualitative and quantitative changes in the electrocortical responses as a function of age (Hunt and Goldring 1951, Scherrer and Oeconomos 1954, Rose, Adrian and Santibanez 1957, Ellingson and Wilcott 1960, Marty 1962, Marty and Thomas 1963, Delhaye-Bouchaud 1964, Pujol, Granier and Marty 1966, Molliver 1967, Fox 1968, Mysliveček 1968 a, Pujol and Marty 1968, Rose 1968 a,b, 1971, Rose and Lindsley 1968, Meyerson and Persson 1969, Pujol 1971, Sedlaček 1971, Thairu 1971, Briquel and Verley 1972, Persson and Stenberg 1972, Rose, Gruenau and Spencer 1972, Verley and Rokyta 1972). In newborn dogs, cats, rabbits and rats, stimulation in the periphery of the somatosensory system generates activity in the cortex as represented by a long-latency surface negative response (Scherrer and Oeconomos 1954, Grossman 1955, Marty 1962, Delhaye-Bouchaud 1964, Thairu 1971). On the basis of studies on effects of pharmacological agents on gross surface responses in the somatosensory cortex of neonatal kittens it has been suggested that both excitatory and inhibitory synaptic processes are involved at different levels of the cortex (Purpura 1961 c, Purpura, Shofer, Houspian and Noback 1964). The relative importance of inhibitory synaptic mechanisms in the newborn feline cortex has been repeatedly stressed (Purpura, Shofer and Scarff 1965, Purpura 1969, 1971). Correlative morphological studies show that the cortical cytoarchitectonics at this neonatal stage are already relatively differentiated with well separated layers containing neurons in different phases of maturation (*e.g.* Cajal 1960, Noback and Purpura 1961, Marty 1962). In addition, electron microscopic investigations on the cortex of perinatal dog, cat and mouse have demonstrated a characteristic abundance of axodendritic synapses in the superficial cortical layers (Voeller, Pappas and Purpura 1963, Meller, Bleipohl and Glees 1968, Molliver and van der Loos 1970, Adinolfi 1971, 1972). The prominent superficial neuropile with well-developed axodendritic synapses has been considered to account for the predominating surface negative evoked and spontaneous electrocortical activities in the neonate (Marty, Chevreau and Scherrer 1961, Marty 1962, Purpura *et al.* 1964). During the late postnatal period the somesthetic evoked cortical potential undergoes a change into its adult positive-negative form. The evolvement of basilar dendrites and axosomatic synapses (Marty *et al.* 1961, Marty 1962, Purpura *et al.* 1964) and a deep neuropile with specific corticopetal fibers as well as dendrites and axonal network of interneurons (Scheibel 1962, Scheibel and Scheibel 1964, 1971) has been regarded to be of importance for bringing about this change.

The data described indicate that the somatosensory afferent pathways and their cortical projections have reached a comparatively high degree of structural and functional maturation in the neonate of the aforementioned animals. Consequently, it is of interest to analyse the initial phases of functional development in the somatosensory system during the early prenatal period.

The classical investigations by Barcroft and Barron (1939 a,b, 1941, 1942) on externalized sheep fetuses kept in umbilical contact with the ewe, indicates that this preparation would be appropriate for the electrophysiological exploration of the immature central nervous system. This technique was adopted by Bernhard, Kaiser and Kolmodin (1959) and several investigations from this laboratory have shown that this preparation is suitable for the electrophysiological analysis of the development of spinal and cortical functions from very early stages of ontogeny (Bergström, Bernhard and Änggård 1960, Änggård, Bergström and Bernhard 1961, Bernhard, Kaiser and Kolmodin 1962, Änggård and Ottoson 1963, Eidelberg, Kolmodin and Meyerson 1965, 1967, Kolmodin and Meyerson 1966, Bernhard, Kolmodin and Meyerson 1967, Molliver 1967, Bernhard and Meyerson 1968, 1973, Meyerson 1968 a,b, Meyerson and Persson 1969, 1973, Persson 1971, 1973, Bernhard, Meyerson and Persson 1972, Persson and Stenberg 1972). Since the sheep is relatively mature at birth from a neurophysiological and behavioral point of view (*cf.* Ruckebusch 1971) the entire cycle of development of various nervous functions can be conveniently studied under the same physiological and technical conditions before a transition takes place from intrauterine to extrauterine life. In addition, basic data on the neuroanatomical development of the isocortex in fetal lambs has been presented by Åström (1967).

It has been demonstrated that the somesthetic evoked cortical response in fetal sheep undergoes a series of changes as a function of age (Molliver 1967). The characteristic surface positive wave form of the somesthetic evoked potential in immature fetal sheep (see also Meyerson and Persson 1969, Persson 1971, 1973), compared to the predominately negative response of neonatal animals (*e.g.* Scherrer and Oeconomos 1954, Marty 1962, Thairu 1971) indicates that a different mode of cortical activation exists in the sensory cortex during the early prenatal stages of development. The knowledge about the cortical generative mechanisms to this immature cortical activity and its structural correlates is sparse.

The present investigation on the development of somatosensory cortical functions during early prenatal ontogeny deals mainly with the following aspects:

1. The functional development in the somatosensory cortex and its morphological correlates.
2. The development of the 'specific' and 'nonspecific' somatosensory systems.
3. The mode of operation in the immature somatosensory system.

These aspects have been studied by means of analysis of gross and unit cortical responses evoked by tactile trigeminal stimulation. The changing characteristics of these responses have been correlated to simultaneous alterations of the cortical morphology.

Preliminary reports derived from this study have been presented (Meyerson and Persson 1969, Persson 1971, 1973).

METHODS

I. Electrophysiology

1. Material

The results are based on 67 experiments performed on sheep fetuses of different Swedish breeds (Gotland breed and Swedish landrace). The gestational age of the experimental animals was known in most cases and in the remainder estimated from weight-age diagrams (Meyerson 1968 b). Fetal ages ranged between 42 days and full term, *i.e.* about 145 days.

2. Animal preparation

The details of the animal preparation have previously been reported (Meyerson 1968 b) and only the general outline of preparation and the control of animal condition will be presented.

On the morning of the experimental day, the pregnant ewe was fastened to an operation table and anesthetized with a short-acting barbiturate, Thiogenal® (Merck-Darmstadt) or Pentothalsodium® (Abbott), 25—30 mg/kg slowly injected into a cannulated foreleg vein. The general anesthesia was maintained throughout the surgical procedure with repeated injections (5—10 mg/kg). The need for additional anesthesia was judged from the corneal reflex.

The animal was tracheotomized and artificially ventilated with a respirator (Harvard respirator Model 613). In most of the experiments the CO_2-content of the expired air was measured (Beckman gas analyzer, Model LB-1) through a small tube inserted into the tracheal cannula and continuously monitored on a Grass-polygraph. The respirator was adjusted to maintain a level of 4—4.5% CO_2 in the end-tidal volume. Respiratory minute volumes were 5.0 to 10.0 l depending on the weight of the ewes (*cf.* Cross, Dawes and Mott 1959).

A catheter was inserted into the proximal end of one of the ligated common carotid arteries for continuous recording of the arterial blood pressure and the pulse rate. The systolic and diastolic pressure was generally about 120 and 90 mm Hg respectively and the pulse rate varied between 60 and 120 per min (*cf.* Spector 1956). Care was taken to maintain the temperature of the ewe at its normal value of 39°C (*cf.* Clawson 1928).

In order to avoid bronchospasm and pulmonary atelectasis an injection of adrenaline (0.2—0.4 mg s.c.) was given; the animal was hoisted to an upright position; a ventriculotomy was performed and the stomach contents evacuated.

The ewe was immobilized with Flaxedil® (Gallamine triethiodide, May and Baker) 2—3 mg/kg i.v. and decerebrated by a section placed at the level of the posterior thalamus. This operation completed the surgical procedure of the ewe and the general anesthesia was now discontinued. Throughout the experiment small doses of Flaxedil® were administered. In the dog, it has been shown that gallamine is present in fetal blood after the injection of large doses (20—50 mg/kg) into the maternal uterine artery (Pittinger and Morris 1955). However, with the small doses used in the present study, there was no sign of any placental transfer of the drug to the fetus.

After about two hours of recovery the fetus was carefully delivered through a caesarian section. The fetus was placed on a plastic cushion and embedded in thin cotton sheets soaked in warm mineral oil. Great care was taken not to damage the cotyledons or to stretch the umbilical cord. The body temperature of the fetus was continuously monitored with a rectal and a skin termistor. The normal temperature (39°C) of the fetus was maintained with the aid of a heating lamp above the fetus and warm water running in the plastic cushion. Two silver pins were placed in the forelegs and connected to a Grass-polygraph for continuous recording of the fetal EKG. The pulse rate of the younger fetuses (60—80 days) was 160—200/min, but was lower in the fetuses near term (*cf.* Barcroft and Barron 1945).

The head of the fetus was then secured to a specially designed headholder. Under a dissecting microscope (Zeiss Epitechnoscope) a small or wide, unilateral or bilateral craniotomy was made according to the purpose of the experiment. The dura was reflected. The exposed cortical surface was covered with thin polyethene sheets and frequently flushed with warm mineral oil.

The majority of the fetuses exhibited spontaneous mobility (*cf.* Barcroft and Barron 1939 a,b, 1942) and where therefore immobilized with a small dose of Flaxedil®, 1—3 mg/kg intraperitoneally. It has been demonstrated in the adult cat, that gallamine has excitatory effects on cuneate neurons (Galindo, Krnjević and Schwartz 1968), on thalamic relay nuclei neurons (Andersen and Curtis 1964) and on cortical excitability (Halpern and Black 1967). These effects were attained with much larger doses (> 6 mg/kg) than those used in the present investigation. No significant effect on the experimental results from the use of gallamine could be observed.

3. Stimulation

As in the adult animal (Nougier 1963) ipsilateral upper lip stimulation in sheep fetuses elicited cortical responses with the most constant form, shortest latency and largest amplitude and was therefore used in the present study.

Tactile stimulation was performed with a spherical probe, which had a diameter of 0.5 mm, connected to an electromagnetical transducer driven by a stimulator (Grass). One or two tactile stimulators were used, each mounted on specially constructed coordinate systems allowing movements in all directions. The stimulation profile was a square wave of variable duration and amplitude. In most experiments the duration of the stimulus was 10 msec. The amplitude of the stimulation was chosen so as to provide reproducible cortical responses.

Sheep fetuses have glabrous nose skin until a gestational age of about 90 days when the first hairs appear on the nose. Not until shortly before full term do the fetuses have well-developed fur. Due to this fact the tactile stimulation was on bare skin in most experiments but in some older fetuses also on skin hairs.

4. Recording

Recordings were made of evoked gross potentials from the surface and the depth of the cortex as well as of evoked unitary activity from single neurons.

The surface exploring, reference and ground electrodes were all matched calomel half-cells connected to the preparation by agar saline bridges in polyethylene tubes with a recording area of 0.5 mm^2. The reference electrode was placed on saline moistened cotton in direct contact with the posterior part of the skull. The ground electrode was placed on a strip of saline moistened cotton wrapped around the neck.

The electrodes were connected to a Grass P 6 amplifier and a Tektronix 502 CRO. D.c.-recording with an upper cut-off frequency of 0.5 or 2 kHz was used in most experiments. The drift of this system was generally less than 50 μV per hour. In some experiments a.c.-recordings were used with a time-constant of 100 msec. A Grass kymograph camera provided the photographic recording.

Evoked field potentials and extracellular single unit activity were recorded with glass microelectrodes filled with sodium chloride (5.5 N) or potassium chloride (2.8 N). It is obvious that leakage of KCl from the micropipettes could affect the single unit activity. However, no change could be detected in the firing pattern of spontaneously active neurons, which were extracellularly recorded with KCl-microelectrodes during 15—20 minutes. Microelectrode impedances amounted to 1—50 MΩ. For the recording of evoked field potentials the tip of the micropipette was broken mechanically before use. The microelectrodes were attached to a microdrive (Stålex) which was rigidly mounted on a stereotactic apparatus allowing movements in all three planes. The same amplifying system as for surface recording was used. The unit activity was also monitored aurally with a Grass AM 5 audioamplifier.

The outputs of the oscilloscope were fed into a two-channel tape-recorder (ReVox with FM-adaptation; the upper cut-off frequency of the FM-recording system was about 650 Hz). One channel with FM-modulation was used to store slow potential activity and the other one to store trigger signals, unit activity and spoken information.

The surface cortical response evoked by tactile stimulation of the trigeminal nose area was first mapped. The exploring electrode was placed in the cortical position from which reproducible responses with minimal latency and maximal amplitude were obtained. The microelectrode was then put in contact with the exposed cortical surface close to the exploring electrode and on the middle of the gyrus. In the younger fetuses the pia was soft and the micropipette could be advanced through the pia without dimpling. However, in the older fetuses the pia was severed locally in order to prevent erroneous depth measurements due to dimpling. A mixture of mineral oil and vaseline was carefully laid out on the surface of the cortex in order to prevent pulsations and to retain moisture. The microelectrode was advanced vertically through the cortex in steps of 2 μ to a depth of 2 500 μ or more. During penetration a search was made for responsive and spontaneous units and their depth location in the cortex was noted.

The same procedure was employed from unipolar recording of the evoked field potentials from various depths below the cortical surface. Recordings ($n = 5$—10) were made at increments of depth of 200 or 250 μ. In a few control experiments recordings were made during both the advancement and the withdrawal of the microelectrode, and similar results were obtained at equal depths. The evoked surface response and the evoked field potentials were recorded simultaneously.

5. Methods of laminar potential analysis

The evoked field potentials recorded within the sensory cortices of adult animals in response to peripheral and thalamic stimulation have been studied by several investigators (Amassian, Patton, Woodbury, Towe and Schlag 1955, Perl and Whitlock 1955, Li, Cullen and Jasper 1956, von Euler and Ricci 1958, Angel and Holmes 1967, Carter, Holmes and Houchin 1968, Borbély 1970). The hypothesis is now well established that the evoked slow waves as

well as the surface evoked responses are the net result of extracellular current flows generated mainly by local postsynaptic potentials of the cortical neurons (*e.g.* Eccles 1951, 1964, Bremer 1958, Purpura 1959, Creutzfeldt, Watanabe and Lux 1966 a,b, Creutzfeldt 1969, Creutzfeldt, Rosina, Ito and Probst 1969, Pollen 1969). Afferent and efferent fiber activity may also contribute to the evoked field and surface potentials if the activity is highly synchronized (Purpura 1959, Creutzfeldt 1969, Pollen 1969). Under normal conditions, glial cells probably do not contribute significantly to the extracellular current flow (Grossman, Whiteside and Hampton 1969, Pollen 1969).

On the basis of the volume conductor theory, the evoked field potentials in the cortex and their corresponding depth-potential profiles have been widely used to indicate the locations on excitable neurons of the extracellular current flow generators ('sources' and 'sinks'). However, the use of voltage gradient has recently been claimed to be more accurate for the analysis of the spatial arrangements of cortical generators (Humphrey 1968 a,b, *cf.* Amassian, Waller and Macy Jr 1964, Towe 1966).

Assuming the conductivity (K) of the cortex to be constant, net current density is proportional to the voltage gradient at any given point:

$$I = -K \operatorname{grad} V$$

In the cortex the average current flowing parallel to the cortical surface is regarded as being effectively zero (*e.g.* Pollen 1969). Under such conditions it is the vertical current flow which primarily contributes to the cortical potentials. The net vertical component of the extracellular current (I_z) is given by

$$I_z = -K \frac{\partial V}{\partial z}$$

where z is a measure of depth from the cortical surface. All changes in the extracellular current are considered to be due to charges leaving ('source') and entering ('sink') the cells. A rapid change in the vertical current flow in positive direction at a restricted region in the cortex occurs because charges are leaving the cells at the same depth. Thus, a net maximal source of vertical current may be said to exist where I_z is increasing most rapidly or where $\frac{\partial I_z}{\partial z}$ is maximally positive. Conversely, a net maximal sink would exist where $\frac{\partial I_z}{\partial z}$ is most negative. Estimates of

$$\frac{\partial I_z}{\partial z} = -K \frac{\partial^2 V}{\partial z^2}$$

were obtained by treating the depth-potential profiles as continuous functions, reversing their sign and graphically twice-differentiating them.

In the present study, the laminar analysis of somesthetic evoked cortical potentials comprised a description of evoked field potentials recorded at different depths below the cortical surface and of depth-potential profiles. These profiles were derived from amplitude values of the evoked field potentials measured at latencies corresponding to the peak of the positivity or negativity (or both) of the surface response. Furthermore, on the basis of the depth potential profiles, estimates were made of the corresponding vertical current gradients to achieve additional data on the location of 'sources' and 'sinks'.

II. Histology

After completion of the experiment, specimens were taken for histology from the somesthetic cortex of 11 fetuses (62 to 127 days of gestation). The tissue samples were fixed in formalin (10% in Ringer's solution) and stained with cresyl violet. In 8 brains the shrinkage caused by the preparation was estimated (see pp. 40).

RESULTS

I. Development of somatosensory evoked surface responses

Cortical responses to tactile stimulation were obtained in all 67 fetuses examined. During development the cortical evoked response to ipsilateral upper lip stimulation underwent a series of characteristic changes in cortical distribution, configuration, latency, amplitude and ability to follow repetitive stimulation. Basic data on the maturation of the somesthetic evoked surface cortical response in fetal sheep have been given in an initial study from this laboratory by Molliver (1967). The present investigation constitutes a confirmation and extension of this work mainly in order to provide a firm basis for the understanding of the depth potential data.

1. Cortical distribution

The distribution on the cortex of the evoked response to tactile stimulation of the ipsilateral superior lip (ISL) was studied in fetuses of various ages. It was observed that a change of the stimulus locus from one point to another on the nose induced a shift in the cortical area from which the maximal responses could be obtained. This indication of a somatotopic organization was found even in the youngest age group. Thus, in a 69-day-old fetus the response could be recorded from an anterior and lateral area which included approximately the whole anterior third of the lissencephalic brain (Fig. 1 A). It is interesting to note this relatively large response area and the similarity between this ISL-representation and that of the adult sheep (Adrian 1943, Hatton and Rubel 1967).

The finding in all fetuses that the responses obtained from the periphery of the cortical receiving area had the same onset latency as those in the center of the field, indicates that the fringe responses do not represent electrocortical activity due to a time-consuming tangential intracortical activation.

In Fig. 1 B is shown the response distribution in a 76-day-old fetus and it can be seen that the cortical response was recorded from a large area of the anterior pole of the brain. A shallow impression on the lateral aspect of the brain denoted the apperance of *s. suprasylvius* (*cf.* Meyerson 1968 b). No responses were obtained from recordings medial to this sulcus, *i.e.* from the anlage of *g. suprasylvius* (association cortex), nor from the prospective *g. frontalis superior* (motor cortex).

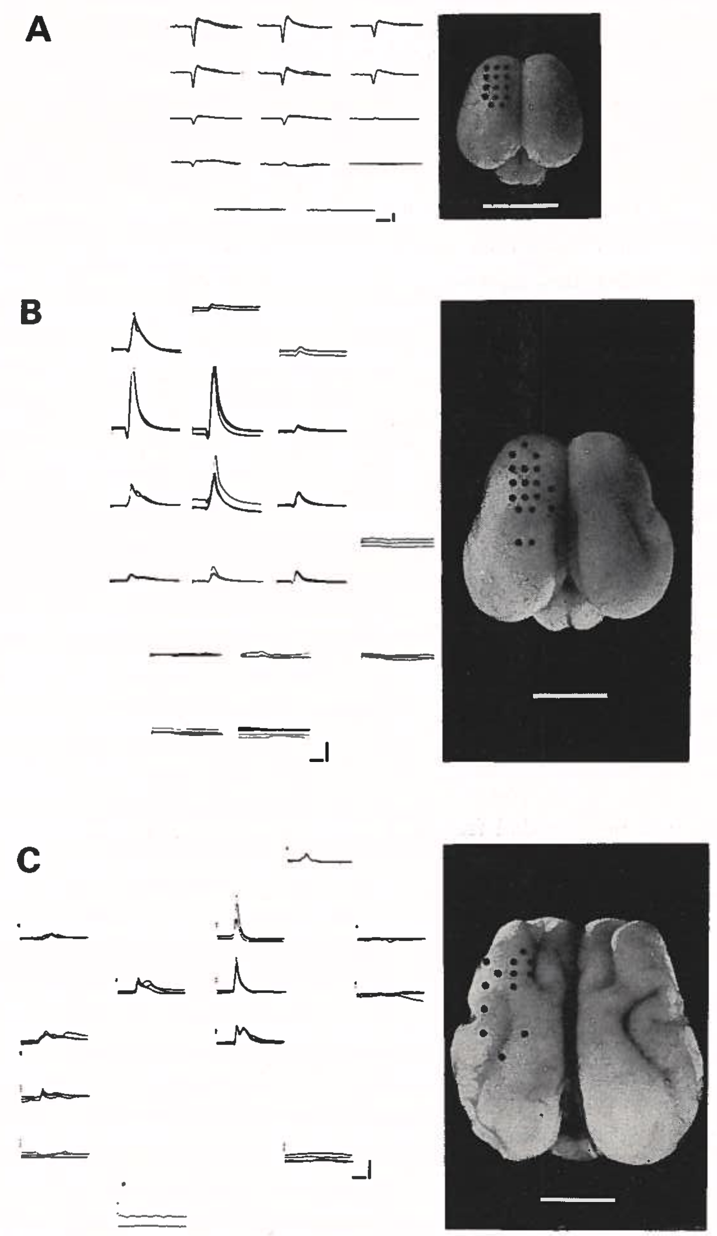

Fig. 1. Distribution of cortical responses evoked by tactile stimulation of the ipsilateral superior lip. A, a 69-day fetus; B, a 76-day fetus; C, a 91-day fetus. The records of the cortical responses correspond to the relative positions of dots on the brains. Horizontal bars below the brains represent 1 cm. Calibration: 200 μV, 100 ms. *Note,* in this and subsequent figures, negativity is upwards.

After the age of about 85 days, it is possible to trace the adult pattern of sulci and convolutions in fetal brains (Meyerson 1968 b). The somesthetic evoked response in a 91-day-old fetus could be recorded from *g. frontalis medialis* and *g. ectosylvius anterior* (Fig. 1 C). These two areas presumably correspond to SI and SII respectively in the adult animal (Woolsey and Fairman 1946). No responses were obtained from *g. suprasylvius* to tactile stimulation of the nose.

2. Configuration

The change in the configuration of the somatosensory evoked cortical response is a prominent developmental feature. Fig. 2 shows superimposed cortical potentials (n = 3—16) evoked by tactile stimulation of the ipsilateral upper lip in fetuses of various ages. A well-defined response was obtained even in

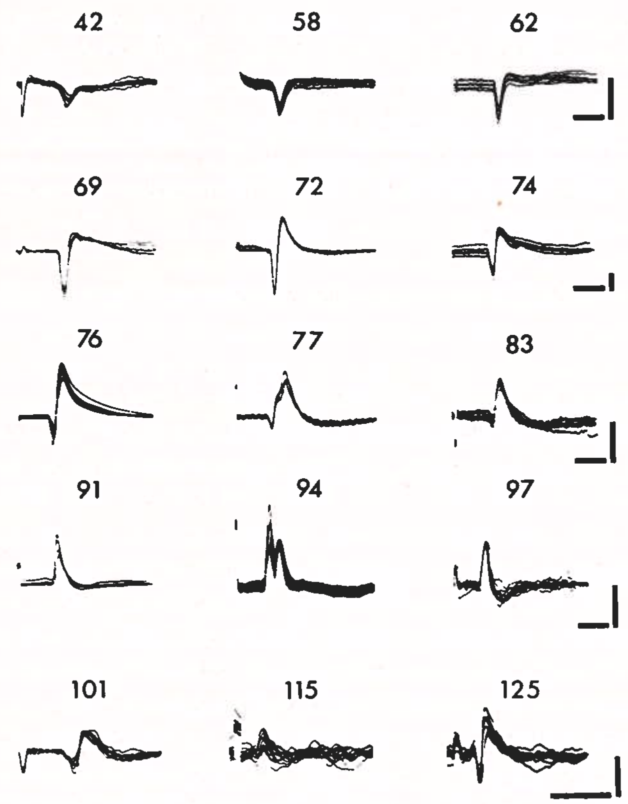

Fig. 2. Development of the configuration of evoked cortical responses in fetuses of various ages. The numbers above each record represent fetal ages in days. Calibration: 200 μV, 100 ms.

the youngest fetus examined (42 days, 12 g, Fig. 2, 42). In this as in the other fetuses younger than 68 days (Fig. 2, 58 and 62), the response had a surface positive form. This unique observation that the somesthetic response of sheep at its appearance in early ontogeny displays a surface positivity was first described by Molliver (1967). At a fetal age of about 68—70 days a small negativity appeared in the response after the positive deflection (Fig. 2, 69). During the following developmental stage between about 70 and 80 days (Fig. 2, 72, 74, 76, 77 and 83), this negativity increased in amplitude and successively became the predominating component. During the same period the initial positivity showed a decreasing amplitude. In most fetuses of 90—100 days, the evoked cortical potential was characterized by a single surface negativity (Fig. 2, 91) sometimes followed by a small positive wave (Fig. 2, 97). However, in a few fetuses responses consisting of a double negative peak were encountered (Fig. 2, 94). Predominating negative evoked responses to peripheral stimulation have also been recorded from the somesthetic cortex of cats (Scherrer and Oeconomos 1954, Marty 1962), rabbits (Marty 1962, Delhaye-Bouchaud 1964, Verley and Rokyta 1972) and rats (Thairu 1971) during the immediate postnatal period of development. Around 100 days of fetal life in the sheep, a small positive component, preceding the negativity, reappeared in the response (Fig. 2, 101). This positivity increased in relative amplitude with age (Fig. 2, 115 and 125) and at about 125 days the somatosensory cortical response displayed a positive-negative configuration similar to that of the adult animal (compare the α-response of Nougier, 1963).

3. *Latency*

The development of the onset latency of the evoked cortical potential and the peak latencies of its main components is shown in Fig. 3 A—D. The onset latency of the initial positive component amounted to 115 msec in the youngest fetus (42 days, Fig. 3 A). This onset latency value should be compared to 20—25 msec obtained in the fetuses near term. The corresponding values of the peak latencies of the positive component were 150 msec and 30 msec respectively (Fig. 3 B). The peak latency of the negative component in 69-day-old fetuses amounted to about 160 msec (Fig. 3 C). The same value in fetuses older than 120 days were 40—50 msec. The latencies of the different components of the cortical response were, thus, about 4—5 times longer in the younger fetuses as compared with the corresponding values in the fetuses near term (Fig. 3 D). For comparison, the onset and peak latency of the positivity and negativity in adult sheep on electrical stimulation of the ipsilateral superior lip have been reported to amount to 5, 12 and 17 msec respectively (Nougier 1963).

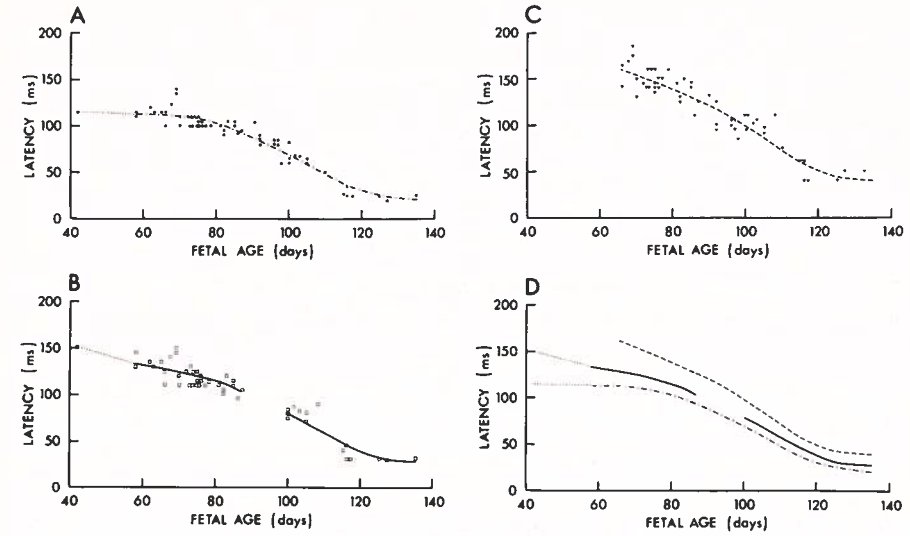

Fig. 3. Changes with age of onset and peak latencies of the evoked cortical response. A, onset latency (dots, dashed-and-dotted curve); B, peak latency of the positivity (open squares, solid curve); C, peak latency of the negativity (triangles, dashed curve); D, the developmental curves of onset and peak latencies shown together (symbols as in A—C). Curves are fourth order polynomial approximations to the experimental data.

The graph in Fig. 3 A (see also Fig. 3 D), illustrating the development of the onset latencies of the somesthetic response, shows a plateau at about 110 msec between 40 and 80 days of age. There is a marked decrease of latency between the 80th and the 120th day of gestation after which the latency levels off. The peak latencies showed a continuous decrease to about the 120th day and then a levelling off (Fig. 3 B, C, see also Fig. 3 D).

4. *Amplitude*

When the intensity of the tactile stimulation was increased stepwise above the threshold, the peak amplitude of the cortical response increased at each step and finally reached a level of saturation. The range in response amplitude from the threshold to the saturation level had a tendency to be larger in younger than in older fetuses. The data plotted in Fig. 4, illustrating the development of the peak-to-peak amplitude of the evoked potential, were derived from responses obtained with supramaximal stimulation. The maximal responses in the fetuses younger than about 63 days were of low amplitudes (150—600 μV). Between 65 and 76 days, cortical responses could be obtained with peak-to-peak amplitudes of up to 1 500 μV. However, there was

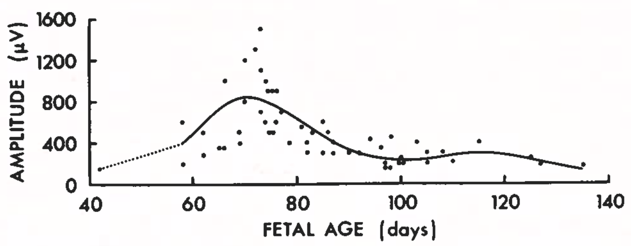

Fig. 4. Development of the peak-to-peak amplitude of the evoked cortical response. Curve is eighth order polynomial approximation to the experimental data.

a large variability in the amplitude of the responses recorded from fetuses of that age and low-amplitude evoked potentials were also observed. During the following developmental period the cortical responses showed a progressive diminution and from a fetal age of about 100 days the potentials had an amplitude of 200—400 μV. Such low amplitude values are typical for the adult animal (for sheep, see Nougier 1963).

5. Repetitive stimulation

In several investigations it has been shown that the ability of evoked cortical responses to follow repetitive peripheral (Hunt and Goldring 1951, Scherrer and Oeconomos 1954, Grossman 1955, Molliver 1967, Myslivešek 1968 a, Thairu 1971, Briquel and Verley 1972, Persson and Stenberg 1972) and central stimulation (Purpura 1961 a,b, Scheibel and Scheibel 1964, 1971, Grafstein 1963, Meyerson 1968 a,b, Conway, Wright and Bradley 1969) increases significantly during development. In sheep fetuses younger than 70 days of age the tactile stimuli had to be given at intervals of 20—30 seconds to obtain reproducible cortical responses. In 75-day-old fetuses, the evoked cortical potential could follow a stimulus frequency of about 0.5 Hz, whereas the response followed a rate of about 1 Hz in fetuses older than 88 days. For comparison, it may be mentioned that in nonanesthetized adult cats the recovery time of the primary somatosensory response has been reported to last 200 msec corresponding to a repetition rate of 5 Hz (Allison 1968).

In order to evaluate the susceptibility of the various response components to repetitive stimulation, experiments were performed in which the rate of stimulation was increased above that giving responses of constant amplitude. Fig. 5 A and B shows a series of successive cortical potentials obtained at a stimulus rate of 1 Hz in a 65- and a 72-day-old fetus respectively. In the 65-day-old fetus the responses were reduced to a low-amplitude positive deflection followed by a slow negative wave (Fig. 5 A). The corresponding

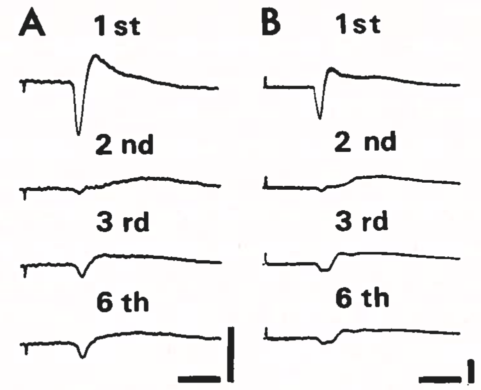

Fig. 5. Cortical responses to repetitive stimulation (1 Hz) in a 65-day fetus (A) and a 72-day fetus (B). Calibration: 200 μV, 100 ms.

data (Fig. 5 B) from the 72-day-old fetus show that the change in the cortical response was similar between the first and the second stimulation. However, in the third response additional components appeared as represented by the second positive deflection and the negative hump superimposed on the slow negative wave (see also Fig. 19).

Facilitation was observed in a few fetuses between 80—120 days of age. In Fig. 6 is shown an example of such a facilitation in the response of an 82-day-old fetus induced by repetitive stimulation at a rate of 1 Hz. From the second stimulation there was a remarkable increase in amplitude of both the positive and the negative components. The facilitation appeared in a waxing and waning fashion and the negativity was split up into two peaks. Facilitation was never observed in younger fetuses. The alterations in the cortical response in older fetuses during high frequency stimulation were highly inconsistent.

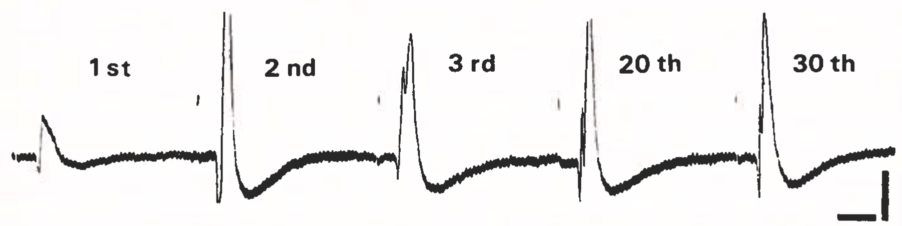

Fig. 6. Facilitation of the cortical response in an 82-day fetus by repetitive stimulation of 1 Hz. Calibration: 100 μV, 200 ms.

6. *Effect of strychnine*

In an attempt to elucidate the development of inhibitory mechanisms in the cortex some experiments were undertaken in which the effect of strychnine on the evoked cortical potential was studied. In Fig. 7 A is reproduced evoked responses in a 76-day-old fetus before and after topical application of 1% strychnine on the cortex. After strychnine there was a slight prolongation of the negative component. No significant change occurred in the response amplitude. Fig. 7 B illustrates corresponding data from a 91-day-old fetus. After strychnine prominent changes could be observed in the response which displayed a twofold increase in the peak-to-peak amplitude together with a marked prolongation of the duration. In addition a small initial positivity appeared and there was also a hump on the rising phase of the negativity. On the assumption that strychnine blocks inhibitory postsynaptic mechanisms in the cortex (Pollen and Ajmone Marsan 1965, Stefanis and Jasper 1965, Phillis and York 1967), the fact that strychnine only had an effect on the somesthetic response in older fetuses may be taken as evidence of a delayed maturation of cortical inhibitory synaptic systems during early periods of ontogeny.

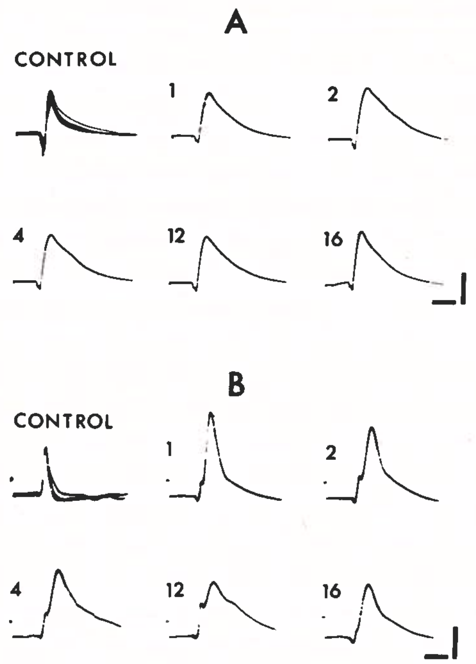

Fig. 7. Effect of topical strychnine (1 %) on the evoked cortical response in a 76-day fetus (A) and a 91-day fetus (B). Numbers above each record represent time in min after strychnine application. Calibration: 200 μV, 100 ms.

7. *Afterdischarges*

In 6 older fetuses (aged 85—120 days) it was possible to evoke cortical afterdischarges in addition to the 'primary' evoked potential (Fig. 8 A—C). The afterdischarge usually consisted of an epoch of spindling activity superimposed on a negative d.c.-shift. The onset latency of the discharge amounted to 400—600 msec and it had a duration of 400—800 msec. The frequency of the waves in the afterdischarge varied from 8—16 Hz. The negative d.c.-shift was generally more pronounced in the older fetuses in which it could attain a value of about 400—600 μV.

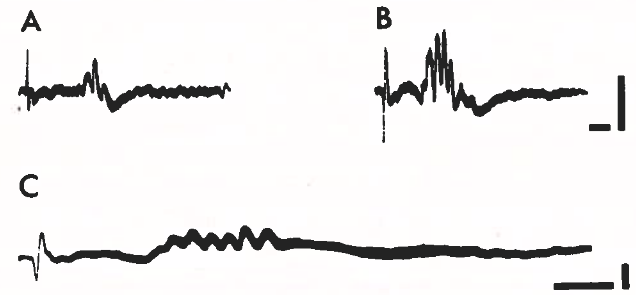

Fig. 8. Cortical afterdischarges evoked by tactile stimulation of the trigeminal nose region. A, a 94-day fetus; B, a 100-day fetus; C, a 105-day fetus. Calibration: 200 μV, 200 ms.

Fig. 9. Selective effect of repetitive stimulation (0.5 Hz) on the 'primary' evoked response and the afterdischarge in a 100-day fetus. Calibration: 100 μV, 100 ms.

The cortical afterdischarge had a comparatively low resistance to repetitive stimulation even compared to that of the 'primary' evoked response. As shown in Fig. 9 the afterdischarge was almost completely abolished at a stimulation rate of 0.5 Hz, whereas the 'primary' response was relatively unaffected. This finding may indicate that the two responses are generated by different subcortico-cortical mechanisms.

II. Development of somatosensory evoked field potentials

In order to evaluate the relative contribution of the activity in the different cortical layers to the building-up of the evoked surface response during development, a series of experiments was performed in which the evoked potentials were recorded at different cortical depths. Because the development of the evoked surface response is characterized by a series of successive changes in the size of its positive and negative components, laminar potential analyses were based on the amplitudes of the evoked field potentials at the latencies corresponding to the peaks of the surface positivity and negativity. On the basis of the measured potential values, depth-potential profiles and estimates of the corresponding vertical current gradient were made (see Methods). The results to be presented comprise laminar analysis of the somatosensory evoked cortical potentials from five successive developmental stages each characterized by a specific pattern of the surface response.

62-day-old fetus

The results of the laminar potential analysis in a 62-day-old fetus exhibiting a surface positive cortical response are shown in Fig. 10. Upper traces in A represent the surface potential and lower traces illustrate corresponding field potentials recorded with a microelectrode at indicated depths. In recordings from depths less than 1 000 μ, the field potentials displayed a monopolar positive form, similar to the surface response. At greater depths the field potentials exhibited negative values with maximal amplitudes at a depth of about 2 000 μ. The peak latency of the deep negative wave was 115 msec which corresponded to that of the surface positivity. The cortical thickness amounted to 700 μ (horizontal dotted line in Fig. 10 B and C, see pp. 40). Thus, the positivity of the surface response corresponds to positive field potentials located within the primitive cortex and to negativities located in the upper subcortical strata. The depth-potential profile shows that the maximal negative values of the field potentials—corresponding to the peak of the surface positivity—are located in subcortical layers (Fig. 10 B).

The graph in Fig. 10 C illustrates the vertical current gradient derived from the depth-potential profile. On the assumption that the negative maximum represents a net maximal current sink, this is located at a depth of about 1 200 μ. Similarly, if the positive maximum represents a net maximal source, this is situated at about 1 000 μ. To check the location of the microelectrode tips, marking experiments were performed with the Prussian blue method. The result revealed that the deep negativity and the net current sink were located in the subcortical strata (intermediate layer) of the immature telencephalic wall.

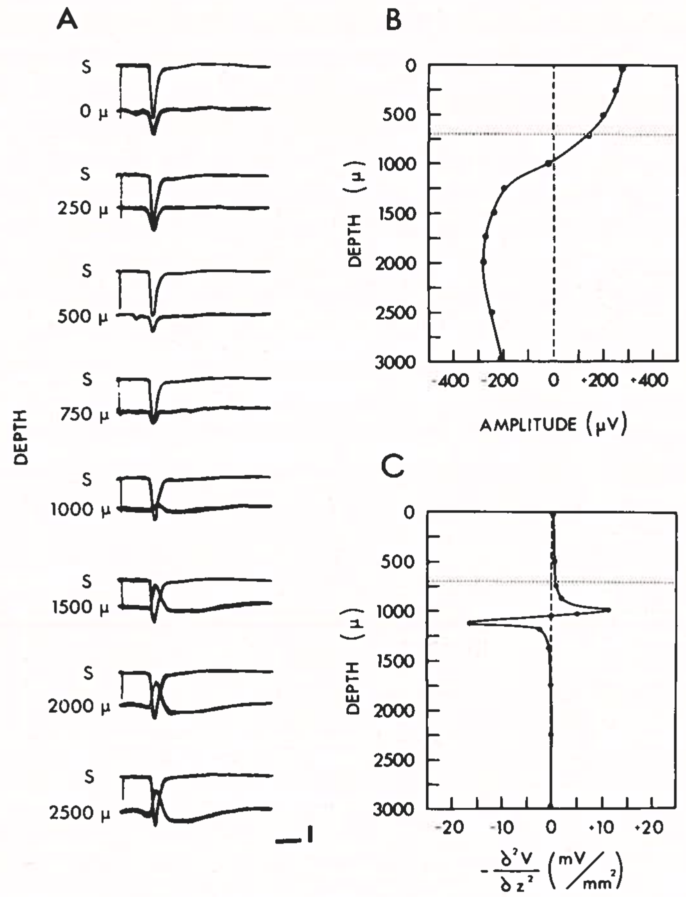

Fig. 10. Laminar analysis of evoked cortical potentials in a 62-day fetus. The upper records in A are surface potentials; lower are field potentials recorded with a microelectrode at indicated depths. Calibration: 200 μV, 100 ms. Depth-potential profile (B) and estimate of the vertical current gradient (C) corresponding to the peak of the surface positivity. A positive value of the gradient curve indicates a 'source' of vertical current and a negative value indicates a relative 'sink' (see Methods). The horizontal dotted lines (B and C) represent the approximate cortical thickness.

These observations indicate that early in development tactile stimulation of the trigeminal nose region does not activate neuronal elements within the cortex proper but evokes activity in strata immediate below the cortex.

70-day-old fetus

Laminar analysis of somatosensory evoked cortical potentials in a 70-day-old fetus is illustrated in Fig. 11. At this stage the surface response displayed

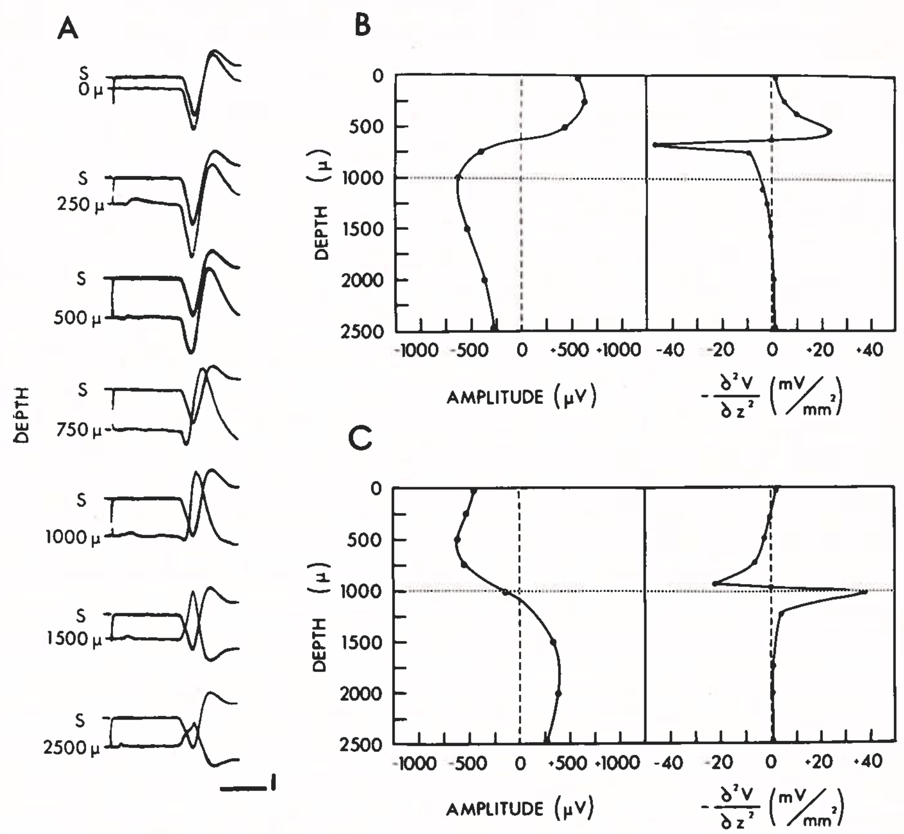

Fig. 11. Laminar analysis of evoked cortical potentials in a 70-day fetus. The upper records in A are surface potentials; lower are field potentials recorded at indicated depths. Calibration: 200 μV, 100 ms. B, depth-potential profile (left) and estimate of the vertical current gradient (right) at the peak of the surface positivity. C, the corresponding data at the peak of the surface negativity. The horizontal dotted lines (B and C) represent the approximate cortical thickness.

a biphasic positive-negative form with a predominance of the positive component (Fig. 11 A, upper traces). The configuration of the evoked field potentials (Fig. 11 A, lower traces) recorded at depths down to 250 μ was almost identical to the surface response. At increasing depths the field potentials displayed a gradual shift in wave form which could be characterized as a gradual shortening in the latency of the negative wave which eventually led to masking of the positivity at the depth of 1 000—1 500 μ. A maximal amplitude of the negative potential was met at a depth of 1 000 μ. The shortest onset latency of the deep negativity was observed in responses obtained at depths of 1 500—2 500 μ, and it appears from the records that at

these depths the field potentials have a monophasic negative configuration. In this developmental stage the lower border of the cortex was found to be situated at a depth of about 1 000 μ (horizontal dotted line in Fig. 11 B and C, see pp. 40).

The graphs in Fig. 11 B show the depth-potential profile (left) and the vertical current gradient (right) corresponding to the peak of the surface positivity. As seen the net maximal current sink was confined to the deep layers of the cortex. Negative values of the vertical current gradient curve correspond to depths of the primordia to cortical layers IV—VI (see Fig. 25 B). Positive values of the gradient were obtained in superficial cortical layers. The depth-potential profile (Fig. 11 C, left) and vertical current gradient (Fig. 11 C, right) of the surface negativity reveal a predominantly deep intracortical location of the net current sink with its maximum at 950 μ. The net current source was located at the lower border of the cortex proper.

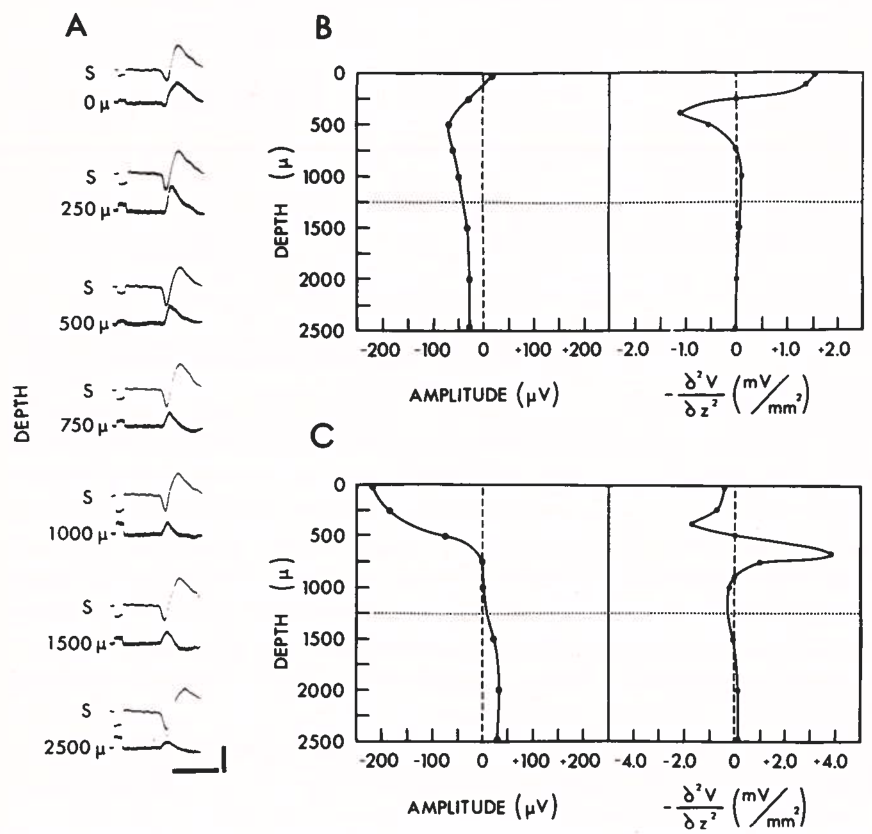

Fig. 12. Laminar analysis of evoked cortical potentials in an 80-day fetus. For further description, see Fig. 11.

These findings indicate that from 68—70 days of fetal life, the neurons *within* the deeper layers of the cortex can be activated by the trigeminal afferent inflow.

80-day-old fetus

The evoked field potentials in the cortex of an 80-day-old fetus displaying a surface positive-negative response with a predominating negativity, show that with increasing depth the biphasic response was transformed into a monophasic negativity (Fig. 12 A). This change in configuration was similar to that observed in the previous stage although it now took place in more superficial strata (down to 250 μ, Fig. 12 A, lower traces). With increasing depths down to 2 500 μ the evoked field potentials remained negative. The depth-potential profile (Fig. 12 B, left) and estimate of the vertical current gradient (Fig. 12 B, right) of the peak of the surface positivity show negative

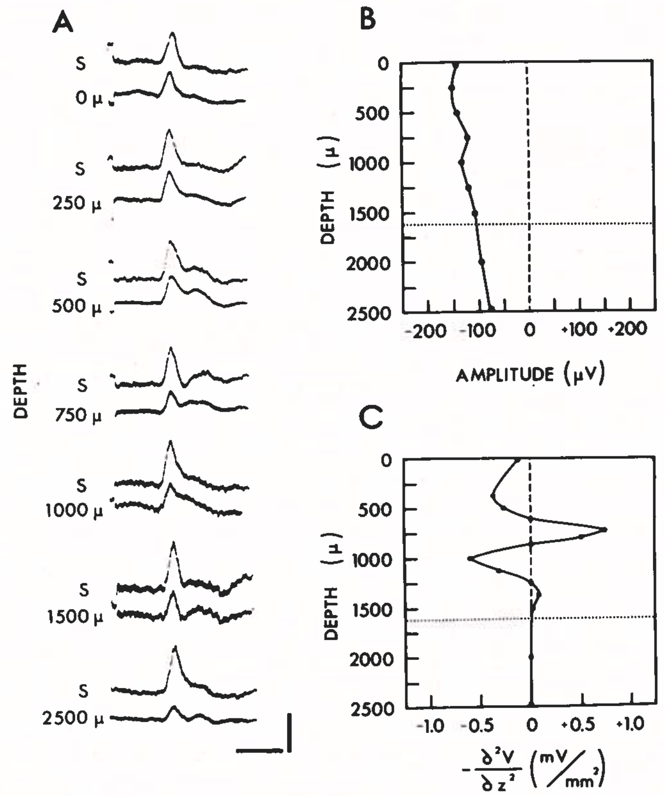

Fig. 13. Laminar analysis of evoked cortical potentials in a 94-day fetus. Depth-potential profile (B) and estimate of the vertical current gradient (C) corresponding to the peak of the surface negativity. For further description, see Fig. 10.

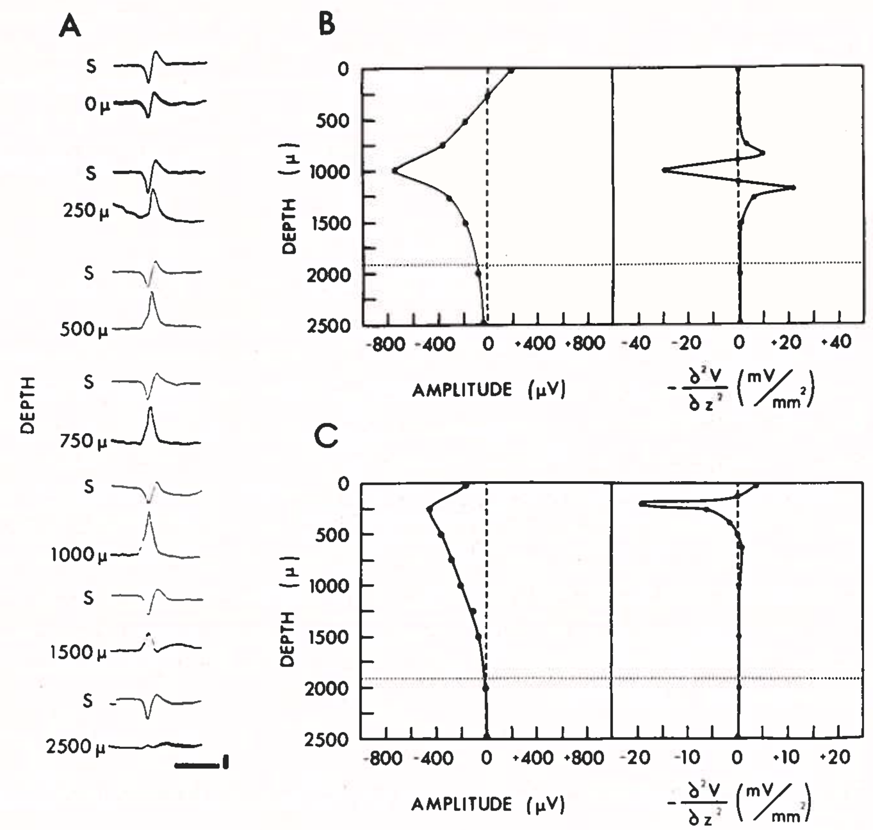

Fig. 14. Laminar analysis of evoked cortical potentials in a 110-day fetus. For further description, see Fig. 11.

maxima in the superficial cortical strata which later form the layers II—III (see Fig. 25 C). The corresponding data for the negative wave (Fig. 12 C) reveal net current sinks in the prospective layers I—III and in the deep strata of the cortex. The positive value of the vertical current gradient may correspond to a midcortical net current source. These results with prominent superficial current sinks are consistent with the assumption that the sensory stimulation now activated neurons throughout the cortex and that there is a predominance of activity in superficial strata.

94-day-old fetus

During the developmental period in which the evoked response had a monopolar negative form, the field potentials remained negative at all depth recordings (Fig. 13 A and B). Two negative peaks in the vertical current gradient graph were located at superficial (350 μ) and deep cortical strata (1 000 μ, Fig. 13 C). In between, there was a high amplitude positivity in the vertical current gradient curve which may represent a midcortical net current source. The results obtained may indicate the existence of two preferential loci of neuronal activity corresponding to the cortical layers I—II and IV—V (see Fig. 25 D).

110-day-old fetus

Fig. 14 A shows the evoked cortical potentials from a 110-day-old fetus displaying a positive-negative surface response. The records of the field-potential show, that during penetration the initial positive component dwindled quickly while the negative component grew and remained of high amplitude throughout the cortex. A shortening of the peak latency of the negative component was observed in superficial layers, and at a depth of 1 000 μ it had a latency amounting to 70 msec, which corresponded to the peak of the surface positivity. The net maximal current sink (Fig. 14 B, right) corresponding to the surface positivity was located in the midcortex at the approximate depth of the layer IV (see Fig. 25 E). There was indication of two net current sources above and below this sink. The corresponding net maximal current sink to the surface negative wave was located in the uppermost part of the cortex (Fig. 14 C, right).

III. Development of somatosensory evoked single unit activity

1. Response characteristics

Altogether, 228 single unit responses were recorded in 32 sheep fetuses aged between 65 and 125 days. Samples of evoked single unit responses are shown in Fig. 15—18 (lower records). In the fetuses younger than 68 days of age the unitary responses (9 of 12 units) generally consisted of a repetitive discharge displaying 2—4 spikes (Fig. 15). The evoked unit activity recorded from the cortex of fetuses between 70 and 90 days was always a single discharge (Fig. 16). Neither an increase of the intensity of the tactile stimulation nor an alteration of the stimulus locus on the nose caused a recruitment of additional spikes, contrary to what is found in the adult animal (Mountcastle 1957, Mountcastle, Davies and Berman 1957, Towe and Kennedy 1961).

Between 90—110 days of fetal age single spike responses were encountered from the majority of the neurons (Fig. 17, 96, left and 105). Occasionally, repetitive discharges were observed (Fig. 17, 96, right and 103). At the same developmental stage a few neurons were seen to fire concomitantly with the cortical surface afterdischarge (Fig. 24). During subsequent deve-

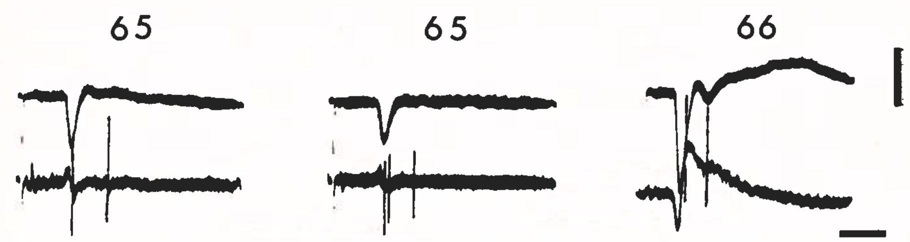

Fig. 15—18. Evoked surface and single unit responses in fetuses of various ages. The numbers above each record represent fetal ages in days. Calibration: 200 μV, 100 ms.

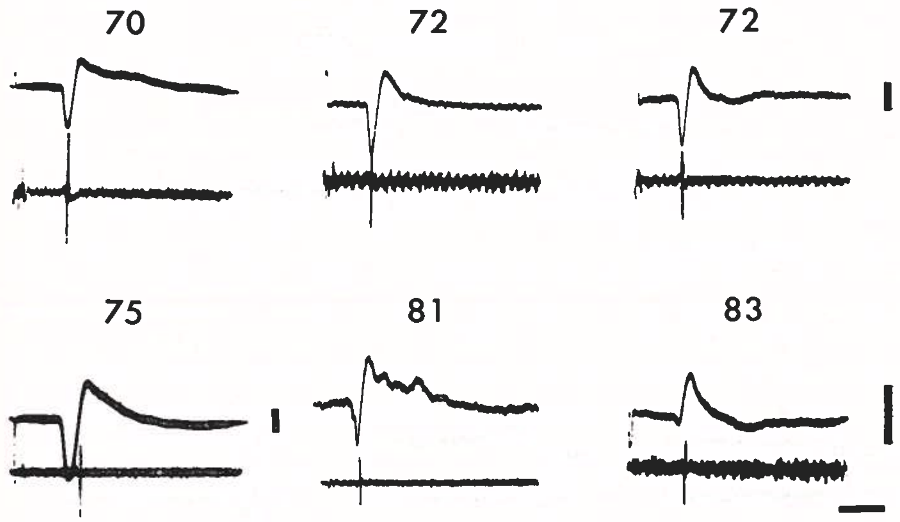

Fig. 16. Legend, see Fig. 15.

lopment the relative number of evoked repetitive unit discharges increased. Thus, in a 115-day-old fetus most of the cortical neurons (12 of 17 units) responded with repetitive spikes (Fig. 18, right records). The train of discharge consisted of one to four spikes. Similar 'modal values' of cortical neurons have been observed in the somesthetic cortex of the adult cat (Mountcastle *et al.* 1957). From the age of about 100 days, it was possible to establish a relationship between the relative site of the stimulation within the excitatory receptive field of the neuron and the intensity of stimulation on one hand and the pattern of discharge on the other. Thus, decreasing of the stimulation intensity or changing of the site of stimulation away from the center of the excitatory receptive field resulted in a reduction of the number of spikes per response and a lengthening of initial response latency. All these response properties have been found to be characteristic for the

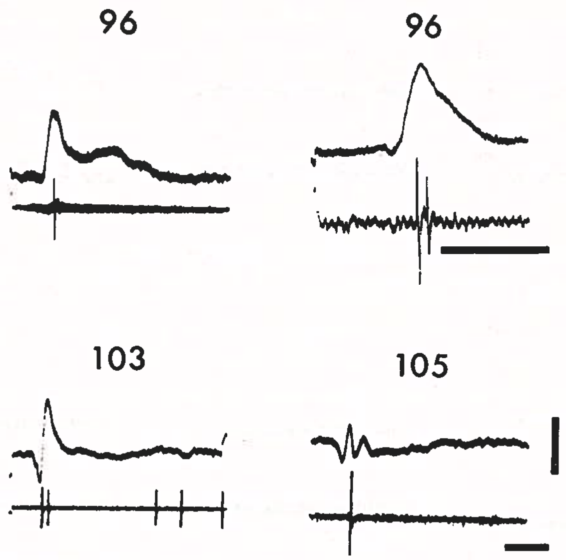

Fig. 17. Legend, see Fig. 15.

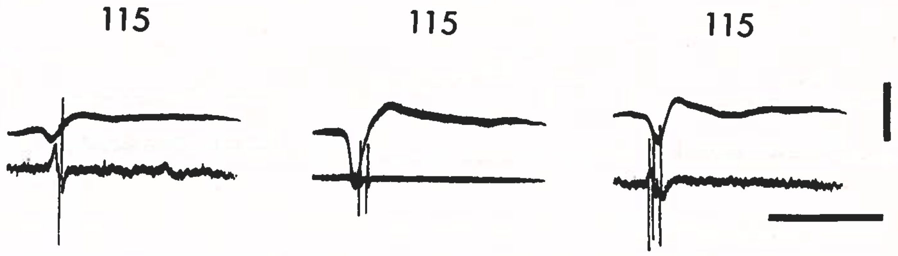

Fig. 18. Legend, see Fig. 15.

somatosensory cortical neurons of the adult cat (Mountcastle 1957, Mountcastle *et al.* 1957, Towe and Kennedy 1961).

Regardless of age, the great majority of the unit responses (80%) had a positive-negative configuration, the remainder being monophasic negative. There was a tendency for the relative number of negative-spike units to increase with age. No relation was observed between spike form and pattern of discharge. Since the units were recorded with a.c.-coupling with varying time constant, no attempt was made to study the development of the amplitude and duration of the spikes. Injury discharges were not observed in cortical neurons of fetuses of the youngest age group. When present in older fetuses the injury discharge displayed a characteristic pattern of a low

frequency burst of activity (*cf.* Huttenlocher 1967) remarkably different from the high-frequency discharge found in adult neurons (*e.g.* Amassian 1961).

2. Repetitive stimulation and recovery cycles

In order to get a further idea of the development of the capacity of the somatosensory system to transmit closely spaced signals, observations were made in a few experiments of the effect of repetitive and paired stimulation on the evoked unit activity in fetuses of various ages. It was found that the evoked unit responses were generally more resistant to repetitive stimulation than the evoked surface potentials. The neurons fired at rates which induced considerable alterations in the wave-form of the evoked gross potentials.

The responses depicted in Fig. 19 were obtained from a 72-day-old fetus stimulated with a frequency of 1 Hz. Except for the second stimulation the evoked unit activity fired in response to stimulations delivered at this rate. At higher frequencies the unit failed to follow and discharged only occasionally. It further appears that the amplitude of the positivity of the gross potential decreased during repetition and that it also showed a tendency towards splitting into two minute positive components. The firing of the concomitant unit activity from the third stimulus occurred simultaneously with the second of these positivities. An interpretation may be that the first positive component of the positivity is of presynaptic and the second one and the negativity are of postsynaptic origin (*cf.* Fig. 5). Figure 20 A shows

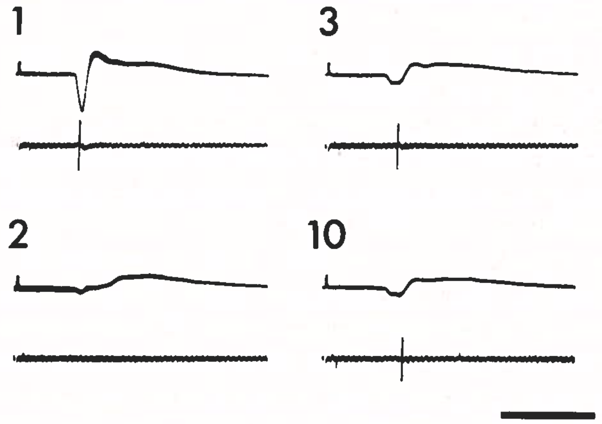

Fig. 19. Effect of repetitive stimulation (1 Hz) on evoked surface and single unit responses in a 72-day fetus. Calibration: 200 μV, 200 ms.

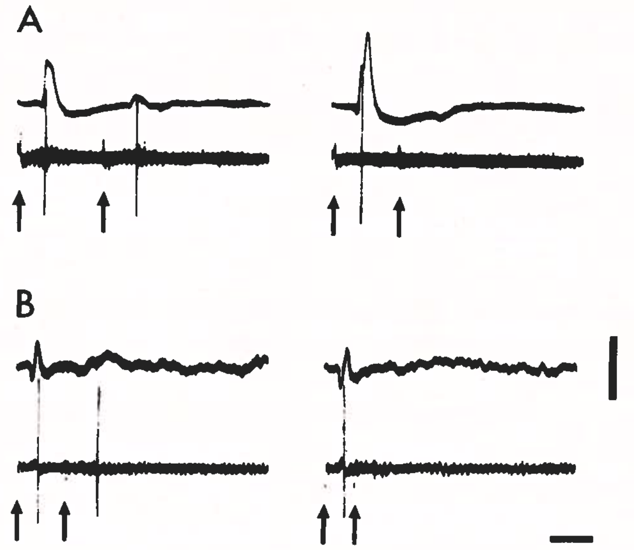

Fig. 20. Effect of paired stimulation on evoked surface and single unit responses in an 82-day fetus (A) with stimulus intervals of 400 msec (left) and 300 msec (right) and in a 105-day fetus (B) with stimulus intervals of 200 msec (left) and 100 msec (right). Arrows, time of stimulation. Calibration: 200 μV, 200 msec.

examples of responses to paired stimulation in an 82-day-old fetus with a separation of the two stimuli amounting to 400 and 300 msec respectively. At stimulus intervals of 400 msec or more both stimuli caused a discharge. A similar experiment is illustrated in Fig. 20 B in a 105-day-old fetus and it appears that with intervals of 200 msec or more the second stimulation evoked a single unit response.

3. Relation to evoked surface responses

The time relation of single neuronal responses to the evoked surface potentials in fetuses of different ages can be observed in Fig. 15—18. In fetuses younger than 68 days, the initial spike of the evoked units discharged at a time corresponding to the peak of the surface positivity. In Fig. 21 is illustrated the latencies of the recorded units in relation to the evoked surface responses for four developmental stages. Each of these stages is characterized by a typical configuration of the surface response. It should be noted, however, that data from the initial developmental stage are not included since the number of units recorded was too small. The black histograms represent the latencies of the initial spike, whereas the dotted areas represent those of the second spike. In the developmental period

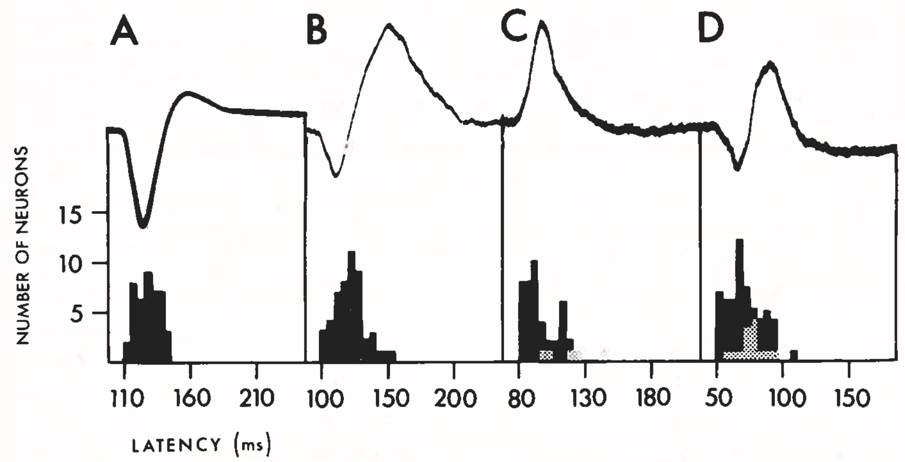

Fig. 21. Latencies of evoked single unit discharges in relation to the surface response in four developmental stages (A—D). Each of these stages is characterized by the configuration of the surface response. The black histograms represent the latencies of the initial spike, whereas the dotted areas represent those of the secondary spike. *Note,* the data from the initial developmental stage are not included.

comprising fetuses of 68 to 75 days of age, all evoked single units discharged during the course of the positivity with a maximum at its peak (Fig. 21 A). During the next stage (Fig. 21 B) the single unit responses fired during the positivity and the initial phase of the negativity with a maximum at a latency value corresponding to the onset of the negativity. In these two stages the neuronal responses always consisted of a single spike.

The evoked units concomitant with the monopolar negative response occured during the entire time course of the response with a preference of discharge during the initial phase (Fig. 21 C). In fetuses older than 100 days characterized by a positive-negative surface response the evoked units fired during the positivity and the initial phase of the negativity (Fig. 21 D). The dotted histograms in Fig. 21 C and D represent the latencies of the secondary spikes of the units with repetitive discharge found in fetuses older than 90 days.

4. Depth-distribution

In the fetuses less than 68 days of age, it was not possible to record more than 12 units despite the fact that a large number of penetrations (about 100) were performed with microelectrodes of different recording characteristics. These 12 units were all encountered at depths of 1 300—2 800 μ below the cortical surface. In order to check the depths from which these units were recorded, several experiments were made in which the location of the micro-electrode tips were marked with the Prussian blue method. In all cases the marked spots in the brain sections were found within the subcortical intermediate layer of the immature telencephalic wall.

In Fig.22 is illustrated the depth-distribution of evoked units isolated in the four stages subsequent to 68 days of age. The horizontal dotted lines represent the approximate thickness of the cortex at each stage and the increase during development can be seen (see pp. 40). It was observed that during the stage shown in Fig. 22 A (68—75 days), neuronal spikes were recorded from the cortical depths (500—1 400 μ) which correspond to the depths of the primordia to layers IV, V and VI (see Fig. 25 B). During the following developmental periods (Fig. 22 B—D) evoked unit activity was obtained from all cortical layers. Generally comparatively few units were recorded from depths of less than 200 μ, *i.e.* from the marginal layer, and from beneath the lower border of the cortex.

Combining the data from the depth- and the latency distribution of evoked unit activity reveal three relevant features. During the fetal period characterized by the monopolar surface positive response, the initial evoked unit discharge was recorded solely within the subcortical intermediate layer and during the positive surface component. During the next developmental stage (Fig. 21 A and 22 A) unit activity was recorded from the deep cortical layers and during the course of the positive component of the surface response. Finally, the evoked units were obtained in all cortical layers and with latencies

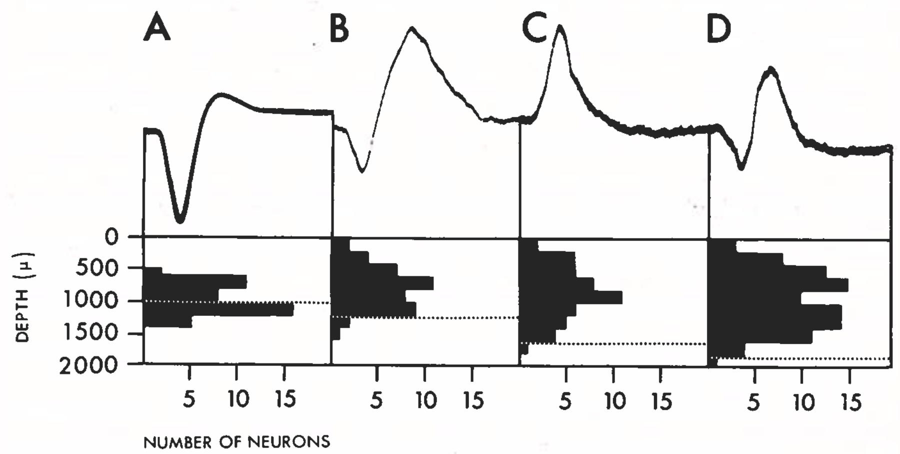

Fig. 22. Depth-distribution of evoked single unit discharges in the same developmental stages shown in Fig. 21 (A—D). The dotted horizontal lines represent the approximate cortical thickness at each stage. *Note,* the data from the initial developmental stage are not included.

corresponding to both the positive and negative components of the surface gross response (Fig. 21 B—D and Fig. 22 B—D).

5. Inhibition of cortical neurons

In the older fetuses (95—125 days of age) the spontaneous discharge of cortical neurons was comparatively high (Persson, in preparation). Thus, in some of these fetuses it was possible to study afferent inhibition by the use of properly placed tactile stimulation to cause an arrest of the spontaneously discharging units (*cf.* Mountcastle and Powell 1959). Fig. 23 shows typical examples of inhibition recorded in a 98- and a 115-day-old fetus. In these cases, the inhibition caused an abrupt and complete cessation of the discharge in the neurons lasting for 400—800 msec. There was no sign of postinhibitory rebound.

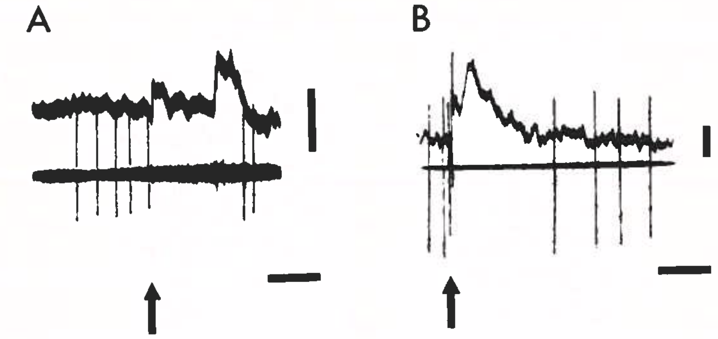

Fig. 23. Inhibition of spontaneously discharging cortical units by tactile stimulation in a 98-day fetus (A) and in a 115-day fetus (B). Arrows, time of stimulation. Calibration: 100 μV, 400 ms.

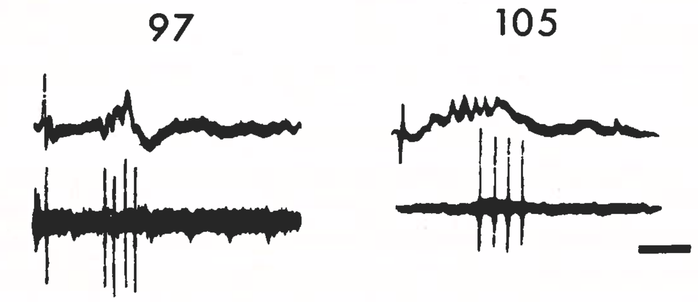

Fig. 24. Evoked single unit activity related to the cortical afterdischarge. Numbers represent fetal ages in days. Calibration: 200 μV, 400 ms.

6. Relation to evoked surface afterdischarges

A single sensory stimulation in some older fetuses evoked long-latency cortical afterdischarges consisting of spindling activity superimposed on a negative d.c.-shift (*cf.* Fig. 8). It was possible to show that this afterdischarge may be accompanied by repetitive unitary responses (Fig. 24). The left record shows a unit which discharged in conjunction with the 'primary' response and during the afterdischarge. Another type of discharge, more frequently encountered, is illustrated in the right record, where there was activity only during the cortical afterdischarge. No constant relation could be observed between the spikes and the individual waves of the afterdischarge.

IV. Development of cortical morphology

Some data on the early morphological development of the neocortex in fetal sheep are presented in this section to facilitate the understanding of the relationship between structure and function. A great deal of information has been collected in an extensive investigation by Åström (1967). In the present study some complementary results will be presented with special regard to the maturation of the cortical stratification. Such data are of particular significance in relating the neuronal events to the cortical structure.

In Fig. 25 is depicted a series of brain sections, stained with cresyl violet, from fetuses of various ages. The specimens were taken from the cortical areas in which somesthetic evoked responses were recorded. In the older fetuses with gyrencephalic brains these areas correspond to the 'area preparietalis' of the adult animal (Rose 1942).

During the early developmental period when the fetal brain is lissencephalic, the neopallial wall is made up of three distinct concentric strata; the cortical plate, the intermediate zone and the germinal layer (Åström 1967). The immature cortex proper consists of two layers, the marginal and pyramidal layers, which successively develop into the 6-layered adult neocortex. In the brain section from a 62-day-old fetus (Fig. 25 A) the cortex proper and the upper subzone of the intermediate layer can be seen. This type of stratification is characteristic for an early phase of neocortical ontogeny. The lightly stained marginal layer (a) contains horizontally orientated cells, the Retzius-Cajal cells (Retzius 1891, 1893, Cajal 1960, Åström 1967). An incipient stratification can be observed in the pyramidal layer (b—d) with an indication of a light band in its middle third (c). The cells in the pyramidal layer have an immature appearance; in the outer part small dark cells of bipolar shape are arranged in compact vertical columns; in the inner layers a widening of the intercellular spaces can be observed. The subpyramidal layer (e) contains some large cells with a relative mature appearance, presumably stellate cells (*cf.* Åström 1967).

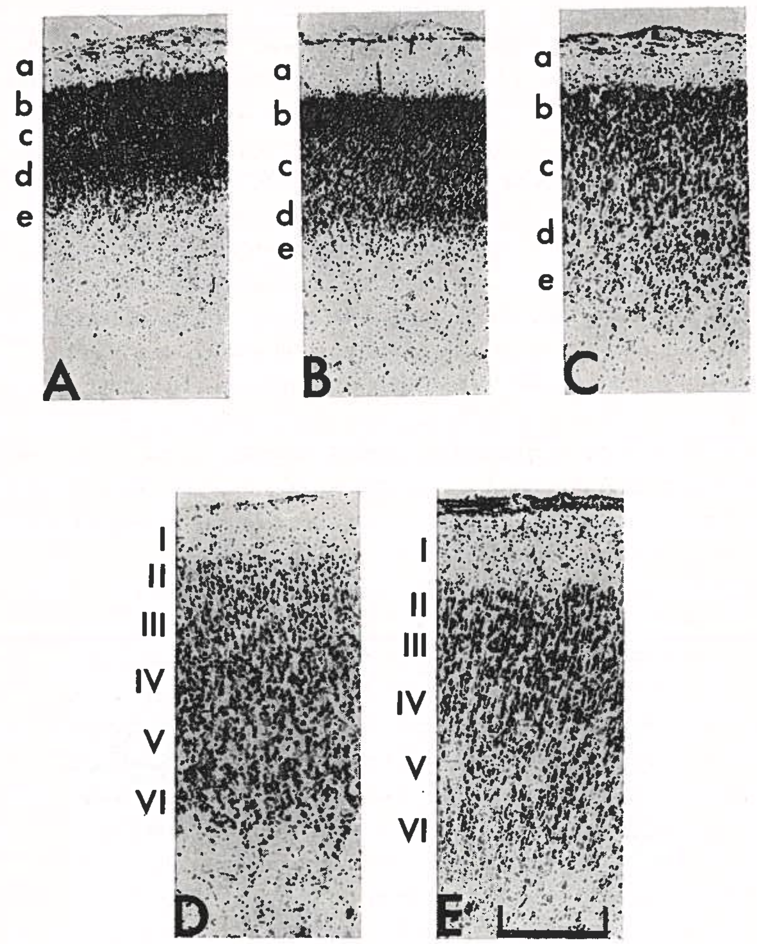

Fig. 25. Somesthetic cortex at different stages of maturation. Brain sections from fetuses of 62 (A), 69 (B), 82 (C), 98 (D) and 127 days of age (E). Cresyl violet stain. Horizontal bar represents 500 μ.

The lamination of the cortex in a 69-day-old fetus stands out more clearly and consists of 5 identifiable layers (Fig. 25 B). The uppermost part (b) of the pyramidal layer is crowded with cells of the same appearance as in the younger animals. Compared to earlier stages the light band in the middle of the pyramidal layer (c) has become wider and more prominent. This is probably due to the fact that the evolvement of dendritic and fibrillar processes has caused a separation of cells and consequently a widening of the intercellular spaces (Lorente de Nó 1933, Åström 1967). The pyramids of the deep dark layer (d) are less packed and more mature than those in the superficial pyramidal layers (b). Large stellate cells can be observed for the first time within the inferior pyramidal layer. These cells are the largest neurons in the neocortex at this developmental stage; a fact which may be of functional significance in the present context. The cellular morphology in this stage has been described by Åström (1967) in detail with the aid of the Golgi method.

The section (Fig. 25 C) from a 82-day-old fetus represents the next developmental stage and a more definite 5-layered stratification is now discernable. In the Nissl preparations most cells appear to have reached a comparatively advanced stage of development. However, the most superficial cells are still immature and form a thin dark stratum (b) below the marginal layer (a).

A clear 6-layered stratification similar to what is found in the adult animal (Rose 1942) is observed in the cortex of a 98- and a 127-day-old fetus (Fig. 25 D and E). Mature pyramidal cells are found in all cortical layers even in the most superficial ones.

To summarize, the cortical cells and strata, as studied in Nissl stained preparations, become differentiated in a definite sequence. The marginal and the subpyramidal layers are the first to become differentiated. These strata will form the layer I and the lower part of layer VI in the adult cortex. Thereafter the lightly stained stratum of the pyramidal layer develops and will become the layers IV and lower III. Parallel with these changes, stellate cells are incorporated in the lower pyramidal layers. The deep pyramids which constitute layers V and VI will then attain their mature appearance. During the subsequent development the cells within layers III and II differentiate to their mature form (*cf.* Åström 1967).

For the interpretation of the results in the current investigation the reliability of the estimations of the depth locations of neuronal activity as well as its morphological substrate are of paramount importance. Therefore it is necessary to know the degree of shrinkage induced by the histological preparation. For this purpose an iron deposit was produced through a microelectrode tip at a fixed cortical depth as read off by the micrometer during an actual experiment (*e.g.* Änggård 1965). By comparing the depths of the Prussian blue spots in brain sections with the corresponding micrometer readings the shrinkage factor could be determined. In the present fetal material the shrinkage of the neocortex amounted to about 30% (range 25—35%) which is somewhat larger than the corresponding value (20—25%) reported for the adult rat cortex (Borbély 1970). This difference may be explained by the fact that the water content of the immature brain is higher

than that of the mature brain (*e.g.* Vernandakis and Woodbury 1962). In Fig. 26 A is shown an example of an iron deposit produced at a depth of 500 μ in the neocortex of a 71-day-old fetus contrastained with cresyl violet. This deposit was located at the border between the immature superficial dark (prospective layers II and III a; *cf.* Fig. 25 B, layer b) and the relatively more mature middle light layers (prospective layers III b and IV; *cf.* Fig. 25 B, layer c).

The markings shown in Fig. 26 B are from an 82-day-old fetus. The whole track down to 500 μ was marked and the lower limit corresponded to the superficial cortical strata (layers II and III, *cf.* Fig. 25 C, layer b). The deposit at 1 000 μ was located at the lower border of the prospective layer IV (*cf.* Fig. 25 C, layer c). On the basis of the shrinkage factor of 30% the approximate cortical thickness was determined from the cresyl violet stained brain sections made at different developmental stages: 700 μ at the age of 62; 1 000 μ at 72; 1 250 μ at 82; 1 650 μ at 98 and 1 900 μ at 127 days. These values have been used to denote the cortical thickness in Fig. 10, 11, 12, 13, 14 and 22.

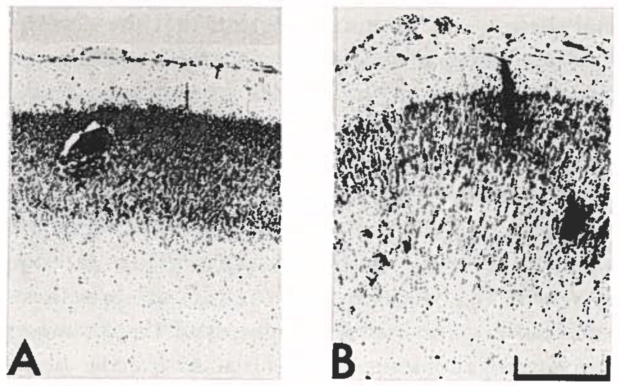

Fig. 26. Prussian blue markings in cortical sections stained with cresyl violet. A, at a depth of 500 μ in a 71-day fetus; B, at depths of 500 μ and 1 000 μ in an 82-days fetus. Horizontal bar represents 500 μ.

DISCUSSION

The present results demonstrate that a somesthetic response to tactile stimulation can be recorded from the cortical surface of sheep fetuses already at a very early stage of ontogeny, thus confirming the original study by Molliver (1967). During the subsequent development the response undergoes a sequence of characteristic alterations. Earlier investigations on cortical potentials evoked by somesthetic stimulation in dogs, cats, rabbits and rats during the postnatal period show that a response is present at birth (Scherrer and Oeconomos 1954, Grossman 1955, Marty 1962, Delhaye-Bouchaud 1964, Thairu 1971, Verley and Rokyta 1972). A comparison of the functional characteristics of the cortical response in these altricial, postnatal animals and in the fetal sheep of different ages suggests that the developmental stage of the somatic sensory system of newborn dogs, cats, rabbits and rats corresponds approximately to that of the 80—90-day-old fetal sheep. In addition, the sequence of changes in the response, in particular with regard to its configuration, during the postnatal period of these animals is very similar to those observed in the later prenatal stages of sheep. These observations lend support to the notion that the difference in rate of pre- and postnatal functional development of these species (Adolph 1970) also applies to the somatosensory system (*cf.* Gottlieb 1971). Thus, the present study on fetal sheep covers the initial periods of development of the somatosensory system, whereas earlier investigations on postnatal animals have been confined to relatively more mature stages of ontogeny.

1. Aspects of the mode of operation in the immature somatosensory system

Unitary recording in the adult cortex is subject to bias (Towe and Harding 1970). This bias may be even more important in the case of immature neurons, which are small and have fragile membranes as deduced from their structural and functional properties different from those found in the adult (*e.g.* Purpura 1972). As a matter of fact, stable recordings during long-lasting sessions are very difficult to obtain and impossible to achieve in the early prenatal cortical stages. Nevertheless, a large number of penetrations were made into the subcortex at each developmental stage with micro-

electrodes of different recording characteristics. It should be recalled that general anesthesia, shown to decrease responsiveness of cortical neurons (Mountcastle *et al.* 1957), has not been used. It cannot be excluded that factors at the stimulation site *e.g.* changes in the tissue properties and size of the stimulated nose area in the relation to the stimulating probe may influence results of the present study such as the development of amplitude and cortical distribution of the response. However, there are reasons to believe that these factors do not contribute significantly and in a predictable way to the parameters of development observed. Thus, for instance, the response amplitude shows both an increase and a decrease during the period of development when the relative stimulation area decreases.

The functional significance of the sensory evoked repetitive discharge in the subcortical units of the young fetal sheep is unknown. A similar pattern of discharge of subcortical neurons evoked by light stimulation has been observed in the newborn kitten (Huttenlocher 1967). When, during development, evoked units were first obtained within the cortex they responded with a single spike. Such a discharge pattern has also been demonstrated in experiments on newborn kittens and shown to represent postsynaptic activation (Purpura *et al.* 1965). Another aspect of the low level of responsiveness of the immature cortical neurons is their characteristic paucity of spontaneous discharge (Persson, in preparation, *cf.* Hyvärinen 1966, Huttenlocher 1967, Laget, Thomsson and Delhaye-Bouchaud 1967, Armstrong-James 1970, Rubel 1971). Contrary to what has been found in the adult animal (Mountcastle 1957, Mountcastle *et al.* 1957, Towe and Kennedy 1961, Darian-Smith 1966) the immature cortical neuron responds only with a single spike regardless of the strength and location of the stimulus within the peripheral receptive field. This finding points to a fundamental difference in the function of the immature and the mature somatosensory system to code information about the stimulus parameters. The appearance during development of cortical neurons capable of evoked repetitive discharge denotes the transition to a stage when the somesthetic system begins to operate in a way qualitatively similar to that of the adult. It is important to recall that this maturational process is highly dependent on extracortical functions such as an increased maturity of the tactile cutaneous receptors and of the peripheral sensory nerves (Ekholm 1967, Kasprzak, Tapper and Craig 1970).

Contrary to the findings in a 76-day-old fetus, the clear-cut releasing effect of strychnine on the evoked potential in a 90-day-old fetus as well as the presence of cortical units, at a comparable developmental stage, whose spontaneous discharge was arrested by peripheral stimulation, strongly suggest that inhibitory mechanisms within the cortex are effective at that later stage of development. In corresponding developmental periods of postnatal kittens, pronounced long-lasting IPSP:s have been observed in cortical neurons as a result of electrical stimulation in the thalamus (Purpura *et al.* 1965). Furthermore, the duration of these IPSP:s is of the same order of magnitude as the duration of the inhibitory arrest of spontaneous units observed in the present study. These findings lend support to the idea that there may be a relative delay in the maturation of cortical inhibitory mechanisms (*cf.* Huttenlocher 1967, Meyerson and Persson 1973). The late development of axosomatic synapses, considered inhibitory in nature (*e.g.* Colonnier 1968) compared to axodendritic ones (Voeller *et al.* 1963, Meller *et al.* 1968, Adinolfi 1971, 1972) may serve as further evidence for such a supposition. However, the significance of axodendritic inhibition in the immature cortex (Purpura 1971) and hippocampus (Purpura, Prelevic and Santini 1968) has been proposed recently. It has been claimed that inhibitory postsynaptic mechanisms, both in the cortex and hippocampus show a precocious development compared to excitatory ones (Purpura 1969, 1971, 1972). The fact that these observations were made on newborn kittens (compare with fetal sheep of 80—90 days of age) implies that no stage was studied sufficient immature to justify a general statement about the relative rate of functional development of excitatory and inhibitory postsynaptic mechanisms in the cortex. Intracellular recordings of the responses in cortical neurons to peripheral stimulation have to be performed in fetal animals to settle this question.

In recent publications (Scherrer *et al.* 1968, 1970) it has been discussed that the 'time, velocity and flow' of neuronal signals are important factors, which contribute to the differences in function of neonatal and mature nervous system. The over-all conduction time from the receptors to the cortex of very young sheep fetuses is long. Between 80 and 120 days, there is a rapid and continuous decrease in conduction time. This change is dependent upon several factors such as changes in synaptic transmission efficiency, increasing of conduction velocity and lengthening of conduction pathways during growth (*cf.* Mysliveček 1968 a). The major factor contributing to the decrease of the onset latency is presumably the increase of afferent fiber diameters and in particular the development of myelin as repeatedly emphasized (references, see Skoglund 1969). In the fetal sheep, myelin can be detected in the trigeminal nerve at 60 days of age (Barlow 1969), in the main sensory trigeminal nuclei at 66 days (Romanes 1947) and in the thalamic radiation at 78 days (Barlow 1969). Conduction time approaching adult values was obtained in fetuses of 120 days of age. The fact, that the distance from skin receptors to cortex in these fetuses is short compared to that of the adult animal, implies that the conduction time attains adult

values long before conduction velocity (*cf.* Scherrer *et al.* 1968). This finding is in accordance with the wellknown fact that the conduction velocities of peripheral (Hursh 1939, Skoglund 1960) and central nerve fibers (Verley 1967 a, Meyerson 1968 b, Conway *et al.* 1969) of fetal sheep and of neonatal cats and rabbits are slow. The fatiguability of the somatic sensory system is extremely marked in young fetuses, as a stimulus interval of up to 20 sec had to be used to obtain reproducible responses with constant amplitudes. During development there is an increased capacity of the system to mediate closely spaced signals and generate constant electrocortical responses (*cf.* Scherrer and Oeconomos 1954, Molliver 1967). Thus, in the fetal sheep one is confronted with an ineffective somesthetic system in terms of low conduction velocities and reduced flow of the sensory neuronal signals which are considered to be of importance for the sensory feed-back mechanisms and memory processes (Scherrer *et al.* 1968, 1970).

2. Development of the 'specific' and 'nonspecific' somatosensory systems

The similarity between the somatotopic organization of the ipsilateral upper lip in the immature fetal sheep and in the adult (Adrian 1943, Hatton and Rubel 1967) indicates that the lay out of adult cortical projection is present already at an early developmental stage. The results from a recent study on the cortical somatotopy of newborn and adult cats (Rubel 1971) are in accordance with this finding, since it was found that the projections from all the contralateral body surface to the primary sensorimotor cortex were present at birth and organized in a similar way to that of the adult animal. From the time when the adult pattern of convolutions and fissures can be observed in the fetal sheep, the ipsilateral evoked potentials were found to be confined to those areas which correspond to the primary and secondary somesthetic areas in the adult as defined electrophysiologically (Adrian 1943, Woolsey and Fairman 1946) and morphologically (Rose 1942). In no case was it possible to record somesthetic responses from other brain areas. The predominately negative evoked response of fetuses between 80—90 days of age is identical to the cortical potential obtained in newborn cat (Purpura 1961 a,b, 1962) and rabbit (Verley *et al.* 1966, Verley 1967 a, Verley and Siou 1967) in response to electrical stimulation of the specific thalamic relay nuclei. In the adult sheep it has been shown that electrical stimulation applied to the sensory endings of the trigeminal nerve evokes prominent responses in the ipsilateral ventroposteromedial (VPM) nucleus (Richard, Auffray and Albe-Fessard 1967, Cabral and Johnson 1971) as well as in the primary somesthetic cortex (Nougier 1963). In view of these findings, it is assumed that the cortical response evoked by tactile stimulation of the ipsilateral trigeminal nose region in sheep fetuses during development results essentially from an activation via the specific thalamocortical system. A similar conclusion about the trigeminal afferent input to the somatic sensory area of newborn rabbit has been reported (Verley 1967 b).

It is a wellknown fact that in the adult unanesthetized animal different types of sensory stimuli may evoke responses within the so-called association areas of the cortex (*e.g.* Buser and Bignall 1967, Thompson, Bettinger, Birch and Groves 1969). The failure to record such responses to trigeminal tactile stimulation in any of the fetuses indicates a relative retardation of this associative somatosensory system. It is of interest in this connection to refer to a recent study by Mayers, Robertson, Rubel and Thompson (1971). They demonstrated that in postnatal kittens, sensory evoked unit responses in association areas developed comparatively late and that the somatosensory units appeared later than visual and auditory ones.

A cortical afterdischarge triggered by single sensory stimulation has been observed in the somesthetic (Scherrer and Oeconomos 1954) and visual cortex (Marty 1962, Huttenlocher 1967, Rose *et al.* 1972) of unanesthetized postnatal kittens. The findings in the present study that the cortical afterdischarge appeared later in development than the 'primary' evoked response, and that it was selectively suppressed by low-frequency repetitive stimulation support the view that these two cortical activities are generated by different subcortico-cortical mechanisms. Furthermore, it was frequently observed that cortical neurons fired solely concomitantly with either of the two electrocortical activities. There is reason to believe that the appearance during development of the cortical afterdischarge is dependent on the functional maturation of nonspecific reticular and thalamic structures and their integration with the afferent specific system. Firstly, the simultaneous appearance and the similar pattern of the evoked cortical afterdischarge and spontaneous EEG-spindles (Bernhard *et al.* 1959, Bernhard and Meyerson 1968, Meyerson 1968 b) may indicate a common subcortical drive for these electrocortical activities. The importance of intrathalamic integration for the synchronization of the thalamocortical rhythmic activities in the adult (references, see Andersen and Andersson 1968, Purpura 1968, 1972) and immature animal (Thatcher and Purpura 1972) has been stressed. Secondly, since the flash-evoked cortical afterdischarge observed in postnatal kittens develops into a desynchronizing activity typical of adult electrocortical arousal, it has been considered to constitute a primitive reticular arousal (Rose *et al.* 1972).

On the basis of the foregoing discussion, it seems likely that there is a differential development of specific and nonspecific afferent systems projecting to the *somatosensory* cortical areas from the trigeminal region. The

specific pathways may activate the cerebral cortex already during early prenatal stages as shown by the presence of the 'primary' evoked response whereas generalized and associative activation involving the ascending reticular system integrated with the specific afferent system, seems to appear comparatively late during ontogeny.

In this context it is of relevance to make a comparison with the differential development of the specific and nonspecific components of the visual and auditory systems. It has recently been demonstrated in the prenatal sheep that the development of visually evoked cortical responses occurs in two phases (Persson and Stenberg 1972). A similar developmental course has previously been described in the postnatal development of cat, dog and rat (Marty *et al.* 1959, Marty 1962, Fox 1968, Myslivešek 1968 a, Rose 1968 a,b, 1971, Rose and Lindsley 1968). Based on the different reactions to selective subcortical lesions of the different components of the cortical response it has been proposed that the early appearing negative component is mediated via the nonspecific optic projection. Components appearing later in development have been considered to be dependent on the specific visual pathways (Rose and Lindsley 1968). On the basis of studies on auditory evoked electrocortical responses in postnatal dogs to electrical stimulation in the periphery and in the medial geniculate body, it has been assumed that the specific thalamic relay nucleus is indispensable for evoked auditory responses in the newborn animal (Myslivešek 1968 b).

3. Functional development of the somatosensory cortex and its morphological correlates

Earlier investigations on the postnatal development of evoked surface responses in sensory cortex in various species have demonstrated the presence of a predominant surface-negative potential immediately after birth. The precocity of the superficial axodendritic neuropile has been considered to account for this feature of the evoked potential (Marty *et al.* 1961, Scheibel 1962, Marty and Scherrer 1964, Purpura *et al.* 1964). However, the characteristic surface-positive wave-form of the somatosensory evoked response in immature fetal sheep suggests a different mode of electrocortical activation in the cortex during early prenatal stages of ontogeny. This is not due to species-specific organization of the sheep's cortex, since it has been reported that predominantly positive evoked cortical responses may be obtained also in the cortex of fetal dog (Molliver, personal communication). In addition, somatosensory evoked cortical responses displaying initial positivity have occasionally been recorded in newborn rats (Thairu 1971).

The results of the laminar recordings of both gross and unit evoked activity disclose that in the most immature fetuses examined, a trigeminal skin stimulus induces neuronal activity in subcortical strata of the telencephalic wall (*cf.* Meyerson and Persson 1969, Persson 1971, 1973). There is no experimental evidence that intracortical elements are excited. The activity is recorded as a surface positivity. Whether the recorded response is an expression of presynaptic activity in the developing thalamocortical nerve fibers (Bernhard *et al.* 1967) or postsynaptic activation of stellate neurons located subcortically cannot be definitely stated on the basis of the present findings. In an investigation on postnatal kittens, it has been shown that spontaneous and flash-evoked single unit activity during development was first obtained from the optic radiation fibers (Huttenlocher 1967). Anyhow, it is not inconceivable that at first the somatosensory system operates as a dead-end afferent system with no functional contacts with the cortical neurons. This supposition is in accordance with the facts that during this developmental period it has not been possible to trace afferent fibers penetrating into the cortical plate and that the cells of all cortical laminae have a primitive bipolar shape (Åström 1967).

The neocortical morphology of prenatal sheep during this early period of maturation has many characteristics in common with what is found in the fetal cat during a stage of cortical development which has been denoted as 'reptilian' (Marin-Padilla 1971, 1972). This morphological organization of the mammalian neocortex undergoes regressive changes during the course of later ontogeny. The results of the present study indicate that this phylogenetically old cortical organization characterizing the initial cortical development is not excitable by the sensory inflow from the trigeminal afferent system.

At a fetal age of 68—70 days it is for the first time possible to activate neuronal elements within the cortex by trigeminal stimulation (*cf.* Meyerson and Persson 1969, Persson 1971, 1973). The neuronal activity takes place in the lower cortical layers (IV—VI) as shown by the depth recordings. Therefore, it seems reasonable to infer that the trigeminal inflow now causes postsynaptic activation. This assumption is not contradicted by the fact that only single spike discharges could be evoked, since intracellular recordings have shown that transsynaptic activation of immature sensorimotor cortical neurons seldom produces repetitive discharges (Purpura *et al.* 1965). A further indication of the change in the cortical excitability at this developmental stage is the appearance of the direct cortical response (DCR; Eidelberg *et al.* 1965) and of the transcallosal response (TCR; Meyerson 1968 a,b). It is conceivable that the surface positivity of the somesthetic response is essentially generated by an early excitatory midcortical activation,

since its net current sink is located in the primordium of layer IV and since the concomitant single unit activity is encountered at the same cortical depths. A small fraction of the surface positivity might be of a presynaptic origin as shown by its ability to follow repetitive stimulation. It has been assumed that superficial inhibitory cortical activation contributes to positive surface potentials in the adult cortex (Purpura 1959, Creutzfeldt *et al.* 1966 a). It is less likely that in young sheep fetuses superficial inhibition substantially contributes to the positive component of the surface response, since topically applied strychnine has no effect.

At the same developmental stage the negative component of the evoked surface response corresponds to a deep current sink-source pair at the lower border of the cortex but no concomitant single unit activity can be recorded. A subthreshold excitatory drive on the deep cortical neurons without spike generation may be suggested, since it has been assumed that immature cortical neurons exhibit a relatively high level of postsynaptic excitability but a strikingly low level of spike responsiveness (Purpura 1972). However, the possibility of an inhibitory activation of neuronal elements situated at the lower cortical border cannot be disregarded. There is no experimental evidence of a synaptic activation of neurons in the superficial cortical strata.

Histological investigations of the cortex of fetal sheep during this developmental stage demonstrates the presence of fairly well-defined lamination appearing as 5 layers of alternating high and low cell density (*cf.* Åström 1967). Layers with low cell density have been considered to be caused by separation of neurons due to the formation of dendrites and axons (Lorente de Nó 1933, Åström 1967). There is a good correlation between the cortical depths from which evoked activity was obtained and the depths of the low cell density layers, which presumably contain the morphological pre- and postsynaptic substrate for the activity.

The afferent fibers reaching the cortex at this developmental stage are directed towards the marginal and midcortical layers (Åström 1967). In recent studies on the fetal cat brain during a comparable developmental stage, it has been shown that a new set of afferent fibers, assumed to be specific, penetrates into the lower region of the pyramidal layer (Marin-Padilla 1971, 1972). The apical dendrites with signs of developing shaftspines and the well-developed basal dendrites of the deep pyramidal neurons and the mature stellate cells, present in deep cortical layers (IV—VI; Åström 1967), may serve as postsynaptic elements. Of special interest is the appearance of spines on the apical shafts of the deep pyramids, since they have been considered to constitute a main postsynaptic locus for the afferent fibers of the specific thalamic nuclei to the somesthetic (Jones and Powell 1970) as well as to the visual cortex of the adult animal (Globus and Scheibel 1967 a,b, Garey and Powell 1971). In a recent electron microscopic study of the vertical distribution of synapses in the neocortex of newborn dog (Molliver and van der Loos 1970), three regions of high synaptic density were found, one corresponding to the marginal layer and two corresponding to the deep layers containing the large pyramidal neurons. On the basis of the functional data presented by Molliver it was assumed that synaptic functions were first established in the deep cortical strata. This idea harmonizes with the results of the present study. It should be added that the evolvement in deep layers of recurrent axonal collaterals and stellate cells in the cortex of fetal sheep may provide the morphological substrate for intracortical connections. The functional role of stellate cells, which in the mature neocortex amount to 25% of total population of nerve cells, has been emphasized (Scheibel 1962, Schadé, Backer and Colon 1964).

During the following developmental period (75—90 days) in fetal sheep, there is a transformation of the surface response from a biphasic positive-negative to a monophasic negative form. This alteration is combined with an increasing amplitude and decreasing latency of the negative component which thus seems to mask and eventually extinguish the initial positive wave. As mentioned earlier the monopolar negative response in the fetal sheep is identical to that obtained in neonatal altricial animals with peripheral somesthetic stimulation (*e.g.* Scherrer and Oeconomos 1954, Marty 1962, Thairu 1971). The observations of net current sinks corresponding to the surface positivity and negativity in cortical layers I—III suggest the presence of superficial 'excitatory' generators. This interpretation is substansiated by the presence of evoked unit activity in these same layers. In addition the laminar potential data suggest that the surface response receives a greater contribution from the neuronal activity in superficial cortical layers than from the activity in the deeper layers. In recent studies on sensory evoked responses in the somesthetic cortex of newborn rabbits (Verley and Rokyta 1972) and in the auditory cortex of postnatal cats (König, Pujol and Marty 1972) similar results have been reported. The observations that during this developmental stage strychnine alters the form and amplitude of the evoked surface response and that peripheral stimulation may inhibit spontaneously active cortical neurons lend support to the view that inhibitory phenomena may play an important role in the cortex. This notion is compatible with the demonstration of prominent and prolonged IPSP:s in cortical (Purpura *et al.* 1965) and hippocampal neurons of newborn cats (Purpura *et al.* 1968).

There are several morphological characteristics which may account for the data indicating a functional maturation of the superficial layers of the

neocortex during this developmental period (75—90 days). Thus, the immature bipolar cortical neurons in layers II—III attain their mature form (Åström 1967). The successive evolvement of apical and, in particular, basilar dendrites of the pyramids in these layers, indicates that this stage constitutes the formative phase of the postsynaptic elements in the superficial neuropile. Electron microscopic investigations of the neocortex of fetal and newborn cat have shown a characteristic abundance of axodendritic synapses in the superficial strata at a corresponding developmental stage (Voeller *et al.* 1963, Adinolfi 1971, 1972). Furthermore, in a synapto-architectonic study on the somesthetic cortex of the newborn dog, a high level of synaptic density was observed in the marginal layer containing the Retzius-Cajal cells and the terminal arborizations of the apical dendrites (Molliver and van der Loos 1970). A spread of neuronal activity can be mediated from deep to superficial strata by the way of recurrent collaterals of the deep pyramids and interneurons. The presence of elaborate interneurons is of particular interest since cells of this class (*cellule à double bouquet dendritique de Cajal,* Cajal 1955) have been assumed to be responsible for the vertical spread of excitation in the vertical columns of the adult cortex (Colonnier 1964). In view of observations made in fetal and newborn cat (Marin-Padilla 1972, Laemle, Benhamida and Purpura 1972), one may also assume that in fetal sheep, displaying surface negative responses, afferent fibers directly activate the superficial layers.

In the present investigation the results obtained from the laminar analysis of evoked field potentials and from the vertical distribution of evoked unit discharges reveal that during the early prenatal ontogenesis of the sheep, the trigeminal afferent inflow initially activates neuronal elements in the immediate subcortical stratum. During subsequent development, the activation takes place in the deep layers of the cortex and successively invades superficial layers. This corticopetal gradient of functional development is expressed by the gradual alterations in the configuration of the evoked response from a surface positivity to a surface negativity. It is relevant to refer to findings on the developing visual (Persson and Stenberg 1972) and transcallosal cortical responses (Meyerson 1968 b) in fetal sheep. At their earliest appearance these responses display a predominating surface positive wave and subsequently undergo changes similar to those of the somesthetic response. These observations suggest that, in general, the functional development of the cortex takes place along a corticopetal gradient. The morphological correlation to this pattern of functional development is the well documented observation that, in general, the maturation of the neurofibrillar organization in the cortex of mammals, takes place along a corticopetal gradient from deep to superficial strata (Vignal 1888, Lorente de Nó 1933, Cajal 1960, Angevine and Sidman 1961, Berry and Rogers 1965, Caley and Maxwell 1968; for discussion, see Molliver and van der Loos 1970).

The beginning of the final developmental period is marked by the reappearance of a small initial positivity in the surface response. Later the positivity increases in amplitude and the response attains the adult positive-negative configuration. The reappearance of the positive component during late prenatal development is paralleled by marked changes of the temporal relationship of the net current sources and sinks. The deep sink observed in previous stages is now recorded at an earlier phase of the cortical activation and this in turn gives rise to the initial surface positivity. Thus, the well-known transformation during development of the evoked cortical potentials from a surface negativity to a surface positive-negative form may tentatively be interpreted as being the result of an unmasking of a pre-existing excitation located in the lower part of the cortex. It is interesting to note that the deep and superficial 'centers' of neuronal activity generating the positivity and negativity of the developing cortical response in fetal sheep resemble the A- and B-generators described in adult cats (Calvet, Calvet and Scherrer 1964, Calvet and Calvet 1965, Calvet, Calvet and Langlois 1965) and in newborn rabbits (Garma and Verley 1965, 1967, Verley 1965, 1968). On the basis of the results described one may assume an early net excitatory activation of neurons in the midcortex followed by the spread of activity to superficial strata much in the same way as has been suggested for the adult somesthetic cortex (Eccles 1964, Towe 1966, Landau 1967).

From studies in postnatal animals it has been proposed (Scheibel 1962, Scheibel and Scheibel 1964, 1971) that the evolvement of the neuropile in layer IV with regard to specific corticopetal fibers and stellate cells may account for the reappearance of the surface positive wave. Alternatively the significance of a further development of basal dendrites of the deep-seated pyramids together with the development of axosomatic synapses has been emphasized (Marty *et al.* 1961, Marty 1962, Marty and Scherrer 1964, Purpura *et al.* 1964). The details of the later morphological maturation of the neocortex of fetal sheep are still lacking. However, well developed basal dendrites in conjunction with the deep pyramids are present in fetal sheep at an earlier stage, and it is therefore likely that the development of the neuropile of the layer IV constitutes a major factor for the reappearance of the surface positivity.

SUMMARY

The prenatal development of somatosensory cortical functions was investigated by recording evoked surface and depth gross responses as well as extracellular single unit activity following tactile stimulation of the trigeminal nose area. Experiments were performed on externalized and nonanesthetized sheep fetuses with ages from 42 days to full term kept in contact with the decerebrate ewe through the intact umbilical cord.

Laminar analyses of evoked field potentials and depth-distributions of evoked single unit responses showed that with age there was a change of the locus of activity in the somesthetic cortex which reflected alterations in the configuration of the surface response. The functional maturation of the somatosensory system was further denoted by changes of the evoked surface potential with respect to its cortical distribution, latency, amplitude and ability to follow repetitive stimulation occuring as a function of age.

During the developmental period between 42—68 days the evoked surface response consisted of a long-latency positive wave. Negative evoked field potentials and evoked single unit responses were obtained only in the subcortical strata of the telencephalic wall. Whether or not this single unit activity is of pre- or postsynaptic origin cannot be definitely stated. No signs of intracortical activation could be observed. Thus, the results indicate that during early ontogeny the trigeminal somatosensory system operates as a dead-end afferent system with no functional contacts with the cortex proper.

During the developmental stage between 68—75 days the evoked surface response had a biphasic positive-negative configuration with a predominating positivity. Both the laminar analysis of the evoked potentials as well as the depth-distribution of the evoked single unit activity showed that around 68—70 days the tactile stimulation activated the cortex for the first time. The evoked cortical activity was present in the primordia of cortical layers IV—VI and there were no signs of activation of superficial strata. The cortical neurons responded with a single spike regardless of the strength and of the location of the stimulus within the peripheral receptive field. Correlative morphological data indicate that afferent fibers shown to reach the mid-pyramidal layers may constitute the presynaptic substrate for the cortical

activation. The dendrites of the deep pyramids and the mature stellate cells, present in the deep cortical layers (IV—VI), may serve as postsynaptic elements.

During the subsequent developmental period (75—90 days) the surface response underwent alterations in configuration from a predominantly positive to a monopolar negative form. The surface negative response corresponded to negative field potentials obtained in all cortical layers. Unit responses from neurons activated by the trigeminal inflow could now be recorded throughout the cortex. Correlative morphological data indicate that this stage constitutes the formative phase of the postsynaptic structures in the superficial neuropile. A spread of neuronal activity from deep to superficial strata may be mediated by way of intracortical connections through interneurons and recurrent collaterals of the deep pyramids as well as of corticopetal afferent fibers directed towards the superficial neuropile.

The laminar analysis of evoked field potentials and the vertical distribution of responding units show that at the end of the first trimester the trigeminal inflow activates neuronal elements in the immediate subcortical stratum. During the following development the activation takes place in deep layers of the cortex and later on also invades more superficial strata. This corticopetal gradient of functional development is expressed by the gradual alterations in the configuration of the evoked surface response from a positivity to a negativity.

On the basis of the selective effects of topical strychnine on the developing somesthetic surface response, it is assumed that there is a delayed development of inhibitory postsynaptic mechanisms in the cortex. Arrest of spontaneously discharging cortical units as a result of trigeminal stimulation was not possible until a fetal age of about 90 days.

The representation of the ipsilateral upper lip in the cortex of immature fetal sheep was similar to that of the adult. When the adult pattern of convolutions and fissures could be traced in the fetal brain, the response was confined to those areas which correspond to the primary and secondary somesthetic areas of the adult sheep. Responses in the cortical associative areas were never obtained. In some older fetuses (85—120 days) the response also displayed a long-latency afterdischarge following the initial 'primary' complex. The finding that the 'primary' response and the afterdischarge showed selective reactions to repetitive stimulation and were accompanied by single unit activity of different characteristics indicates that these two electrocortical activities are generated by different subcortico-cortical mechanisms. On the basis of these findings it has been suggested that the 'specific' and, 'nonspecific' afferent inputs to the somatosensory cortex have a

differential rate of maturation.

From a fetal age of around 100 days, the evoked surface response changed from a monopolar negative to a positive-negative form similar to that of the adult. The results from the laminar potential analysis lend support to the view that the reappearance of the surface positivity results from an unmasking of a pre-existing excitatory generator located in deep cortical layers. In these later stages of development the cortical neurons were capable of responding with repetitive discharges to tactile stimulation. The observations of the present study suggest that, in the perinatal sheep, the somatosensory cortex has reached a comparatively high degree of functional maturation.

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Workers' Protection Act and Workers' Protection Proclamation

The National Board of Occupational Safety and Health
Stockholm, Sweden 1971

Workers' Protection Act and Workers' Protection Proclamation

The National Board of Occupational Safety and Health
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I

Workers' Protection Act. Dated 3 January 1949. *(Svensk Författningssamling* No. 1; amendments 1950, No. 70, 1955, No. 100, 1958, No. 111, 1962, No. 248, 1963, No. 245, 1966, No. 109, 1967, No. 461, 1970, No. 694, 1971, No. 599.)

Chapter 1. Scope

1. Subject to the restrictions given hereinafter, this Act shall apply to every activity, in which employees are used for work on account of an employer.

In this Act, the expression "employee" means any person who executes work on account of another (other than a person who is to be treated as an independent contractor in relation to the latter); and the expression "employer" means any person on whose account work is executed by such employee without the intervention of a third person who has undertaken as an independent contractor to take charge of the execution of the work.

2. In addition to what is provided in section 1, this Act shall apply, save as otherwise provided hereinafter, to—

(1) work which two or more persons execute on their joint account under such conditions that, if employees were engaged in the concern or undertaking, this Act would apply to it under section 1;

(2) work which is executed by a pupil in any vocational training institution or section thereof, in respect of which the Crown orders that this Act shall apply;

(3) work which is executed by a conscript in his capacity as such under such conditions that this Act would apply to it under section 1 if the work were executed by an employee on account of an employer; and

(4) work which an inmate of an institution for prison discipline or compulsory work, working home according to Public Assistance Act, a public institution for inebriates, a mental hospital or other institution for the care of the mentally diseased executes on the instructions of the management of the institution, in the said institution.

In the cases here referred to, the provisions of this Act which relate to employees shall apply, *mutatis mutandis,* to the person who executes the work; and the provisions of this Act which relate to employers shall apply to the person or persons carrying on the business in which the work is executed.

3. The following shall be excepted from the scope of this Act:

(a) work which is executed in the home of the employee or elsewhere under such conditions that the employer cannot be held responsible for supervising the arrangement of the work;

(b) work which is executed by a member of the employer's family, if it takes place in the home of the employer or is to be treated as belonging to agriculture or any subsidiary thereof which is not carried on as an independent undertaking, or to constructional work in agriculture or any such subsidiary thereof;

(c) work which is executed in the home of the employer; and

(d) work which is to be treated as employment in shipping.

From the scope of this Act shall be excepted training within the Forces or civil defence or otherwise for the purpose of total defence and other work within the Forces or civil defence other than such executed mainly under the same circumstances as corresponding work in other activities.

4. Sections 17-21, 23-25 and 27-44 shall not apply as regards the types of work mentioned in (1), (2) and (4) of section 2. The provisions of sections 17-21, 23-25, 27-31 and 33-38 shall not cover work which is executed by a member of the employer's family.

[In respect of work covered by the Act to provide for supervision of employment in radiology, this Act shall only apply as regards protection against injuries other than those due to the action of X-rays or radioactive substances.][1]

5. In any case where work which is not subject to this Act under the foregoing provisions and is not to be treated as employment in shipping is carried on under such conditions that the persons engaged therein are exposed to grave danger of accident or injury to health, the Crown may order that the appropriate provisions of this Act shall apply to the said work, and issue such directions as may be required in connection therewith.

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[1] Through an act 1958 No. 111, chapter 6, co-operation between employers and employees, is applicable to safety work according to the act respecting protection against radiations.

6. As regards the special duties imposed in sections 45 and 46 in relation to the technical equipment and places of employment there mentioned, this Act shall apply even where the type of business is not one covered by this Act under the foregoing provisions.

Chapter 2. General provisions regarding hygiene and safety measures

7. It shall be the duty of the employer, with particular regard to what is prescribed below or in pursuance of this Act, to take all steps which can reasonably be required of him in view of the nature of the work, the conditions under which it is carried on and the age, experience and other qualifications of the employees, for preventing the persons employed by him from suffering injury to health as a consequence of the employment or from meeting with accidents therein.

It shall be the duty of the employee to use the safety equipment provided, to observe strictly the rules given in this Act or prescribed in pursuance thereof, and in all other respects to exercise due care and co-operate in so far as it lies with him in preventing injury to health and accidents.

8. The workplace shall be arranged in accordance with any special directions which may be issued.

9. In so far as they are required, water for drinking and washing, sanitary conveniences, a suitable place for changing, keeping and (in appropriate cases) drying clothing and a suitable place for taking meals shall be made available to the employees at or near the place of employment in such manner as may be considered satisfactory in view of their number, the proportion of each sex, and the nature and duration of the work.

Where it appears necessary in view of the conditions under which the work is carried on, a suitable place for resting or a shelter offering adequate protection against cold, rain and snow shall be provided for the employees.

10. In enclosed workplaces there shall be sufficient air space, as a rule not less than 10 cubic metres for each person therein employed. Adequate ventilation shall be provided in such places and, where necessary, at other places where work is carried on.

While work is proceeding, there shall be adequate and suitable lighting, and the temperature and degree of humidity shall be such as may reasonably be required in view of the character of the work and the place where it is performed.

Suitable arrangements shall be made where possible to prevent dust, smoke, gas or steam from spreading in such quantities as to be injurious or offensive to the employees, and to prevent them from being harmed by exposure to noise, vibration or other similar inconvenience.

The place of employment shall be kept clean and tidy.

Work shall be so arranged that it may be carried out in a manner not involving unnecessary fatigue.

11. For the prevention of accidents in employment, all prime movers, transmission gear, working machinery and other similar mechanical equipment, boilers and other pressure containers, and hoisting and transport equipment, shall be provided with the necessary safety devices and shall in general be so made and arranged as to offer adequate security.

Such measures to prevent employees from being injured by falls, falling objects, collapsing masses, by splinters, splashes, sharp or hot objects or hot liquids, by being crushed or struck, by inflammable, explosive, corrosive, poisonous or other noxious substances, by electrical current, cold or heat, or by dazzling light, shall be taken as will eliminate the danger as far as possible.

12. Where no other measures for obtaining the necessary protection against injury to health or accident can be adopted or can reasonably be required, personal safety equipment of a suitable type shall be provided for the employees. It shall be the duty of the latter to use the equipment during work and to take good care of it.

13. Such arrangements shall be made for the provision of first aid in the event of accident or illness as may be considered necessary in view of the size and situation of the place of employment, the character of the work and the conditions under which it is carried on.

14. Detailed directions regarding the matters referred to in sections 8-13 shall be issued by the Crown.

15. Where any direction issued under section 14 prohibits the use of a given type of machinery, tool or other appliance, or prohibits its use with or without a certain device, the Crown may also direct that the object of which the use is prohibited shall not be transferred to or made available for use by another person unless such steps have been taken that it is no longer covered by the prohibition or unless it may be taken as certain that the object will be used solely for a purpose to which the prohibition does not apply.

The provisions of the first paragraph shall apply, *mutatis mutandis,* in cases where the use of a certain substance or of certain materials is prohibited under section 14.

16. The Crown may prescribe special conditions for the employment of persons on work which is considered to involve special danger of accident or injury to health. Is work considered to involve particular danger of injury to health the Crown may order that persons shall not be employed on such work.

Chapter 3. Special provisions regarding hours of work

17. When an employee is at work for six hours or more a day, his work shall be interrupted to the extent which appears necessary having regard to its character and duration and to working conditions in general, by allowing one or more suitably spaced rest intervals of adequate length. Exceptions to this rule may be made on occasion, where illness or other unforeseen occurences render it necessary.

In this Act, the expression "rest interval" means an interruption of work, of which the length is fixed beforehand and during which the employee is free to dispose of his time and is not required to remain at the place of employment.

Where it is found unavoidable in view of the nature of the work and the working conditions in general, time off for a meal at the work site or in the immediate vicinity may be substituted for the rest interval.

18. Where, by reason of its connection with a mechanical process or as a result of other circumstances, the work involves continuous strain or is particularly trying in other ways, the employee shall be allowed the requisite number of suitably adjusted and spaced breaks in the work.

In this Act, the expression "break in the work" means a short intermission in the work fixed beforehand, which is ordered with a view to allowing the employee to detach himself from his work and which is not to be counted as a rest interval or time off under section 17.

19. Every employee shall have the necessary free time for rest at night. The said free time shall include the period between 12 p.m. and 5 a.m.

Exceptions to the above rule may be made where certain types of work must, in view of their nature, the needs of the public or other special circumstances, be continued during the night or must be carried on during the time before 5 a.m. or after 12 p.m. If a natural occurrence, accident or other circumstance which could not be foreseen causes an interruption of operations or imminent danger of such interruption or of damage to life, health or property, the employees may to the extent which is needful in view of the circumstances be required to work during the period between 12 p.m. and 5 a.m.

Employees in positions of authority may, where necessary, be required to work during the period between 12 p.m. and 5 a.m., notwithstanding the provisions of the first paragraph.

20. Where there are special reasons for so doing, the National Board of Occupational Safety and Health may permit employees to be given work during the period between 12 p.m. and 5 a.m. in other cases not covered by the provisions of section 19.

Such exceptions may also be authorised by the National Board of Occupational Safety and Health where it appears, from the statements of the employees' organisation or organisations or otherwise, that the majority of the employees who would be affected by the exception consider it desirable and no danger to health or overstrain is likely to arise therefrom.

21. In every period of seven days, an employee shall have not less than 24 consecutive hours of free time save where special circumstances occasionally require an exception to be made. The said weekly rest shall be given as far as possible on Sundays and at the same times for all persons employed at the same place of employment.

The National Board of Occupational Safety and Health may, after hearing the appropriate organisations of employers and employees, permit exceptions from the foregoing in respect of certain types of work or certain places of employment.

If any reduction takes place in the weekly rest period referred to in the first paragraph, corresponding time off from work shall be allowed as far as possible.

Chapter 4. Special provisions regarding the employment of young persons

22. In this Act, the expression "young person" means any person who has not attained the age of 18 years.

23. No young person shall be employed unless he has attained the age of 14 years or will attain the said age during the calendar year, and unless (in the case of employment other than during the holidays) he has completed the prescribed elementary school course or has duly obtained permission to leave the elementary school.

The National Board of Occupational Safety and Health may allow exceptions to the foregoing as regards admission to employment on light duties which may be expected to have no harmful effect on the health or

physical development of the young person, or on his capacity to benefit from school education.

24. No young person who has not attained the age of 15 years or will not attain the said age during the calendar year shall be employed in handicrafts, industry, construction, or work in a mine, quarry, gravel-pit or any other similar place of employment, in forestry, lumbering or charcoal-burning, in passenger or goods transport, or in hotels, restaurants or cafés. The foregoing shall not apply to the carrying of messages, running of errands or light distribution work.

As regards employment during the holidays, the National Board of Occupational Safety and Health may permit exceptions to the first paragraph in the case of certain types of work which are to be considered as particularly light. The Board may also in particular cases permit young persons who have attained the age of 14 years or will attain the said age during the calendar year to be employed on work to which the first paragraph applies, where this appears necessary with regard to the vocational training of the young person or otherwise to his advantage.

25. Young persons shall not be employed below ground in mines, quarries or in other work sites comparable with mines or quarries.

Where there are special reasons for so doing, the National Board of Occupational Safety and Health may permit exceptions to the provisions of the first paragraph in respect of male young persons who have attained the age of 16 years and who are found on medical examination to be of good health and physical development. Exceptions may be permitted in respect of male young person who has attained or during the calendar year attains the age of 15 years and who on medical examination are found to be of good health and physical development, if so required with regard to his vocational training.

26. It shall be the duty of the employer to take special care that the employment of young persons does not involve danger of accident or overstrain or other harmful effect on the young person's health or physical development, and that the young person is not employed on work which gives rise to risk from the moral point of view.

If it is found that the employment of young persons on a certain type of work involves particular danger in any respect mentioned in the first paragraph, the Crown may prescribe special conditions for the employment of young persons on such work or order that young persons shall not be employed thereon.

27. No young person shall be employed unless the employer has received a work book for him, containing particulars as to his age and education, and a medical certificate. The said certificate must not be more than one year old at the time when the work book is handed to the employer, unless the engagement of the young person is for less than one month or is for work during the holidays. The certificate may consist of a note entered in the work book when the medical examination is made under section 28.

The foregoing shall not apply to work not lasting more than three days or involving little effort.

28. At every place of employment where a young person is employed, a medical examination of the young person or young persons shall be made once in every calendar year in order to ascertain whether the employment of the young persons is detrimental to his health or physical development. The foregoing shall not, however, apply to forestry work and log-floating (other than work at sorting places).

The said examination shall be carried out by a medical practitioner appointed for the purpose by the county administration ("examining surgeon"). The cost of the examination shall, with the exception of the travelling expenses and allowances of the surgeon, be defrayed by the employer, who shall also be responsible for making available a suitable place for the examination.

If there are no means of providing a suitable place for the examination, the examining surgeon may in agreement with the employer transfer the examination elsewhere.

29. In the case of work involving very little effort or lasting only a short time each year, the National Board of Occupational Safety and Health may grant exemptions from the examinations under section 28. Where such exemptions are granted, a young person may be employed on the work to which the exemption refers, notwithstanding the provisions of section 27, even where the last medical certificate entered in the young person's work book before the said book is handed to the employer is more than one year old.

30. No young person shall be employed on work which is incompatible with the certificate appearing in his work book unless the National Board of Occupational Safety and Health has seen fit to allow such employment.

31. As regards the hours of work of young persons, the following rule shall apply in addition to anything else prescribed in enactments or statutory instruments for the limitation of hours of work, namely, that a young person shall (subject to the following exceptions) in no case be employed for more than 10 hours a day or 54 hours a week.

If a natural occurence, accident or other circumstance which could not be foreseen causes an interruption of operations or imminent danger of such interruption or of damage to life, health or property, the hours of

work of a young person may to such extent as is needful exceed 10 hours a day and 54 a week. The employer shall be required to give notice to the National Board of Occupational Safety and Health of employment of a young person in excess of the said hours and of the reason, extent and duration, within two days after the beginning thereof. The employment shall not be continued beyond the last-mentioned period unless the permission of the said authority is applied for. A decision in respect of such applications shall be issued without delay. The above notices and applications shall be deemed to have been given and made at the time when they are posted in the form of a prepaid letter.

Where it appears necessary in any other particular case, the National Board of Occupational Safety and Health shall have power to authorise the employment of young persons for a short period in excess of the hours given in the first paragraph.

32. It shall be the duty of the employer to allow every young person employed the necessary free time to attend courses of religious instruction or any vocational or continued education of which the cost is paid wholly or partly by the State or out of the funds of the communes.

33. Every young person employed shall be allowed a continuous period of free time of not less than 11 hours each day for his nightly rest. In the case of young persons under 16 years of age, the said period shall include the time between 7 p.m. and 6 a.m. and, in other cases, the time between 10 p.m. and 5 a.m., or, if the National Board of Occupational Safety and Health so authorises for a particular locality, a particular category of work or a particular establishment, some other period of seven consecutive hours between 10 p.m. and 7 a.m.

The following exceptions to the foregoing shall apply:

(a) In the circumstances referred to in the second paragraph of section 31, a young person who has attained the age of 16 years may be employed to such extent as may be necessary notwithstanding the provisions of the first paragraph. The provisions of the said section shall apply, *mutatis mutandis,* as regards notification of such employment and application for permission to continue it.

(b) The National Board of Occupational Safety and Health may, where it appears necessary, permit young persons under the age of 16 years to be employed between the hours of 7 p.m. and 10 p.m., on condition that no departure from the rules requiring a nightly rest period of at least 11 hours results therefrom.

(c) Where there is special reason to do so, the National Board of Occupational Safety and Health may permit a young person who has

attained the age of 16 years and is medically certified to possess good health and physical development to be employed outside the hours prescribed in the first paragraph.

(d) A young person who has attained the age of 15 years and is medically certified to possess good health and physical development may with the permission of the National Board of Occupational Safety and Health be employed on log-floating to such extent as the circumstances require.

Chapter 5. Special provisions regarding the employment of women

34. No woman shall be employed below ground in a mine or quarry.

The provisions of the first paragraph shall not apply in the case of female employees occupying superior posts who are not manual labourers.

The National Board of Occupational Safety and Health may allow a woman, notwithstanding the provisions of the first paragraph, to be employed below ground.

35. If a woman produces a certificate from a medical practitioner or midwife to the effect that she can probably expect delivery within six weeks, she must not be refused leave from work.

A woman who has borne a child shall not be employed on work to which the first paragraph of section 24 applies during the first six weeks following childbirth unless it is medically certified that she can begin earlier without detriment to herself or the child.

A woman who is nursing her child must not be refused the necessary time off for the purpose.

36. (Abrogated 1962.)

37. (Abrogated 1962.)

38. If it is found that a given type of work involves particular danger of accident when women are employed thereon or particular strain or danger to health for women, the Crown may prescribe special conditions for the employment of women on such work or order that women shall not be employed thereon.

Chapter 6. Co-operation between employers and employees

39. With a view to achieving safe and healthy working conditions in the place of employment, the employer and the persons employed by him shall collaborate under the direction of the employer in maintaining a suitably organised safety service.

40. At every place of employment where five or more persons are regularly employed, one or more of the employees shall, unless there are special circumstances which justify the making of an exception, be appointed as safety delegates to represent the employees in matters relating to hygiene and safety at work. A safety delegate may, where it appears necessary, also be appointed in places of employment with less than five employees.

The elections of the safety delegates shall be organised by the employees or, at their request, by a local organisation which may be considered as representing them.

Where conditions in a given type of business so require, the National Board of Occupational Safety and Health may authorise the said local organisation to appoint safety delegates from outside the group of employees in a given place of employment, and issue instructions to be followed in this connection. The foregoing shall not prevent the appointment of safety delegates under the second paragraph as well.

Substitutes shall be appointed for the safety delegates.

41. At every place of employment where 50 or more persons are regularly employed, there shall be a safety committee consisting of representatives of the employer and of the safety delegate or delegates, with the duty of promoting hygiene and safety at work. Where it appears necessary, a safety committee may also be appointed at places of employment with a smaller number of employees.

42. The safety delegates shall be permitted to carry out their duties without hindrance. An employee shall not suffer any deterioration of his working conditions as a result of his being appointed as a safety delegate or on account of his activity as a safety delegate; and the employer shall not for that reason dismiss him from his post or vary the conditions of appointment to his disadavantage.

If any employer or employee contravenes the provisions of the first paragraph, he shall be required to make good any loss or injury caused. In determining whether loss or injury has been caused and (if so) the extent thereof, circumstances which are not of a purely economic character shall also be taken into account. If it appears reasonable in view of the small degree of blame attached to the injurer, the attitude of the injured party in the dispute, the extent of the loss or injury in comparison with the injured party's resources or any other circumstances, the amount of damages may be reduced; complete exoneration from liability for damages may also be given. If two or more persons are responsible for the loss or injury, the liability for damages shall be apportioned among them in such manner as appears reasonable in view of the greater or lesser degree of blame attached to each and of the other circumstances.

Any termination of a contract or other similar legal act which is in contravention of the provisions of the first paragraph shall be invalid.

43. Actions under section 42 must be brought not later than six months after the ending of the measure in respect of which the claim is made. If this is not done, the right of action shall be lost.

44. Cases relating to the application of section 42 shall be examined and determined by the Labour Court; but actions against employees shall be brought in the ordinary court.

A trade union or other similar union of employees shall have the right to bring and prosecute an action before the Labour Court on behalf of a member of the union; and the said member shall not himself have the right to sue unless he can show that the union refuses to plead on his behalf. The rules for parties in respect of summons, personal appearance, hearing on oath and other matters connected with evidence shall likewise apply to the person for whom a union sues.

Chapter 7. Certain obligations of manufacturers, vendors, etc.

45. The manufacturer or vendor of machinery, tools or other technical equipment and any person who makes such equipment available for use shall ensure that the equipment, when delivered to be taken into use in the Kingdom or when displayed here for sale or advertisement, is fitted with the necessary safety devices and offers adequate security against accident and injury to health; and shall also furnish the necessary instructions for the putting up, use and care of the equipment.

Where there are special reasons for so doing, the National Board of Occupational Safety and Health may prescribe that the equipment also shall be furnished with a plate or a marking with the name of the manufacturer or with other information which the Board thinks necessary.

The National Board of Occupational Safety and Health may also, where there are reasons for so doing, as to special equipment as mentioned in the first paragraph, prescribe that the equipment shall be approved by the Board before delivered to be taken into use in the Kingdom or displayed here for sale or advertisement.

Where the person who installs the equipment referred to in the first paragraph is an independent contractor, he shall ensure that the prescribed safety devices are fitted and all other directions for the installation of the equipment are complied with.

46. It shall be the duty of every owner of land where a gravelpit or similar place of employment is situated, when allowing any person for a consideration to extract gravel or the like therefrom, to ensure that the place of employment is kept in a satisfactory condition from the point of view of safety, even where this Act in other respects does not apply to it. Where the right to extract gravel or other right of use has been assigned, the foregoing provisions shall apply to the user instead of to the owner.

Chapter 8. Administration

47. The National Board of Occupational Safety and Health and, under their superintendence and direction, the labour inspection officers, and commune supervision representatives shall supervise the observance of this Act and of the directions issued in pursuance thereof. The inspecting staff shall consist of labour inspectors and subordinate personnel. The Crown may also order that special inspectors shall be responsible for supervising a certain type of business, relieving the above-mentioned officers and representatives from all or part of the liability therefor.

The provisions of this Act which relate to labour inspectors shall apply, *mutatis mutandis,* to special inspectors.

Detailed provisions as to the organisation of supervision shall be issued by the Crown.

48. Each public health committee shall appoint one or more suitable persons to be responsible for the duties of commune supervision under section 47, for a specified period or until further notice. The public health officer shall also be required to act as a commune supervision representative under this Act if he is appointed to do so.

The commune supervision representative shall receive reasonable compensation for his duties from commune funds.

49. If any commune supervision representative is remiss in the performance of his functions and the public health committee receives a report to that effect from the labour inspector or becomes aware of the fact in any other manner, the said committee shall take the necessary action to remedy the situation.

If any public health committee fails to appoint a commune supervision representative or to take action under the first paragraph, the county administration may entrust all or part of the duties of supervision to a person appointed by it as commune supervision representative and, where necessary, order that compensation under the second paragraph of section 48 shall be paid to the said representative.

50. Every person who is responsible for supervising the observance of this Act or of the directions issued in pursuance thereof shall have the power whenever he so requests, to enter the places of employment which are liable to supervision by him and the right to undertake any investigation required for the performance of his official duties.

The employer and his representative at the place of employment shall, on request, furnish the supervising officer or body with all explanations required for the due exercise of supervision.

The foregoing provisions as to supervising officers or bodies shall likewise apply to medical practitioners who are responsible for inspections or examinations under this Act or in accordance with directions issued in pursuance thereof.

51. No person who is or has been responsible for supervising observance of this Act or of directions issued in pursuance thereof, or who has been called upon to assist in the work of supervision, shall disclose or make improper use of any trade secret with which he has become acquainted in the course of his duties; and no such person shall reveal, unless it can be deemed to be in the official interest, any method of work or business matter which becomes known to him in like manner. The foregoing shall apply, *mutatis mutandis,* to members and substitutes in council of representatives of the Labour Inspectorate as also to medical practitioners who are or have been responsible for inspections or examinations under this Act or in accordance with directions issued in pursuance thereof.

52. Every medical officer in the service of the State or of a commune who becomes aware of any circumstance which is contrary to this Act or to directions issued in pursuance thereof shall report the fact to the appropriate supervising officer or body. It shall be the duty of such medical practitioners and of education committees, school authorities, public health committees, building committees and police authorities to furnish the supervising officer or body with such explanations and assistance as may be required for the official duties of the latter under this Act.

53. If at any place of employment an unsatisfactory state of affairs exists in respect of any matter referred to in sections 8-13 or a matter which, while not relating to Chapters 3-6 as a whole, is covered by section 7, and the said state of affairs does not constitute a contravention of any provision for which a special penalty is prescribed, the labour inspector shall have power where necessary to order the employer in writing to take such action within a reasonable time limit as will remedy the situation, or prohibit him in writing from carrying on certain work or using certain premises, machinery,

tools or other appliances, certain substances or materials, or certain methods of work, after a reasonable time limit, unless certain conditions laid down in the notice are observed. Before issuing such order or prohibition the employer (and, in the case of measures in premises which the employer has taken on lease, the lessor also) shall be given an opportunity of stating his point of view.

Where an unsatisfactory state of affairs referred to in the first paragraph involves considerable danger to the lives or health of the employees, the labour inspector may issue a prohibition under the said paragraph with immediate effect and until further notice, without awaiting a statement from the person concerned; and may also, if necessary, cause any action required for enforcing the prohibition to be taken by the police authorities at the employer's expense.

Where, in a case referred to in the first or second paragraph, the action to be taken relates to premises which the employer has taken on lease, the labour inspector shall have power to prohibit any leasing of the premises as a workplace or place for certain work or certain purposes until certain specified action is taken.

The National Board of Occupational Safety and Health may, without any prior decision of the labour inspector, order action under this section.

54. If any employer contravenes the provisions of sections 17-21 and the first paragraph of section 26, the National Board of Occupational Safety and Health shall have power, after giving the employer an opportunity to make a statement in the matter, to issue any necessary directions for ensuring that the provisions contravened are henceforth observed.

55. If any employer employs a young person who has not undergone the medical examination prescribed in section 28 during the last preceding calendar year although this should have taken place, the labour inspector shall have power, if the circumstances so require, to forbid the employer in writing to employ the young person after a reasonable time limit unless he has been previously examined by a medical practitioner and a certificate of the examination has been entered in the work book.

56. Where it is found necessary to prevent a manufacturer or vendor of machinery, tools or other technical equipment, or a person who makes such equipment available for use, from delivering the equipment to be taken into use in the Kingdom or from displaying it here for sale or advertisement without having complied with the provisions of the first paragraph of section 45 or the directions in virtue of the second and third paragraph's of the named section, then the National Board of Occupational Safety and Health shall have power, after giving the said manufacturer, vendor or person an opportunity of stating his point of view in the matter, to prohibit him from delivering or displaying the equipment unless such steps are taken as the Board considers to be necessary.

If there is special reason to do so, the Board may issue a prohibition under the first paragraph with immediate effect and until further notice, without awaiting a statement from the manufacturer, vendor or person making the equipment available; and may also, if necessary, cause any action required for enforcing the prohibition to be taken by the police authorities at the said manufacturer's, vendor's or person's expence.

57. If any installation contractor referred to in the fourth paragraph of section 45 contravenes the provisions of that section, the National Board of Occupational Safety and Health shall have power, if necessary, to lay down certain conditions to be observed by him when carrying out the work of installation, or to prohibit him from executing a certain type of installation work. Before issuing the order or prohibition, the installation contractor shall be given an opportunity to state his point of view in the matter.

58. If the owner of land where a gravel-pit or similar place of employment is situated or the person to whom the right to extract gravel or other right of use has been granted fails to comply with his obligations under section 46, the owner or user may be required to take certain safety measures, or may be forbidden to allow other persons for a consideration to extract gravel or other similar substance from the gravel-pit or at the place of employment unless he complies with certain specified conditions. The provisions of section 53 shall apply, *mutatis mutandis*.

59. For the purpose of ascertaining whether substances or materials used or manufactured by an employer in his business involve a risk that the persons employed by him may incur damage to their health or meet with accidents, the said employer shall, at the request of the National Board of Occupational Safety and Health or labour inspector, arrange for the substances or materials to be examined or furnish the necessary samples for such examination.

It shall also be the duty of persons who manufacture, sell or otherwise make equipment referred to in the first paragraph of section 45 available for use, at the request of the National Board of Occupational Safety and Health or labour inspector, to arrange for an examination of the said equipment for the purpose of ascertaining whether it affords adequate security against accident and injury to health, or to furnish the necessary samples for such examination.

If any person fails to comply with a requst under the first or second paragraph, the National Board of Occupational Safety and Health shall have

power to require him to take the requisite action within a reasonable time limit, under penalty of a fine not exceeding 1,000 kronor.

An investigation according to this section shall, where the National Board of Occupational Safety and Health so prescribes, by payed for by the employer or, in cases referred to in the second paragraph, by the vendor or by the person who makes the equipment available for use.

60. If any case referred to in sections 53 and 54 arises in connection with any business carried on by the State, the provisions of those sections shall not apply. If the National Board of Occupational Safety and Health finds, as a result of a report from the labour inspector or otherwise, that in the said business an unsatisfactory state of affairs exists within the meaning of the said sections, the Board shall call upon the authority responsible for superintending that business to take the necessary action. If such action is not taken, the Board may submit the matter for examination by the Crown or, if the matter concerns the Riksdag or its institutions, that parliamentary institution the Riksdag decides.

61. A complaint against an order or prohibition of the labour inspector may be made to the National Board of Occupational Safety and Health. In the decision of the labour inspector it has to be proclaimed what a complainant who wants to persue his claim has to observe.

The provisions of section 73 shall apply as regards complaints against decisions of the National Board of Occupational Safety and Health.

Chapter 9. Penalties

62. If any employer employs a young person or woman in contravention of the provisions of section 23, 24, 25, 27, 30, 31, 32, 33, 34 or 35 (second paragraph), he shall be liable to a fine.

Where the offence consists of or relates to the employment of a young person, the person having custody of the young person shall be liable to a fine of not less than five and not more than 50 kronor if the employment occurred with his knowledge and consent.

63. If any person fails to comply with an order, prohibition or direction issued to him in pursuance of the provisions of section 53, 54, 55, 56, 57 or 58, he shall be liable to a fine or, in the event of exceptional aggravating circumstances, to a term of imprisonment not exceeding six months.

64. If any employer fails to fulfil his duty to give notice under section 31 or 33, he shall be liable to a fine of not less than five and not more than 300 kronor. If the employer or any other person on behalf of the employer furnishes particulars in a notice under the said sections which he knows are incorrect, he shall be liable to a fine.

65. If any person furnishes the National Board of Occupational Safety and Health or labour inspector with particulars which he knows are incorrect regarding the taking of any steps which he has been instructed to take under this Act or in accordance with directions issued in pursuance thereof, he shall be liable to a fine.

The foregoing shall likewise apply where any manufacturer, vendor or person referred to in section 45 furnishes particulars which he knows are incorrect to the National Board of Occupational Safety and Health or labour inspector respecting equipment referred to in that section.

If any person on behalf of another furnishes any such particulars, knowing them to be incorrect, he shall also be liable to the said penalty.

66. If any employer disregards his obligation under section 28 to provide a suitable room for the medical examination of young persons, he shall be punished with a fine.

67. If any employee unlawfully and without valid reason removes any safety device or renders it unserviceable, he shall be punished with a fine of not less than five and not more than 200 kronor.

Such offence shall not be prosecuted unless the appropriate labour inspector has reported it.

68. If any person contravenes the provisions of section 51, he shall be punished with a fine or imprisonment.

A public prosecution in respect of such contravention shall not be instituted unless the aggrieved person lays an information.

69. The proceeds of the fines imposed under this Act shall go to the Crown.

Chapter 10. Certain special provisions

70. As regards business carried on by the State, the provisions of this Act which relate to employers and to manufacturers or other persons mentioned in section 45 or 46 shall apply to the persons in charge of the work.

In the case of business carried on by a commune, the provisions which relate to employers shall also apply to the person in charge of the work as regards observance of Chapters 4 and 5 and orders or prohibitions issued to employers in accordance with section 54 or 55. The foregoing shall also apply in the case of business not carried on by the State or a commune, if the National Board of Occupational Safety and Health at the request of the employer accepts a certain person as being in charge in his stead.

71. In the final determination by the National Board of Occupational Safety and Health of matters concerning the application of this Act or of directions issued in pursuance thereof, special members appointed on the recommendation of the national associations of employers and employees shall take part, the number of such members and the appropriate procedure being prescribed by the Crown.

72. The National Board of Occupational Safety and Health shall have power to charge the labour inspectors, to such extent as the Board thinks fit, with the duty of authorising exceptions under sections 23 and 29, in accordance with detailed directions issued by the Board.

73. No complaint may be brought against the decisions of the National Board of Occupational Safety and Health in matters under section 23, 24, 25, 29, 30, 31, 33, 40 (third paragraph) or 70 (second paragraph).

Proceedings against the decision made by the National Board of Occupational Safety and Health concerning prohibition, order or direction according to sections 53—59, shall be instituted by an appeal to the Fiscal Court of Appeal.[1]

Proceedings against the decision of the National Board of Occupational Safety and Health in other matters under this Act or against the decision of a county administration in such matters shall be instituted by an appeal to the Crown.

74. Detailed directions regarding the application of this Act shall be issued by the Crown.

In connection with the application of this Act, the National Board of Occupational Safety and Health shall have power to give advice and instructions.

75. When issuing directions in pursuance of this Act, the Crown may at the same time prescribe penalties for offences against the said directions; but such penalties shall in no case exceed six months' imprisonment.

This Act shall come into operation on 1 July 1949; but matters relating to exemptions under this Act may be dealt with by the National Board of Occupational Safety and Health before that date.

This Act repeals the Workers' Protection Act of 29 June 1912 (No. 206), and the Act of 19 February 1926 (No. 21) to prohibit the employment of workers in certain cases on painting operations in which lead colours are used; but this Act shall not affect the provisions of other enactments or statutory instruments concerning the matters dealt with in this Act.

[1] Will come into force on Jan 1, 1972.

Where in any enactment or statutory instrument there occurs a reference to a section which is replaced by the provisions of the new Act, the latter provisions shall apply in lieu thereof.

All exemptions authorised under the former Act shall continue to be valid until the expiration of the period prescribed therefor or, where the exemption was authorised without limitation of time, until the appropriate authority has reason to revoke it.

Where at the commencement of this Act certain work is carried out between the hours of 11 p.m. and 5 a.m., it may continue to be carried out between the said hours, notwithstanding the provisions of section 19, for two years after the commencement of the Act.

The provisions of sections 23-25 and 27 shall not prevent a young person from being employed on work on which he or she was properly employed at the date of commencement of this Act.

The certificate books *(intygsbok)* issued to young persons under section 9 of the former Workers' Protection Act shall be regarded as work books *(arbetsbok)* under the new Act. Medical examinations under section 35 of the former Act shall be regarded as having been carried out under section 28 of the new Act.

Any order or prohibition issued in pursuance of section 38, 38A or 39 of the former Act shall, in relation to the period after the commencement of the new Act, be regarded as having been issued under the corresponding provisions of the new Act.

II

Royal Proclamation: Regulations under the Workers' Protection Act (»Workers' Protection Proclamation»). Dated 6 May 1949. *(Svensk Författningssamling* 1949, No. 208; amendments 1956, No. 476, 1958, No. 660, 1963, No. 657, 1966, No. 520, 1970, No. 520.

General provisions

1. It shall be the duty of the employer to see that the persons employed by him are informed of the special risks of accident and injury to health which the work involves and, where necessary, to issue rules and instructions to be observed by the employees for the avoidance of the said risks.

No person who lacks experience in a given type of work shall be placed in charge of such work if danger of accident or injury to health may be expected to result therefrom.

In the case of work in which insufficient knowledge or skill may be expected to involve danger of accident or injury to health, care shall also be taken that employees lacking the necessary experience are not used on such work without adequate instruction and supervision.

2. No person shall be employed on work which makes special demands upon the workers' health or physical development, if a medical examination has shown him to be lacking in, or it is otherwise evident that he does not possess, the necessary physical or mental qualifications for the work, and he may consequently expose himself or others to risk of accident or injury to health. In such cases, the employee should, if possible, be provided with other more suitable employment.

3. The necessary rules as to the special precautions which employees are required to observe in order to avoid accidents and injury to health shall be posted in the place of employment.

In places where there is particular danger of accident or injury to health, warning of such danger shall be given by means of conspicuous posters, signboards or notices painted on the machine, apparatus, etc.

At the request of the employer, the labour inspector shall examine, free of charge, any proposed rules or notices of the kind referred to above.

It shall be the duty of the employee to comply strictly with the rules and notices referred to in this section.

4. Where an employee is required to work alone consideration shall be given, when determining the need for safety precautions, not only to the nature and degree of the accident risk present, but also to the possibility of the employee obtaining the necessary assistance in case of accident or illness.

5. Whenever an accident has resulted in death or serious bodily injury or has involved two or more employees, and also whenever an accident or dangerous occurence is of such a character that it may be assumed that it is of particular importance to bring it to the notice of the Labour Inspectorate, the employer shall without delay inform the labour inspector thereof.

Notice, as provided for in the first paragraph, shall also be given of cases of disease which are covered by the Act of 14 May 1954 respecting insurance against occupational injuries (No. 243)[1] or other diseases which can be assumed to have been caused by employment that is dangerous to health.

Prior examination of proposals for workrooms, etc.

6. An employer who intends to construct, reconstruct or extend any workroom or staff accomodation may submit the proposal to the labour inspector, accompanied by such drawings and other particulars as may be required for the examination of the proposal. The labour inspector shall give his written opinion of the proposal as soon as possible, without charge to the employer. If, after the proposal has been examined, it is proposed to make any modification not already prescribed by the labour inspector and if the modification has a bearing on hygiene and safety in the employment, the proposed modification should be submitted to the labour inspector for examination.

The foregoing shall apply, *mutatis mutandis*, in the case of any re-organisation of the working arrangements or of any considerable alteration in the method of work.

7. If a labour inspector has received for examination from a building committee or from an employer any proposal of the kind referred to in section 6, he must request the employer to submit any additional drawings and particulars which may be required for the examination of the proposal from the point of view of labour protection.

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[1] *ILO, Legislative Series,* 1954 (Swe. 4).

8. No mining workshop or similar workroom situated entirely below ground shall be installed except with the permission of the National Board of Occupational Safety and Health. Such permission shall be subject to the condition that the rules laid down by the Board for the installation of the workshop or workroom are observed.

The foregoing provisions shall not apply to work sites below ground in mines or quarries or to military works or other State installations of importance for national defence which the Crown has ordered to be located in the mountains or below the ground.

9. Before any premises formerly used for other purpose are taken into permanent use as workrooms for any industrial purpose (even if a building permit is not required in connection therewith), the employer shall give notice to the labour inspector: Provided that such notice shall not be required if the labour inspector has already examined a proposal for re-construction or extension of the premises for their new employment.

For the purposes of this section, the expression "permanent use" means regular use during more than six consecutive months or during seasonal work.

If in view of the new operations, special rules for the use of the premises or for the conduct of the work are necessary, it shall be the duty of the labour inspector to issue such rules without delay.

10. Every mine or quarry of which the whole or a considerable part is below ground shall, if the National Board of Occupational Safety and Health considers it necessary to so prescribe, be connected with the surface by two or more suitably situated exits. Where a shaft is used as an exit, it shall be provided with an adequate ladderway.

Where it appears necessary, the labour inspector may prescribe that underground work sites in mines or quarries shall be provided with two or more exits.

Certain hygiene arrangements

11. When giving effect to section 9 of the Workers' Protection Act, the provisions of sections 12 to 18 below shall be observed, while having regard to the requirements of each particular case in view of the nature of the work and other circumstances.

12. Drinking water of suitable quality shall be provided at easily accessible places by a method satisfying the requirements of hygiene.

Suitable water for washing shall be provided at an adequate number of suitably placed wash-basins, situated as far as possible in an enclosed space or special room ("washroom"). In appropriate cases, the water for washing should be heated.

Where required by the nature of the work, shower-baths or foot-baths shall be installed in or beside the washroom.

Unless otherwise agreed, soap or other suitable cleansing agents and, where no other satisfactory means of drying are available, an adequate supply of towels, shall be provided for the employees by the employer at his expence.

13. Rooms for changing and keeping clothes ("changing rooms") shall be conveniently situated and provided with appropriate and satisfactory fittings.

Places for the drying of clothes ("drying rooms") shall be conveniently situated in or beside the changing rooms and shall be provided with satisfactory arrangements for heating and ventilation.

14. Places for taking meals ("dining rooms") shall be conveniently situated, and set apart and equipped for the purpose; where prepared meals are not supplied by the employer or otherwise, the necessary equipment for keeping and warming up food and drink brought by the employees shall be provided.

15. Sanitary conveniences shall be conveniently situated and separated from one another and, as a rule, there shall be separate conveniences for men and women; they shall be installed and ventilated in a manner satisfying the requirements of hygiene. Where practicable, sanitary conveniences and urinals shall be provided with flushing arrangements. If possible a wash-basin should be available in or near the convenience.

16. In certain types of activity where, owing to the nature of the work, individual employees are frequently obliged to spend the night elsewhere than at the place where they live, a suitable room with the necessary number of beds ("dormitory") should be provided.

17. Where the work is of such a nature that waiting periods occur more or less regularly, the employees should have a suitably situated and equipped room ("waiting room") at their disposal during waiting periods.

18. On building, engineering construction and similar sites where the extent and duration of the operations are such that the employer cannot reasonably be required to provide the rooms and other arrangements for the employees referred to above, huts, wagons or other arrangements for the accommodation of the employees may be provided in lieu thereof.

Measures for the prevention of injury to health

19. When giving effect to the general provisions of the Workers' Protection Act respecting the prevention of injury to health, the provisions of

sections 20 to 30 below shall be observed, while having regard to the requirements of each particular case in view of the nature of the work and other circumstances.

20. Workrooms shall be supplied with the requisite amount of fresh air in the way which is found most suitable for meeting the requirements of ventilation in each particular case and so that draughts are avoided as far as possible. Where conditions so require, the fresh air supplied shall be heated, cleaned or subjected to other special treatment.

Where work is carried out below ground in mines, quarries, mountains, tunnels or other similar workplaces, the necessary arrangements for changing the air shall be provided. Similarly, where work is carried out in wells, containers or chambers where there is risk of lack of oxygen or poisoning, arrangements for changing the air shall be made or other adequate protective measures taken.

Where there is a risk of lack of oxygene or of poisoning the employees shall satisfy themselves, before work, that the necessary change of air has taken place.

21. The lighting of places of employment shall be suitably arranged having regard to the requirements of each workplace. Where natural lighting is insufficient or where, owing to the nature of the work or other particular circumstances, such lighting is out of the question, other lighting suited to the type of work shall be provided. In addition to general lighting, local lighting shall be provided where required. Suitable measures shall be taken to afford protection against glare.

22. Where necessary, appropriate arrangements shall be made to enable the work to be carried on in suitable conditions as regards temperature and humidity. In this connection, due regard shall be had as to whether the work is light or heavy in character and whether it requires the worker to move around or is performed while sitting or standing in one place. Where it appears necessary, work-sheds, drivers' compartments on motor vehicles, motor equipment and cranes and other similar spaces where persons work should also be heated.

23. In the case of work where the employees are exposed for considerable periods of time to a high degree of humidity, to wet, cold or heat, or to strong light, adequate protective measures shall be taken unless such measures may be regarded as impracticable owing to the nature of the work or other circumstances.

Where the work is regularly performed while standing or sitting in one place, measures shall be taken, where necessary, to guard against cold from the floor.

24. In the case of work where dust, smoke, gases or vapours are released in such quantities as to be injurious or offensive to the employees, the working process shall, as far as possible, take place in closed apparatus or the work shall be performed in a separate room or enclosed place. If this is not feasible, satisfactory arrangements for collecting and carrying off the dust, smoke, gases or vapours or otherwise rendering them harmless shall be made as far as possible at the place where such contamination of the air originates and can spread.

Exhaust equipment shall not be installed in such a way that the employees are exposed, through contaminated air from such equipment, to influences of the kind referred to in the first paragraph.

If certain work or certain kind of work is found to cause special risks for bad health on account of the existence of dust, smoke, gases or vapours, the National Board of Occupational Safety and Health may, as condition for employment of persons to such work, prescribe investigation of the conditions of the air. The Board will decide the extent of the investigation and give directives required regarding the accomplishment of the investigation.

Investigation report and other necessary document for the judgment of the findings of the investigations shall be submitted to the labour inspector if so prescribed by the National Board of Occupational Safety and Health.

All expences incidental to the investigation shall be paid by the employer, unless by the National Board of Occupational Safety and Health decided, that the expences, when special circumstances render it desirable, shall to a certain extent be paid by Governmental funds.

25. In the case of work where poisonous or other substances injurious to health are used or where the conditions of work are such as to involve a risk of poisoning or infection, effective protective measures shall be taken. Poisonous or other substances injurious to health shall, where practicable in the circumstances, be replaced by non-poisonous or less injurious substances.

26. In the case of work where the employee is exposed for a considerable period of time to continuous or frequently and regularly recurring noise or vibration, suitable protective measures shall as far as possible be adopted. Riveting, forging, the cleaning of castings and other types of work which are accompanied by noise or vibration that cannot be reduced or eliminated shall, if possible, be carried out in a special workroom or workplace.

If any work is carried out under such air pressure as to involve risk of injury to the employees, effective protective measures shall be taken.

Employees must not be employed on such work, under increased pressure, which is carried out under water with diving equipment or diving-bell without lock (diving work) or other work in direct connection thereto,

if he does not have the knowledge of and experience in the work as prescribed by the National Board of Occupational Safety and Health. The National Board of Occupational Safety and Health may allow exeptions.

27. The work shall be so planned and arranged that postures which are unnecessarily tiring for the employee are avoided. Where the work can be regularly carried out in a sitting position without detriment to it, suitable seats shall be provided. In other cases where working conditions allow the employees to sit from time to time, a sufficient number of seats shall be made available for them.

Where the work involves the carrying or lifting of heavy objects, special appliances should, if possible, be used for the purpose.

Where work is regularly performed in a standing position and the flooring is not of suitable composition, the employee shall be provided with a suitable surface to stand on.

28. Workrooms and fittings, machinery, apparatus and appliances, and also rooms for the employees, stairs and passageways shall be kept clean and tidy. Where the nature of the work permits, in addition to the daily cleaning and clearing up, a general cleaning of the workrooms shall be undertaken at regular intervals when floors, walls, ceilings, windows and fittings shall be thoroughly cleaned. Painting or other surface treatment of walls, ceilings, floors, fittings, machinery, apparatus and the like shall be reasonable well maintained.

Sweeping shall be so carried out that dust is not spread unnecessarily. Sweeping of workrooms should be avoided during working hours. Sweepings, chips or other waste shall be collected in a suitable manner and removed.

It shall be the duty of the employees to comply strictly with the instructions issued with respect to the matters dealt with in this section.

29. Personal protective equipment for the special purpose of preventing injury to health shall, unless otherwise agreed, be paid for by the employer and kept at the place of employment. Equipment of this kind, such as respirators, eye protectors, protective clothing, gloves or footwear shall, to such extent as the National Board of Occupational Safety and Health prescribes, be approved by the Board.

Personal protective equipment should be provided even if the work is only of an occasional character and protective measures which would otherwise have had to be taken are consequently inappropriate for practical reasons as, for instance, in spray painting steel structures, sandblasting the outsides of buildings or the repair of gas mains.

30. Where possible, the time during which an employee is employed on work entailing special risks to his health shall be suitably reduced by giving him other work not involving risk to health for a certain period in each work-day or week, or for longer periods.

Measures for the prevention of accidents

31. When giving effect to the general provisions of the Workers' Protection Act respecting the prevention of accidents, the provisions of sections 32 to 47 below shall be observed, while having regard to the requirements of each particular case in view of the nature of the work and other circumstances.

Instructions respecting the inspections and tests referred to in sections 33, 35, 36 and 39 and rules prescribing the conditions for appointment as inspector shall be issued by the National Board of Occupational Safety and Health.

32. Prime movers, transmission gear, working machinery and other comparable mechanical equipment shall be so constructed and equipped as to be sufficiently safe; they shall be provided with the necessary guards and shall be so erected, installed or placed as to remove to the greatest extent possible any accident risk connected therewith.

The equipment referred to in the first paragraph shall be properly maintained. In addition, the following special provisions shall apply;

(a) Rotating and other moving machine parts shall not be run at such speed or under such load that they cease to be sufficiently safe.

(b) Transmission belts, ropes or chains shall not be mounted or shifted while the transmission is running, unless a device suitable for the purpose has been provided or an exception is deemed to be justified in view of the low speed of the transmission or the small amount of mechanical force transmitted by it.

(c) Before any prime mover or transmission gear which drives a working machine is set in motion, warning thereof shall, where necessary, be given to the employees concerned in good time by a special signal in a manner to be announced in advance.

(d) Where this can reasonably be required, working machinery shall be furnished with suitable and clearly marked devices by means of which the machinery can be quickly stopped. Such devices shall as far as possible be easily accessible from the place by the working machine where it is expected that the employee will normally stand while working.

Where this can reasonably be required, working machinery shall also be fitted with satisfactory devices to prevent unintentional starting of the machine.

The above provisions respecting devices for stopping and preventing unintentional starting of working machinery shall also apply to transmission gear.

33. Steam boilers, cookers, containers and other vessels for liquids, steam, air or any other gas under pressure (hereinafter referred to as 'pressure vessels') shall be of such material and shall be so constructed and equipped as to be sufficiently safe, and shall be suitably installed and erected. What in this paragraph is said about pressure vessels shall also apply on pipings for liquids, vapours, air or other gases under pressure.

Pressure vessels shall be properly maintained and shall, to such extent as is prescribed or, if nothing is prescribed, to such extent as is deemed necessary, be inspected and tested and be subject to satisfactory and constant supervision. Certificates of inspection and testing and other documents necessary for determining the safety of such vessels shall, in so far as the National Board of Occupational Safety and Health so prescribes, be submitted to the labour inspector.

Pressure vessels shall neither be used at a pressure higher than the maximum pressure permitted in each case, nor shall they be used unless prescribed inspection and test have taken place.

At a suitable place on every pressure vessel that is subject to inspection and testing under the second paragraph there shall, in so far as the National Board of Occupational Safety and Health so prescribes, be a plate or stamp indicating the maximum permissible pressure and the date of the most recent inspection. In order to prevent substitution, mobile containers of gas under pressure shall be clearly marked in the manner prescribed by the National Board of Occupational Safety and Health.

A steam boiler register shall, if the National Board of Occupational Safety and Health so prescribes, be kept in respect of every steam boiler. The model for such register shall be prescribed by the Board.

34. With respect to the rules to be observed in the construction and arrangement of, and in working at or near, electrical machines, apparatus and wiring with a view to preventing employees from being injured by electric current, the special provisions relating thereto shall apply.

35. Lifting appliances, such as hoists, lifts, cranes, transporters, winches and other similar appliances, and likewise the fixed equipment belonging thereto, shall be of such material and be so constructed, erected and otherwise arranged as to ensure adequate safety, and shall be provided with the necessary guards.

Lifting appliances shall be properly maintained and shall, to such extent as is prescribed or, if nothing is prescribed, to such extent as is deemed necessary, be inspected and tested, checked for proper assembly and be satisfactorily and constantly supervised. Certificates of inspection and testing and other documents necessary for determining the safety of such appliances shall, in so far as the National Board of Occupational Safety and Health so prescribes, be submitted to the labour inspector.

Lifting appliance shall neither be used for a load heavier than the maximum permissible load prescribed for that appliance or in contravention of any regulation prohibiting or restricting the transport of persons on the appliance, nor shall lifting appliance be used unless prescribed inspection and test have taken place.

At a suitable place on or beside every lifting appliance that is subject to inspection and testing under the second paragraph, unless special circumstances require that an exception be made, the maximum permissible load, the date of the most recent inspection and, in the case of lifts or similar appliances, particulars of any prohibition or restriction of the transport of passengers shall be clearly indicated.

In the case of engine-driven or transmission-driven lifting appliances, the relevant provisions of section 32, paragraphs *(c)* and *(d)*, shall apply.

36. Transport equipment, such as cable railways, suspended railways, rollways and tramways, conveyors, trucks, vehicles and wagons of various kinds, shall be of such material and be so constructed and equipped as to ensure adequate safety, and shall be provided with the necessary guards.

Transport equipment shall be properly maintained and shall, to such extent as is prescribed or, if nothing is prescribed, in so far as is deemed necessary, be inspected and tested and be supervised in a satisfactory and constant manner. Certificates of inspection and testing and other documents necessary for determining the safety of such equipment shall, in so far as the National Board of Occupational Safety and Health so prescribes, be submitted to the labour inspector.

Transport appliance shall neither carry a load heavier than the maximum permissible load prescribed for it or be used in contravention of any regulation prohibiting or restricting the transport of persons thereon, nor shall transport appliance be used unless prescribed inspection and test have taken place.

In so far as is prescribed, the maximum permissible load and the date of the most recent inspection and particulars of any prohibition or restriction of the transport of passengers shall be clearly indicated at a suitable place on or beside every transport appliance. In addition, particular attention shall be paid to the following provisions:

(a) Plant railways shall be so arranged that there is sufficient free space alongside the track to avoid employees being crushed between any vehicle, wagon or load and any wall, pillar, post, pile or stack along the track, or in any other manner. The same shall also apply to multitrack plant railways with regard to any risk of injury which may arise from vehicles or wagons being moved simultaneously over the different tracks: Provided that in the case of underground railways in fines or quarries and also in other cases where there are special grounds therefor, the above requirements as to free space along the tracks may be relaxed to such an extent as may be considered reasonable in view of the traffic conditions and the method of transport.

Where this is considered necessary, a suitable walkway shall be arranged along plant railway tracks. Plant railways shall, in appropriate cases, be equipped with reliable signalling devices.

(b) Where this is required in view of the construction of the equipment, the inclination of the road or other conditions relating to the transport or in view of the nature of the goods to be transported and the method of transport, vehicles, wagons and other similar transport equipment shall be fitted with reliable braking devices.

(c) In the case of engine-driven or transmission-driven transport equipment, the relevant provisions of section 32, paragraphs *(c)* and *(d)*, shall apply.

37. In loading and unloading operations, and in other work involving the moving of heavy objects, care shall be taken that the work is carried out in a safe manner and, where necessary, under special direction and supervision, and that suitable equipment and other aids are used for the work.

In transport work, care shall be taken as far as possible that employees occupied in the work are not exposed to injury from sharp corners or edges of the goods transported or from protruding nails, wire ends or iron bands on the packing of the goods.

Where heavy objects are transported, the weight of the object shall be clearly indicated, to such extent as is considered necessary, on the outside of the object or of the packing. With regard to the marking in certain cases of the weight of objects to be loaded on board ships, the provisions of the Act of 11 march 1932 (No. 55)[1] shall apply.

38. Lubrication, cleaning, repair or similar maintenance work on prime movers, transmissions, working machines or other mechanical equipment

[1] *ILO, Legislative Series,* 1932 (Swe. 1).

shall only be carried out after the equipment has been stopped and secured against unintentional starting, unless adequate safety precautions have been taken or the mechanical equipment is so enclosed that contact with its dangerous parts is impossible, or other special conditions justify an exception.

When repair work or alterations are being carried out near moving machinery or in other dangerous places, the necessary precautions shall be taken for the protection, both of the persons employed on the work and of others who may thereby be exposed to danger.

39. Tools and implements of every kind shall be of suitable and satisfactory material and workmanship. They shall be kept in good working order and shall be stored and transported in a satisfactory manner.

Lifting tackle shall, to such extent as is prescribed or, if nothing is prescribed, in so far as is deemed necessary, be inspected and tested and be supervised in a satisfactory and constant manner. Certificates of inspection and testing and other documents necessary for determining the safety of such tackle shall, in so far as the National Board of Occupational Safety and Health so prescribes, be submitted to the labour inspector.

Lifting tackle shall neither be used to raise a load heavier than the maximum permissible load prescribed therefor, nor shall lifting tackle be used unless prescribed inspection and test have taken place.

Save where special circumstances warrant an exception, the maximum permissible load shall be marked on all lifting tackle.

With regard to tools or equipment put at the employee's disposal by the employer, it shall be the duty of the employee to report any defects observed by him which may entail a risk of accident.

40. In order to avert risk of injury from falls, falling objects or collapsing masses, care shall be taken that the work is arranged and carried out in a safe manner and that the necessary safety precautions are taken. The following special provisions shall apply:

(a) Floors, passageways and roads at the place of employment shall be suitably constructed and laid out, be of sufficient size and carrying capacity and so far as possible be kept in such a condition that the employees will not be exposed to risks from stumbling or slipping. When necessary, sanding or other suitable means shall be used to prevent slipping.

(b) Objects shall not be stored unnesessarily in passageways and on roads. Neither shall such places be encumbered with bicycles used for riding to and from the work. Where conditions allow, bicycle stands with a protecting roof or other suitable arrangements shall be available near the place of employment.

(c) Basins, tanks and other open vessels, wells, pits, excavations, trenches and the like shall be arranged in a safe manner as regards position, contents and depth, and shall be fenced or covered to the extent necessary. This provision shall apply, *mutatis mutandis,* to floor openings. Wall openings for loading or unloading shall be suitably protected.

(d) Stairs, ladders, gangways, scaffolds and platforms shall be of such material and be so constructed and erected as to ensure adequate safety, and shall be provided with the necessary handrails, fencing and other safety arrangements. They shall be properly maintained.

(e) Materials, equipment and other objects shall be stacked or piled in a safe manner.

(f) Roofs intended to be walked on shall be of sufficient structural strength and shall be fitted with suitable safety arrangements to the extent prescribed or, if nothing is prescribed, to the extent considered necessary.

(g) Slopes or walls of excavations, diggings and other similar works shall be given a suitable inclination or be stepped, having regard to the nature of the soil and to the height of the slope or wall: where necessary, they shall be suitably shored or braced. If undermining cannot be avoided, the resultant overhang shall be reliably supported.

(h) The roof and walls of workplaces, galleries and haulageways in mines, quarries, tunnels and other spaces blasted out of the rock shall be kept free of loose rock. Where in such places there is a risk of loose stones or collapsing masses, props, braces, full timbering (lining) or other adequate methods, shall be adopted. Places in which no work is going on and which are consequently not kept free of loose rock shall be shut off to prevent the entry of unauthorised persons; employees should be instructed not to enter such places unless duly authorised.

41. For work in places where there is a risk of falling, and other satisfactory means of protection cannot reasonably be arranged, except work on piles of planks, straw-ricks, vehicles carrying high loads or other work in which such equipment cannot be used, the employer shall provide safety belts and lifelines of suitable workmanship and good quality. It shall be the duty of the employee to use such safety equipment. If there is no satisfactory device for attaching the lifeline or where it is necessary for any other reason the employer shall arrange for the employee to receive suitable assistance for the purpose of ensuring that the life-line is properly secured.

Work carried out in the open at great height should to such extent as is reasonable be interrupted when strong wind, heavy snowfall or other severe weather conditions entail a greatly increased risk of accidents through falling.

In work of wharfs, jetties or other similar workplaces where there is a risk of drowning, the necessary rescue equipment shall be kept in readily accessible places. This provision shall apply even if the work is only of an occasional character.

42. In work involving a risk of accident through gas poisoning, care shall be taken that employees occupied in such work can receive the necessary aid as quickly as possible in case of poisoning.

For this purpose there should be a person at the workplace who can carry the poisoned person to a room with fresh air or into the open and arrange for him to receive suitable treatment. Where this can reasonably be required, an apparatus for the administration of oxygen shall be available.

43. Where necessary, effective fire alarms shall be installed to warn the employees in case of fire.

With regard to the arrangements in other respects for the rescue of employees in case of fire, special provisions in this behalf shall apply.

44. Satisfactory lighting arrangements shall be provided, not only at the places where employees carry out their work, but also in stairways and passageways and on roads at the place of employment over which employees have regularly to pass at the beginning or the end of the work or during working hours.

In mines and quarries below ground where other satisfactory lighting cannot reasonably be required, portable mine lamps may be approved for the purpose.

45. With regard to personal protective equipment specially intended to prevent accidents at work, such as helmets, eye protectors, hair protectors, protective gloves, leg and foot protectors, safety shoes, protective clothing or special aprons for protection against the spilling of live coals, molten metal, acids, lye, etc., the provisions of section 29 shall apply, *mutatis mutandis*.

46. In work at machinery where the moving parts cannot conveniently be enclosed or shielded, employees shall as far as praticable wear suitable clothing. In other cases also, employees should endeavour to use such working clothes as will not lead to accidents.

47. At every place of employment a suitable person shall be made responsible for keeping and issuing dressings and other supplies reguired for first aid in case of accident or illness. At places where a considerable number of persons are employed or where other special conditions so require, there shall be the necessary staff of persons possessing the requisite training in nursing.

At the larger places of employment, an ambulance room or sickroom in which first aid can be rendered in case of accident or illness shall be installed if conditions so require. Such rooms shall be suitably situated and arranged, and shall be provided with the necessary equipment.

A sufficient number of notices indicating the place where first-aid materials and equipment are kept, the name of the person responsible therefor and the nearest available person competent to render first aid shall be posted at places where any considerable number of persons are employed.

Certain provisions concerning juvenile employees

48. When giving effect to sections 27-30 of the Workers' Protection Act, the provisions of sections 49-61 below shall be observed, while having regard to the restriction on the application of the said provisions to certain kinds of work under section 4 of the said Act.

49. Workbooks for young persons shall contain—

(a) the young person's full name, date and year of birth; and, except in the case of work during holidays,—

(b) a certificate to the effect that the young person has completed the elementary school course or acquired corresponding knowledge and skills, or has obtained proper permission to leave the elementary school.

In addition, the workbook shall contain a medical certificate concerning the young person's state of health and physical development. If a young person shows signs of ill-health, weakness or deficient physical development, the medical certificate shall state in what respect this is so and under what conditions he may nevertheless be employed.

The form for the workbook shall be prescribed by the National Board of Occupational Safety and Health after consulting the Schools Supervisory Board.

50. A workbook containing the particulars required under paragraphs *(a)* and *(b)* of section 49 shall be issued to the young person free of charge by the appropriate teacher or principal of the school, or otherwise through the intermediary of the school authority, when the young person or the person having custody of him so requests, on the occasion of the young person's departure from elementary school or other public educational institution or at any other time.

If in a particular case there is difficulty in obtaining a workbook from the school authority, such book shall be issued by the pastor and, if so, the latter shall be responsible for entering in the book the particulars prescribed above, if they are known or certified to him.

Where the certificate referred to in paragraph *(b)* of section 49 could not be entered in the workbook when the latter was issued, it shall on request, if the young person shows that he is entitled to receive it, be entered by the person who issued the book or by another school authority or pastor.

51. When a workbook is issued under the first paragraph of section 50, it shall be the duty of the school doctor to enter in the book the certificate referred to in the second paragraph of section 49 and at the same time to enter the necessary particulars of the medical examinations which the young person has undergone during his schoolyears and of the vocational guidance given in connection with the said examinations.

If there is difficulty in obtaining the entry of medical certificate in the workbook by the school doctor, another doctor may be approached for this purpose.

52. It shall be the duty of the employer, unless the young person is also employed by another employer and the latter employment is to be considered as the principal employment, to retain the young person's workbook for the duration of the employment. If the young person's employment ceases before he has attained the age of 18 years, the workbook shall be returned to him.

An employer who has charge of the workbook of a young person shall, when the latter attains the age of 18 years or when for other reasons the workbook is no longer required by the young person, hand it to the labour inspector.

53. Every employer who employs a young person shall enter in the young person's workbook the name and address of the place of employment, the nature of the undertaking, the date on which the young person started work, the nature of the work on which the young person is employed and the daily hours of work of the young person: Provided that the said entries

need not be made where the young person is employed for a shorter period than one month.

If the young person terminates his employment or is given other employment or other working hours for any period exceeding one month, an entry to that effect shall be made in his workbook, indicating the date of the termination of employment or of the change of employment or working hours.

54. No entry or mark capable of giving other information concerning a young person than is prescribed in this Proclamation shall be made in any workbook.

55. Every employer who employs one or more young persons shall, if such employment is intended to last longer than one month, notify the labour inspector of the fact in writing. Such notification shall be sent within 14 days from the date on which the young person or young persons started work. If the employer ceases entirely to employ young persons and it is not a question only of a temporary interruption, he shall likewise notify the labour inspector of the fact in writing within 14 days.

If a young person is only employed on seasonal work and if the employer is able to give reliable information to that effect beforehand, a notification containing such information shall be valid for so long as the conditions notified continue to exist.

The provisions of this section shall not apply to forestry work or to log-floating (other than work at sorting places). Where an exemption from the examination prescribed in section 28 of the Workers' Protection Act has been granted under section 29 of the said Act, the National Board of Occupational Safety and Health may also grant an exemption from the requirement of this section respecting notifications.

56. If five or more young persons are normally employed at any place of employment, the employer shall for each calendar year keep a register of all the young persons employed during that year. In the said register, which shall be started before the first day of February in each year, there shall be entered the young person's names, the year and date of birth, the dates on which they began work and, where a young person ceases to be employed, the date on which the employment terminates. When a new register is begun, care shall be taken to enter therein all the young persons who at the turn of the year were still employed. If a young person is engaged after the register has been started for a given calendar year, the above-mentioned particulars in respect of the young person shall also be entered in the register. Forms for the said register shall be prescribed by the National Board of Occupational

Safety and Health, which shall also have power to permit the use for this purpose of other forms of record of a type approved by it.

The registers or records referred to above shall be kept at the place of employment (or, if the work there has ceased, by the employer) for one year after the calendar year to which the register or record relates.

The provisions of this section shall not apply to forestry work or to log-floating (other than work at sorting places).

57. The procedure for medical examinations under section 28 of the Workers' Protection Act shall be governed by special provisions.

If during the calendar year a young person has undergone a medical examination as prescribed in the second paragraph of section 49, no further medical examination as mentioned above shall be required during the year unless the examining surgeon considers it necessary in view of the young person's type of employment. This provision shall also apply, *mutatis mutandis*, where the young person has undergone such medical examination earlier in the year at another place of employment.

If a young person is employed in forestry work or log-floating (otherwise than in work at a sorting place), he or the person having custody of him shall see that the medical certificate in the young person's workbook is duly renewed each year.

58. When carrying out the medical examination referred to in section 57, the examining surgeon shall enter in the workbook of each young person examined the date of the examination and his observations respecting the young person's state of health and physical development. If the examination surgeon considers it necessary to lay down special conditions for the young person's continued employment on a certain type of work or to prohibit him from continuing such work, he shall make an entry to that effect both in the young person's workbook and in the inspection book (if any) referred to in section 69. Where a change of employment is prescribed, the examining surgeon shall as far as possible give indications as to the kind of work on which the young person may suitably be employed.

Before an examining surgeon makes any order under this section, he should consult the employer.

59. If in respect of a given young person the National Board of Occupational Safety and Health has reason to vary or revoke an order entered in the young person's workbook by an examining surgeon, the Board shall cause an entry to that effect to be made in the workbook and, where the order has been entered in the inspection book referred to in section 69, in that book also.

60. It shall be the duty of the examining surgeon, when examining the young persons employed at a place of employment for the first time and also on other occasions if there is a reason to do so, to acquaint himself with the working conditions of the juveniles at the place of employment.

The employer shall, so far as it lies with him, see that all the young persons employed at the place of employment present themselves for the examination referred to in section 57.

It shall be the duty of the young persons to present themselves for such examination.

61. The examining surgeon shall inform the employer in good time of the date of the medical examination. If the employer has engaged a special medical officer for the employees, the latter may be present during the examination.

Local safety activities

62. Employers who do not themselves wholly direct the work of accident and disease prevention at the place of employment shall commission one or more persons (safety inspector, personnel consultant or other person in their employ) to deal with matters of safety and health in employment to a greater or less extent on behalf of the employer. Where this has been done, the employer shall inform the safety delegates of the fact and also of the manner in which proposals shall be made to the employer in such matters. The employer shall also see that both the supervisory staff and the other employees co-operate in the work of prevention.

63. Suitable persons with good judgment and the necessary knowledge of, and interest in, matters of safety and health in employment shall be chosen as safety delegates. Safety delegates shall be well acquainted with the working conditions within their respective safety sections.

The number of safety delegates shall be determined in relation to the size of the place of employment, the nature of the work and the working conditions. If there is any doubt among the employees as to the number of safety delegates to be appointed in a given place of employment, or as to the division of the place of employment into safety sections, they should consult with the employer and the appropriate labour inspector before the election. At places of employment where there are several departments, a safety delegate should be appointed for each department or group of departments engaged in similar work. Where work is carried on in shifts, there should as far as possible be a safety delegate at each shift for relays comprising two or more employees. Where a considerable number of female employees are employed, a suitable number of safety delegates should also be appointed from among them.

At places of employment where work is carried on by employees belonging to different trades (as in the building industry), safety delegates may be appointed from each occupational group. In places of employment where the employees are distributed among two or more workplaces (as in loading and unloading work, forestry or log-floating or other comparable work), a safety delegate may be appointed for each separate workplace at which several employees are employed simultaneously.

64. The safety delegates, who must make themselves fully acquainted with the relevant conditions in their respective sections, shall promote health and safety at work and endeavour to enlist the co-operation of the other employees for this purpose. If a safety delegate considers that a particular protective measure should be taken, he shall make a proposal to the employer in the manner prescribed by the latter. Any person who has received such a proposal from a safety delegate shall without delay give a reply to the delegate on the matter. If a proposal submitted by a safety delegate in the prescribed manner has not received consideration within a reasonable time, the delegate may request the labour inspector to intervene in the matter or in cases respecting protection according to Radiations Protection Act the Committee of protection against radiations at the National Institute of Radiation Protection (Statens strålskyddsinstitut).

Where a safety committee exists, the safety delegates may directly request the committee to consider any matter of safety or hygiene that they consider sufficiently important.

Safety delegates shall have the right to acquaint themselves with the particulars contained in workbooks and in the register mentioned in section 56, with any advice and instructions entered in the inspection book mentioned in section 69, with such written communications relating to safety and hygiene matters as are annexed to the said inspection book, with document mentioned in section 24 paragraph four and with the certificates of inspection and testing referred to in sections 33, 35, 36 and 39.

65. The number of members of safety committees shall be determined in relation to the number of employees at the place of employment, the nature of the work and the working conditions.

The safety committee shall consider measures for the promotion of health and safety at work and make proposals to the employer regarding such measures. The said measures shall include matters of education and propaganda. The safety committee should acquaint itself with any statistics of accidents and occupational diseases in the place of employment and with any advice and instructions entered in the inspection book referred to in section

69, and also with any written communications on safety and hygiene questions which may have been annexed to the said book.

66. As soon as possible after election, the names and safety sections of the safety delegates shall be communicated to the employer and labour inspector by the employees or union that held the election. Such notification shall not be required when a delegate is re-elected. If a new safety delegate succeds a previously elected delegate, the name of the person replaced by the new delegate shall be given.

If an employer has appointed a deputy to deal with safety and hygiene questions or if a safety committee has been appointed, the labour inspector shall be informed in writing.

The employer shall post notices at the place of employment, indicating the name of the deputy referred to in the second paragraph as well as the names of the safety delegates and of the members of the safety committee.

67. When carrying out inspections or other business at a place of employment, the labour inspection officials shall get into touch with any safety delegates who are available at the place of employment.

It shall be the duty of the labour inspection officials to deliver free of charge to the safety delegates or safety committee copies of any advice, instructions or other written communications given or sent to the place of employment in respect of safety and hygiene matters. Copies of such communications shall be kept by the safety delegates or safety committee for at least two years, reckoned from the date of the communication. If a safety delegate resigns, such copies shall be handed over to his successor.

Inspections

68. Inspection shall primarily be directed towards activities which, in view of the nature of the work or of the conditions under which it is carried out, may be regarded as involving special danger of accident or injury to health.

In carrying out these duties, the inspection officials shall have regard to what may be considered as reasonable in each case in view of the existing conditions, and consider how, in each particular case, the objects of labour protection can be attained without imposing an unnecessary burden on the employer.

Inspection officials should furnish employers, employees and safety delegates with information, advice and instructions in questions concerning health and safety at work, and promote co-operation in such matters.

69. At every workplace where as a rule five or more persons are permanently employed, except in cases where the labour inspector or the

National Board of Occupational Safety and Health has granted an exemption, an inspection book shall be kept in which the inspection officials shall enter such advice and instructions as they see fit to give in writing when they inspect the workplace. If the labour inspector so requires, an inspection book shall also be kept in smaller workplaces. The model for the inspection book shall be prescribed by the National Board of Occupational Safety and Health.

Written communications transmitted otherwise than in the manner described in the first paragraph shall be annexed to the inspection book or kept together with it in a suitable manner. The same shall apply as regards the certificates of inspection and testing referred to in sections 33, 35, 36 and 39.

The inspection book, communications and certificates referred to above shall be kept in such manner as to be readily accessible. They shall be kept at the workplace or, if operations at the workplace have ceased, by the employer, for at least five years reckoned from the date of the last entry (in the case of the inspection book) or the date of issue (in the case of communications or certificates). The National Board of Occupational Safety and Health may prescribe a period differing from that laid down in this paragraph in the case of the aforementioned certificates. If the business carried on at the workplace is transferred, all inspection books, communications and certificates kept on the premises shall be delivered by the former owner to the new owner.

Special provisions

70. At every place of employment where as a rule five or more persons are permanently employed, there shall be kept a copy of the Workers' Protection Act and this Proclamation, together with any enactments amending or supplementing them or made in pursuance of the Workers' Protection Act and concerning the type of activity carried on at the place of employment.

The National Board of Occupational Safety and Health may prescribe that the provisions of the first paragraph shall also apply to other places of employment.

71. Unless an exemption from the provisions of section 21 of the Workers' Protection Act has been granted for all the employees, a notice indicating the time of weekly rest for the employees (or, where this time is not the same for all employees or groups of employees, the time for each group or employee) shall be posted at a suitable spot in every place of employment where handicraft, industrial, building or transport operations are carried on. Where a table of hours of work, as prescribed in the Act of 16

May 1930 (No. 138) respecting the limitation of working hours[1], contains the particulars referred to in this section, no special notice need be posted.

72. Any employer who fails to make arrangements for an investigation or inspection and test prescribed by the National Board of Occupational Safety and Health under section 24, 33, 35, 36 or 39 or uses any pressure vessel, piping, lifting appliance, transport appliance or lifting tackle in contravention of the provisions of section 33, third paragraph, section 35, third paragraph, section 36, third paragraph, or section 39, third paragraph, shall be liable to a fine *(dagsböter)*.

Any employer who does not discharge his obligation under section 5, 9 or 55 to make notification or fails to submit to the labour inspector any investigation report, certificate or other document mentioned in sections 24, 33, 35, 36 and 39 or to comply with regulations issued under section 33, fifth paragraph, or to discharge his obligations under sections 52, 53, 54, 56, 69, 70 and 71 shall be liable to a fine of not less than 5 and not more than 300 crowns:

Provided that any person who fails to make arrangements for an investigation or inspection and test or to discharge his obligation to make notification or who neglects to submit an investigation report, a certificate or other document shall not be liable to a fine if the circumstances of the case clearly show that the omission or neglect was due to an accidental oversight.

73. If any person installs a mine workshop or similar workroom situated entirely below ground without having obtained the permission of the National Board of Occupational Safety and Health, where this is required under section 8, or fails to comply with the conditions prescribed for such permission, he shall be punished with a fine unless an offence under section 53 of the Workers' Protection Act has been committed.

74. (Abrogated 1970.)

75. The provisions of section 70 of the Workers' Protection Act shall apply, *mutatis mutandis*, as regards compliance with section 5, the second, third and fifth paragraphs of section 33, the second and third paragraphs of section 35, the second and third paragraphs of section 36, the second and third paragraphs of section 39, sections 52 to 56, the second paragraph of section 60 and sections 69 to 71 of this Order.

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[1] *ILO, Legislative Series*, 1930 (Swe. 1); amendments: *ibid.*, 1938 (Swe 5), 1940 (Sve. 1 D), 1942 (Swe. 2 B).

76. Proceedings against decisions of the National Board of Occupational Safety and Health on matters dealt with in this Proclamation shall be instituted by an appeal to the Crown.

This Proclamation shall come into force on 1 July 1949.

This Proclamation repeals the Proclamation of 31 December 1912 (No. 388) respecting fees for the issue of certificate books for young workers.

Where at any place of employment there is a register, as prescribed in section 30 of the Act of 29 June 1912 (No. 206), the said register shall be regarded as an inspection book for the purpose of section 69 of this Proclamation. Entries under section 32 of the said Act shall be regarded as entries under section 56 of this Proclamation.

PAYSYSTEM, PRODUCTION, AND SAFETY -

A STUDY IN A SWEDISH IRON ORE MINE

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PAYSYSTEM, PRODUCTION, AND SAFETY - A STUDY IN A SWEDISH IRON ORE MINE

Jan Kronlund, dr. phil.

Since a wellknown contract (Saltsjöbadsavtalet) was signed by the employers´ federation and the workers´ union in 1938, the Swedish labour market has been known all over the world for its peace and calm.Swedish labour market relations have been characterised by cooperation instead of fights and discard.This official picture has always had its cracks and it has been more and more evident during the late 60´s that the antagonism between employers and workers is still there.

A law passed in 1928 makes strikes illegal between the central negotiations between employers and workers held evey third year.All the same ,the workers still go on strike when they find it necessary and the number of strikes has been rising during the last decade.In 1970 the employers´federation paid 10 million Swedish crowns (2 million dollars) to member firms as compensation for lost production through "wild cat" strikes,which must be seen as a sign of hardening conflicts in the local industrial areas.

Most strikes concern wages and related incomeproblems, but during the last years new features have appeared among the demands from the workers.An example of this was a big strike at the state-owned mines in the north of Sweden,where 6 000 workers went on a "wild cat" strike for 3 months in the winter of 1969-70.First of all the workers demanded a change in pay system,monthly pay instead of piece-rate.Secondly,they wanted higher wages.There then followed a list of demands for changed working conditions,such as better ventilation, impartial investigations into environmental factors and their effects on the workers,etc.

The main result of the strike was a change in pay system.The workers got their monthly pay,only based on time worked,without any sort of merit system or production ranking tied to it. This system has now been in function for 3 1/2 years.

In the spring 1970 a research project was started with the aim of studying the effects of the change in pay system in the production system in general as well as changes in power relations and organisational set-up as consequences of the strike.

This paper will present part of this study,the part which concerns the effect of the change in pay system on safety at work and risktaking.

We were four research workers doing the field study during 2 1/2 years.The team was interdisciplinary with economist, civil engineer,sociologist and psychologist working in cooperation with specialists at the company such as doctors,production engineers etc.We used quantitative analyses of different statistics concerning accidents,production,economy,turnover, etc as well as qualitative methods like unstructured interviews, observations while taking part in the work etc.We followed different decision processes in the formal production organisation as well as in the meetings of management,labour union etc.

The following presentation is based on accident statistics, some economic statistics,interviews with about 300 workers and their foremen and observations at the places of work.

Our frame of reference for studying the effects of the pay system on accidents and safety at work was a modification of the systems model drawn up by Dr. P. Cazamian at the 4th International Ergonomics conference in Strassbourg 1970.
The model states in brief: In any production system there are two different parties with different interests,or rather evaluations of the same phenomena in the production system, management(employers) and the workers.Both parties try to maximize their benefits and minimize their costs.The employer offers a job to the workers where he has made an optimization as regards the economy of machinery and work place layout in relation to safety laws and regulations,social and cultural norms taken into account as well.The optimization is a compromise of conflicting demands ,where the economic requirements forces the employer to accept a risk which is not minimal but optimal with regards to his own objectives.To compensate

for risks and dangerous situations the employer brings safety equipement into the situation and defines for the worker a particular working method,which will reduce the risk,but he does so at the cost of requiring the worker to provide a supplementary effort.To wear gloves,inhalation protectors,etc. and to work in a specified manner introduces an extra strain for the worker to get his job done and thereby his money.There is a "price to be paid" for the safety in the work situation and both parties try to put the costs on to the other.The workers will find situations where the inherent risk of accident is acceptable with regard to what they will earn if they work against the safety regulations (not wearing the safety equipement will raise his working speed etc).Piece rate payment gives an extra bonus to the workers the more risks they are prepared to take. The piece rate system is introduced by the employers to "motivate" the workers to high production,but it seems probable that it has a motivating effect on risk-taking behaviour as well.

That the piece rate system has the speedrising effect particularly in an inflation economy with continously rising rents and prices is indicated in the Swedish labour market statistics.It has already been said that negotiations between eployers and workers are held every third year.Now it is found that 50% of the rise in income statistics for industrial workers during the 60´s was taken out outside the central negotiations,mainly by speeding up the working rate when piece rate was paid or by manipulating the piece rate system locally.It was in fact said at the congress of the Swedish labour unions in 1971 that the working speed was so much rised in most industries with piece rate pay that dangerous situations were created to a large extent. Thus the congres was recommended to work against piece rate systems as such in favor of monthly pay.

Thus there seemed to be good grounds for our hypothesis that a change from piece rate system to monthly pay without any sort of performance evaluation tied to it,would mean changes in the risktaking behaviour of the workers and thus in the accident statistics of the company.

The results of our study shows that a dramatic change in the accident rate took place immediately after the introduction of the monthly pay system.It is a qualitative jump rather than a quantitative change,see table 1.

	1969	1970	1971	1972
Severe accidents	88	16	5	4
Less severe acc.	144	66	43	37
slight accidents	472	520	685	625

Table 1. Number of accidents 1969 - 72,the Kiruna mine.

The severe accidents almost disappeared(a 95% fall) in two years and the less severe accidents made a 70% fall.Severe accidents include injuries such as destroyed hip or back, amputation,etc.,with consequences like pension or in the "best" cases re-employment in a very light job in some sort of sheltered workshop.Less severe accidents include broken bones etc.with consequences of some time spent in a rehabilitation departement and/or in a sheltered work shop for some time and then back to the ordinary job.
The rise in slight accidents (smaller injuries from tripping and falling,pinched fingers,etc.) is 45% .It was clearly demonstrated in the inteviews with workers and foremen that when the monetary stress had disappeared the workers had adopted another,smother working rythm.Before,when disturbances such as machine breakdown happened,the workers later tried to compensate the production loss (and thus money to themselves) by intensive work rate peaks the following hours.During these peaks a lot more risks than ordinarily were taken: workers went into tunnels which were temporarily closed because of risk of falling rocks,too much gas,etc.The safety equipement was now used when the workers were no longer given "extra bonus" when not wearing them.A lot of examples on this was seen in practice.
A drastic example of the effect of a piece rate system on security regulations occurred a year after the introduction

of monthly pay.There was a fall of rocks in a big area of the Kiruna mine,a part of the mine collapsed.This was because the regulation diameter of the tunnels was exceeded by 5 meters:instead of a 9 meter diameter they were 14 meters. These tunnels had been prepared in 1969 when the piece rate system was used,which meant that the drillers and loaders were paid for each ton of rock,and so they had an interest in increasing the diameters of the tunnels. This increase had been done step by step over many years and the result was that the ceilings of the tunnels which are the floors to other groups working above,became too weak.Fortunately anough the collapse took place on a sunday when the mine was empty.

Our conclusion is that the pay system plays a critical role in ergonomic work on safety at the work place.Safety becomes a bargaining variable in the game between management and workers.A nice example was given in a daybreak mine (Svappavaara) during wintertime.The roads of the mine were very slippery and the supervisors neglected to send a truck to spread out sand because the production plan called for all trucks to load iron ore.The workers found/ that they had reached what they thought was a fair bargaining point between risk and income,that the "price to be paid" had become too high,so they decided on a joint action to show their discontent.They took up the instruction books in truck driving and started to drive accordingly.The instruction book tells you to use the same gear downhill as uphill. Management imediately understood that the lowering in driving speed downhill was a demonstration of discontent with the lack of sand on the roads, so a truck was sent to spread out sand.After that the workers closed the instruction books and continued to drive as before - against regulations.

Looking at the production statistics there is no change in the production or productivity measures that can be attributed to the change in pay system (or rather to changes in working pace).The total production of rock/manyear (including waste rock) is increasing during the studied period,while the production of refined,finished products is decreasing.This is found to be the effect of deeper mining in combination with more resources spent on refining the products.Some of these figures are given in table 2.

	1967	1968	1969	1970	1971	1972
Number of employees	3,512	3,681	3,866	4,064	4,098	4,043
Total prod. ton/man year	6,770	7,651	7,778	7,147	8,378	9,344
Refined prod. ton/manyear	4,998	5,724	5,319	4,660	5,030	5,192

Table 2. Number of employees and two productivity measures for the period 1967 - 72,The Kiruna mine.

The bargaining situation we have sketched earlier can be drawn up in a very simple model, which just is to show that what is a cost for the workers is a benefit to management or rather the firm and vice versa.

Management

$$\begin{tikzcd} \text{cost} \arrow[r, leftrightarrow] \arrow[d, leftrightarrow] & \text{benefit} \arrow[d, leftrightarrow] \\ \text{benefit} \arrow[r, leftrightarrow] & \text{cost} \end{tikzcd}$$

Workers

Another example of this bargaining situation was found in a battery production unit.The most important risk in battery-production is the cadmium in the air,which causes severe diseases in the lungs and the kidneys.The workers asked for safety equipement and management installed breathing masks connected with pipes to the fresh air.However,the masks were not used,because the workers found that they were a great hindrance in work,reduced the working rate and thus,as the workers were pais by piece rate, reduced their pay with about 30%.This was thought to be a too big price for the safety of the workers and the union asked for monthly pay in negotiations with the employer.This was refused with the following argument:"It is not right to pay for safety.Safety is not a problem of pay,it is a technical problem and needs a technical solution.We have offered you such a solution."

A last example should be given from the mine-study.The drillers had been complaining about their drilling machines for a long time.The drilling machine consisted of a simple platform on wheels with to drilling arms and a motor on it.The controls were placed on the platform without any roof or cabin,and the workers were thus exposed to falling rocks,humidity,cold, vibrations and a very high noise level (.125 Dba).After the strike the employer ordered some new machines from a manufacturer who got the workers´ specification for a good drilling machine.The machine was delivered equipped with an insulated safety cabin.The noise inside the cabin was reduced to 85 dbA and it was safe and warm.But,instead of two drilling arms this machine had got three and the drilling speed in each arm was doubled.Because of the high drilling speed the worker spent most of his time outside the cabin in order to be able to serve the arms and the cabin became a sort of hindrance because the controls were inside the cabin and could not be reached from the outside.It was only when working with very hard rock that the workers got time to be inside the cabin while drilling.Working with hard rock is a situation when the risk for falling rocks is very small and thus a situation when a safety cabin is less needed.

To sum up: Our study has shown that a conflict model gives a good explanatory frame of reference in the understanding of the effects of pay systems on accidents and risk taking behaviour.The ergonomist seems to be working in a situation where his work influences the positions of workers and management in a bargaining situation.If a machine is designed to be safer its speed is often increased,which puts a cost on the worker,whos interest it is to put the costs on the employer and the firm.In our study we have found an overwhelming amount of evidence for this conflict situation.Changes at the work place in machinery,layout,etc., reflects the power positions of the two parties,workers and management(employers). There is always a price to be paid and the costs are always put on to the weaker part.

This then shows that a conflict model should be a good base for further practical ergonomic work.If we neglect the powerrelations and work from some sort of "harmony"-model, there is a great risk that good ergonomic work will fail and leave the main criterion unchanged: the number of accidents.

It is just an embryo to a systems model which has been presented here.We need more empirical work and data before we can start to design a more elaborate systems model or theory. This autumn we hope to be able to start further studies into the problem of the effects of pay systems on risk-taking and accidents.There are many pay systems in use,many of which contain merit and production evaluation systems,the effects of which we know almost nothimg about.The straight unconditioned monthly pay of LKAB is still an exception in Sweden.

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EXCERPTUM

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Differential Effects of Ethyl Alcohol on Retinal Functions

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Abstract

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The action of ethyl alcohol on retinal function was analyzed by comparing its effects on the conventional and low-intensity ERG in the dark-adapted intact sheep eye. The results showed an increase of the *b*-wave and a decrease of the *a*-wave amplitude after small doses of alcohol (b.a.c. 20—40 mg %). The low-intensity ERG, *i.e.* the electroretinographic responses below *b*-wave threshold has recently been shown to consist of a slow, corneanegative receptor response and two fast d.c. responses of opposite polarities from the inner nuclear layer. The negative d.c. response is considered inhibitory in nature and the positive d.c. response excitatory. Administration of alcohol had no effect on the isolated receptor response but elicited an amplitude increase of the positive d.c. response. The results from the low-intensity ERG experiments suggest the mechanism behind the effects of alcohol on retinal functions to be a selective suppression of the negative d.c. response. Hereby the "controlling" function on the cells generating the positive d.c. response is suppressed, thus "releasing" the positive d.c. response and the *b*-wave, which has been shown to be built up by the positive d.c. response. The decrease of the *a*-wave appears to be secondary to the increase of the *b*-wave, all the more as it was shown that alcohol had no effect on the receptor response. At high blood alcohol concentrations, the *a*-wave as well as the *b*-wave amplitude were found to diminish as an expression for a presumed, general depression of the c.n.s.

Ethyl alcohol has long been popularly regarded as a "stimulant". From a more biological point of view, however, there seems little doubt that ethyl alcohol (alcohol) is a primary depressant of the c.n.s., and that the apparent stimulation is the result of a depression of certain inhibitory control mechanisms. Such an effect, for instance, was demonstrated on the retinal functions in the excised and opened eye of the frog (Bernhard and Skoglund 1941) and tortoise (Bernhard 1942). These authors recorded the ERG after local administration of alcohol and found the *a*-wave to diminish and *b*-wave to increase in amplitude. This was interpreted as an effect of selective suppression of the negative component P III (in terms suggested by Granit 1933). The ERG changes obtained by Bernhard and Skoglund were later confirmed in studies on the isolated retina of frog (Tomita, Funaishi and Shino 1951, Forbes, Burleigh and Neyland 1955) and turtle (Forbes *et al.* 1955).

Bernhard and Skoglund also demonstrated a selective suppression by means of alcohol on the inhibition of the impulse discharge in the optic nerve during reillumination after stimulation had ceased. This "disinhibitory" effect on the discharge of the frog optic nerve was confirmed by MacNichol and Benolken (1956), who found a similar effect on the lateral inhibition in the functionally well-defined *Limulus* preparation.

Recently, as judged by results from experiments on cold-blooded vertebrates (Murakami and Kaneko 1966, Murakami and Sasaki 1968 a, b, Sillman, Ito and Tomita 1969) as well as on mammals (Hanitzsch and Trifonow 1968, Pautler, Murakami and Nosaki 1968, Knave, Møller and Persson 1972) it has been suggested that P III consists of a proximal part from the inner nuclear layer and a distal part from the receptor cells. In one of these works alcohol was applied to the isolated carp retina (Murakami and Sasaki 1968) and the effects obtained were interpreted as due to a selective suppression of the proximal P III.

The effects of alcohol on the mammalian ERG, reported in earlier works were not quite consistent with those just described, and to a certain extent they also were at variance with one another. In cat and rabbit, only the *a*-wave was left after the administration of high, lethal doses of alcohol (Praglin, Spurney and Potts 1955). On the other hand, after relatively small doses in the rabbit, an increase of the *b*-wave amplitude was recorded (Straub 1960, Manfredini and Trimarchi 1968). In these works the *a*-wave was not evaluated, since the stimulus intensities used were below *a*-wave threshold.

In other studies, again, an increase of the *a*- and *b*-wave amplitudes were reported after small and moderate doses of alcohol intravitreally injected in the rabbit (Morita 1970) and intravenously in man (Jacobson *et al.* 1969). In another study on the ERG after peroral administration of a small dose of alcohol, the amplitude of the *b*-wave was found to increase, while no change in the *a*-wave could be observed (Ikeda 1963).

These seemingly controversial results prompted an approach with a new technique to the problem concerning the effects of alcohol on retinal functions. Recently, a reinterpretation of the components of the mammalian ERG was presented (Knave, Møller and Persson 1972). This was based on longterm experiments, in which summated retinal responses from the intact eye in sheep to light stimuli within an intensity range about 2.5 log units below the *b*-wave threshold were recorded. This method has opened new possibilities for the evaluation of the effects of alcohol on retinal functions in experiments on the intact mammalian eye.

Methods

12 successful experiments were performed on sheep in the dark-adapted state. The method used has recently been described in full (Knave *et al.* 1972).

Since the intensity-amplitude curve of the *b*-wave is known to have two saturation levels (see *e.g.* Arden, Granit and Ponte 1960, Knave *et al.* 1972) the stimulus intensity was always well above the lower of these levels. Duration of light stimulation was 0.1 s. Intervals between flashes were 1 min. The *a*-wave was measured from the isoelectric line, and the *b*-wave from the trough of the *a*-wave. When recording the summated ERG below *b*-wave threshold, the duration of stimulus was one sec and the interval between flashes was 10 s. A 20 per cent solution (Ringer) of alcohol was administered either intravenously or via a ventriculotomy into

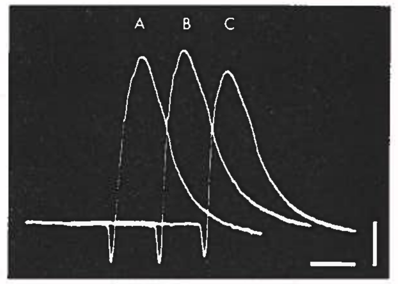

Fig. 1. ERG of the dark-adapted sheep eye before (A) and after (B and C) alcohol administration to the stomach. The B and C records were taken at a blood alcohol concentration of 25 and 140 mg %, respectively. Stimulus intensity: 5.0 log units above *b*-wave threshold. Stimulus duration: 0.1 s. Time calibration: 0.1 s. Amplitude calibration: 200 μV.

the stomach. Capillary blood samples were taken and the ADH-method (alcoholic dehydrogenase) was used for determining their concentration of alcohol[1].

Results

Effects of alcohol on single flash ERG at different blood concentrations

In studying the effects of alcohol on the ERG, two reasons are in favour for choosing the stomach route for drug administration. First, this is the "natural" way. Secondly, the resorption is slow enough to allow a detailed study of the sequence of the effects. As will be pointed out below, however, some effects could be demonstrated more

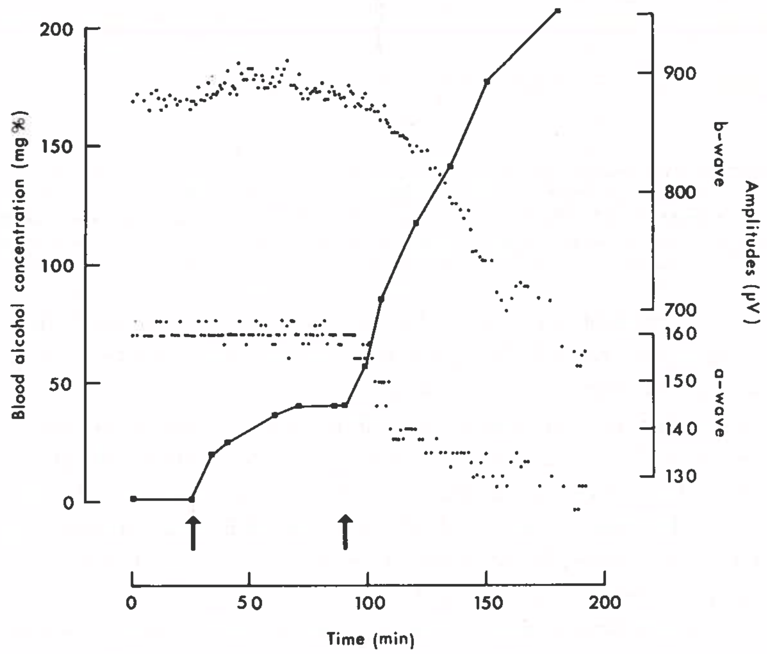

Fig. 2. Effect of alcohol on *a*-wave and *b*-wave amplitudes of the dark-adapted sheep eye. 35 and 65 ml of a 20 per cent alcohol solution (Ringer) were administered to the stomach after 25 and 90 min, respectively (arrows). Solid line between squares: blood alcohol concentration in mg %. Lower and upper arrays of filled circles denote *a*- and *b*-wave amplitudes, respectively. Stimulus intensity: 5.0 log units above *b*-wave threshold. Stimulus duration: 0.1 s.

[1] The analysises were made at the Government Laboratory for Forensic Chemistry and at the Department of Alcohol Research, Karolinska institutet.

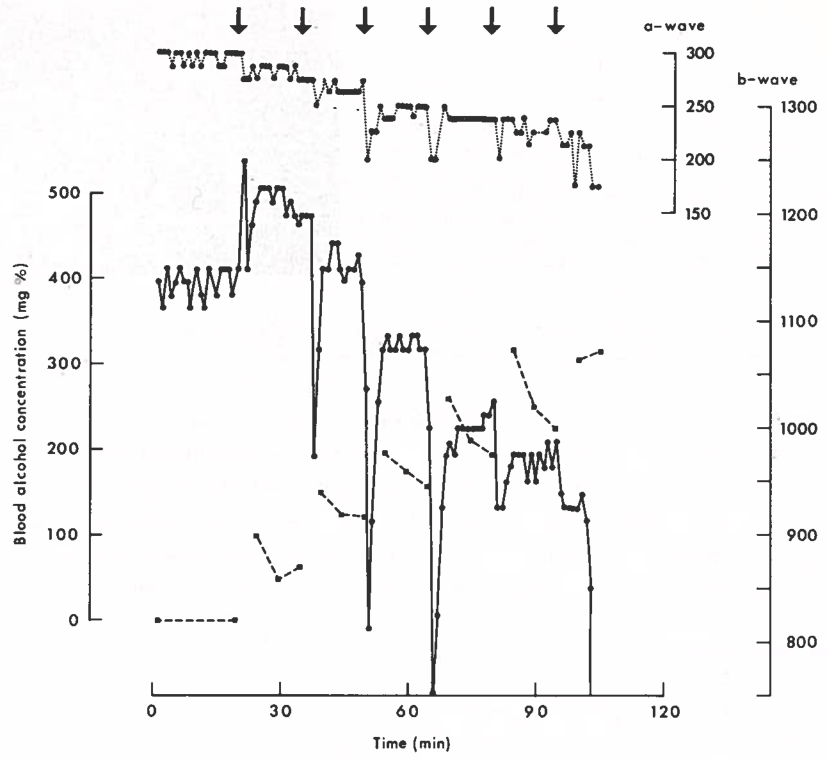

Fig. 3. Effect of intravenously administered alcohol on *a*- and *b*-wave amplitudes of the dark-adapted sheep eye. 6 successive i.v. injections of 50 ml of a 20 per cent alcohol solution (Ringer) were given at 20, 35, 49, 64, 79 and 100 min, respectively, (arrows). Dashed lines: blood alcohol concentration in mg %. Dotted and solid lines denote *a*- and *b*-wave amplitudes, respectively. Stimulus intensity: 4.7 log units above *b*-wave threshold. Stimulus duration 0.1 s.

clearly after i.v. administration. Thus, typical results will be presented, first from an experiment in which alcohol was given into the stomach, and then from another experiment after i.v. injection of the drug.

Fig. 1 shows the configuration of the ERGs obtained before (A) and after administration of alcohol to the stomach (B and C). At low blood alcohol concentrations (b.a.c.), the *b*-wave amplitude was found to increase, as illustrated by the record in Fig. 1 B taken at a b.a.c. of 25 mg %. At high concentrations, the *b*-wave as well as the *a*-wave amplitudes were found to diminish, as seen in Fig. 1 C, the record being obtained at a b.a.c. of 140 mg %.

In Fig. 2, the amplitudes of the *a*- (lower array of filled circles) and the *b*-wave (upper array of filled circles) as well as the b.a.c. (squares, solid line) are graphically illustrated from the same experiment. After 25 and 90 min respectively (arrows), 35 and 65 ml of 20 per cent solution were given.

After the first small dose of alcohol, the b.a.c. slowly increased to a plateau at 40 mg %, and after the second dose there was a steep rise to high values (200 mg % at the end of the experiment).

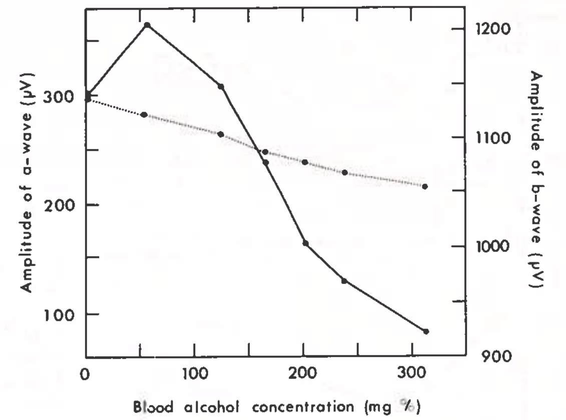

Fig. 4. Effect of alcohol on *a*- and *b*-wave amplitudes of the dark-adapted sheep eye. The figures of this graph are obtained from the experiment illustrated in Fig. 3. The means of the blood alcohol concentration 10 and 15 min after each injection are plotted against the mean amplitudes obtained during these periods.

A temporary increase of the *b*-wave amplitude was noted about five min after the first dose was given, coinciding in time with the first slow increase of the b.a.c. to a value of about 20 mg % (see also Fig. 1 B). Between 70 and 90 min after administration, *i.e.* when the b.a.c. reached the plateau at 40 mg %, the *b*-wave amplitude returned to normal values. After the second dose of alcohol there was a fast decrease of the amplitude of the *b*-wave, (see also Fig. 1 C).

The *a*-wave was found to be fairly constant up to the administration of the second dose of alcohol, after which the *a*-wave amplitude also diminished. As a matter of fact, a decrease in amplitude was vaguely indicated already before the second dose, during the time when the b.a.c. reached its plateau at 40 mg %.

This suspected decrease of the *a*-wave amplitude at low b.a.c. was manifested after giving the alcohol intravenously. In Fig. 3, the amplitudes of the *a*-wave (dotted line) and *b*-wave (solid line), as well as the b.a.c. values (dashed line), are shown after six successive i.v. injections of 50 ml of a 20 per cent alcohol solution at 20, 35, 49, 64, 79 and 100 min, respectively (arrows). Determination of the b.a.c. was made 5, 10 and 15 min after each injection (except for the last one, when blood samples were taken after 5 and 10 min only).

After each injection the b.a.c. increased, the value obtained 5 min after each injection being higher than the values obtained after 10 and 15 min. Rapid, transient changes in the ERG amplitudes also occurred after each injection. Constant values were not obtained until after about 5 min. The initial, transient changes were most probably due to a redistribution of the injected alcohol (see Ritchie 1970). Since the central nervous tissue has a rich blood supply and a high coefficient of affinity for alcohol, the effects on c.n.s. are especially rapid after i.v. administration. However, the alcohol is soon redistributed to other tissues, and not until this redistribution is finished can constant values be expected. The transient effects immediately after the injections will not be dealt with further, since we do not know the actual concentrations of alcohol, either in the blood or in the retina, during these phases.

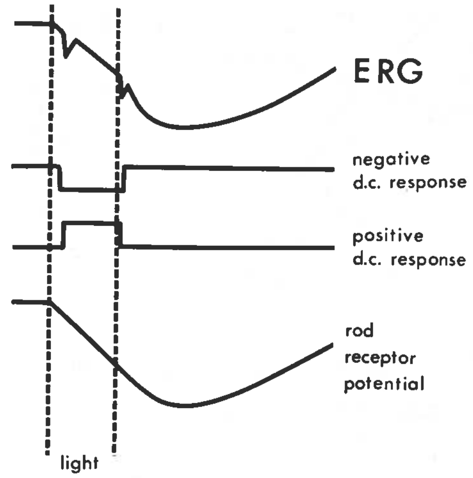

Fig. 5. Schematic representation of ERG components below *b*-wave threshold of the dark-adapted sheep eye. Upper diagram depicts a typical low-intensity ERG, which is assumed to be built up of a receptor response (lower diagram) and a negative and a positive d.c. response (middle diagrams).

It is more appropriate to evaluate the effects 10—15 min after each injection because at that time the b.a.c. has reached constant levels.

As can be seen in Fig. 3, there was an enhancement of the *b*-wave amplitude after the injection of the first dose of alcohol. Increased amplitudes were still obtained after the second dose, although their magnitude was now less than after the first dose. The amplitudes diminished below the original level after the third dose, and after the fourth, fifth and sixth doses successively decreasing amplitudes were recorded. The *a*-wave amplitude did not increase initially; instead there was a stepwise decrease with every injection.

These changes in ERG amplitudes are depicted in the graph of Fig. 4. Here the means (six individual values) of the b.a.c. 10 and 15 min after injection are plotted against the mean amplitude obtained during these periods. The decrease in *a*-wave amplitude (dotted curve) was found to be almost linear with increasing concentrations of alcohol. The solid line shows the initial increase and subsequent decrease of the *b*-wave amplitude.

Effect of alcohol on the summated ERG below b-wave threshold

Recently, a reinterpretation of the components of the ERG was presented (Knave *et al.* 1972). This analysis was based mainly on averaged responses below *b*-wave threshold of the dark-adapted, intact sheep eye. At these low stimulus intensities it was possible to separate three components, which were assumed to represent a rod receptor potential and a negative and a positive d.c. response, generated in the inner nuclear layer. Such a low-intensity ERG is schematically depicted in Fig. 5 (upper diagram), as well as its components, *viz.* the rod receptor potential (lower diagram) and the d.c. responses (middle diagrams).

Furthermore, the negative d.c. response was tentatively interpreted to have an inhibitory effect on the activity giving rise to the positive d.c. response. It was suggested that the negative d.c. response represented the proximal P III. This is of special interest, in as much as alcohol has been claimed to selectively suppress the

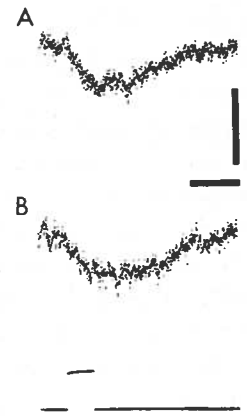

Fig. 6 (left). Effect of alcohol on the ERG below *b*-wave threshold in the dark-adapted sheep eye. The slow corneanegative potential represents the isolated receptor response elicited just above its threshold with a stimulus intensity 2.4 log units below *b*-wave threshold. 100 summated responses are shown before (A) and 10 min after i.v. administration of 50 ml of a 20 per cent alcohol solution (B). The blood alcohol concentration determined immediately before and after the latter ERG summation (record B), were 60 and 79 mg %, respectively. 1 s light stimulus marked in the lowest record. Time calibration: 2 s. Amplitude calibration: 1 μV.

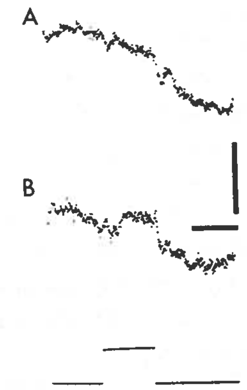

Fig. 7 (right). Effect of alcohol on the ERG below *b*-wave threshold in the dark-adapted sheep eye. The records are taken at a stimulus intensity of 1.8 log units below *b*-wave threshold. At this stimulus intensity the summated response has a configuration similar to that of the top record in Fig. 5. 100 summated responses are shown before (A) and 10 min after i.v. administration of 50 ml of a 20 per cent alcohol solution (B). The blood alcohol concentration, determined immediately before and after the latter ERG summation (record B), were 50 and 60 mg %, respectively. One sec light stimulus marked in the lowest record. Time calibration: 1 s. Amplitude calibration: 10 μV.

proximal P III (Murakami and Sasaki 1968 b). Thus there are reasons to expect an effect of alcohol on the d.c. components of the low-intensity ERG.

The experiments on the low-intensity ERG were designed to study the effects on the receptor response isolated just above its threshold (Fig. 6) as well as on the d.c. responses at somewhat higher stimulus intensities (Fig. 7). The averaged ERGs were elicited by one-second flashes with an intensity 2.4 and 1.8 log units below the *b*-wave threshold (Fig. 6 and 7, respectively), before (upper records) and 10 min after i.v. administration of 50 ml of a 20 per cent alcohol solution (lower records). B.a.c., determined immediately before and after the latter averagings, varied between 50 and 70 mg %, *i.e.* the concentration at which maximal *b*-wave amplitudes were obtained after i.v. injection (see Fig. 4).

As can be seen in Fig. 6 the shape and amplitude of the isolated receptor response were of the same order of magnitude before and after alcohol administration. At somewhat higher stimulus intensities, however, the electroretinographic response changed in configuration after alcohol (Fig. 7). A positive plateau developed between the two negative notches on the falling phase of the receptor response indicating an increase of the positive d.c. response (*cf.* Fig. 5).

Discussion

The result of the present studies on sheep shows that small doses of alcohol are followed by an increase of the *b*-wave, as was first shown in experiments on cold-blooded animals (Bernhard and Skoglund 1941, Bernhard 1942). The reduction of the *a*-wave observed is also in accordance with the earlier results on cold-blooded animals but not with the results reported in man (Jacobson *et al.* 1969) and rabbit (Morita 1970), where the *a*-wave was found to increase after small doses of alcohol.

In the recently performed analysis of the mammalian ERG by Knave *et al.* (1972), three main components have been separated (see above). According to the present study on the effects of alcohol on the low-intensity ERG, there was no effect on the isolated receptor response but a clear amplitude increase of the positive d.c. response at somewhat higher stimulus intensities (see Fig. 6—7). In the above-mentioned work it was concluded that the negative d.c. response is inhibitory and the positive one excitatory in nature. The authors also suggested that the negative d.c. response exerts an inhibitory influence on the functions signalled by the positive one. With this theory in mind it is tempting to suggest that the primary effect of alcohol on the ERG is a selective suppression of the negative d.c. response. By such a mechanism the "controlling" function on the positive d.c. response is suppressed, thus "releasing" the positive d.c. response. It should also be pointed out that the negative d.c. response has been suggested to correspond to the so-called proximal P III (see introduction). Thus the finding that alcohol primarily suppresses the proximal P III (Murakami and Sasaki 1968 b) is supported by the results of the present study.

The results indicating that the primary effect of alcohol is a selective suppression of the negative d.c. response may also serve as an indirect confirmation of the alcohol effects recorded by Negishi and Svaetichin (1966). These authors found that alcohol in low concentration suppressed the function of cells producing the S-potential, whereas the photoreceptor cells, spike-producing neurons and synaptic transmission had a greater resistance to the drug. In the reinterpretation of the ERG components, mentioned above, suggestive evidence was presented for the conclusion that the negative d.c. response was generated in the inner nuclear layer, probably by the horizontal cells, which have been shown to generate the S-potentials (Kaneko 1970).

The complementary results on the effects of alcohol on the low-intensity ERG may offer an explanation of the increase of the *b*-wave and decrease of the *a*-wave amplitude at low concentrations of alcohol in the blood. As mentioned above, the most striking effect of alcohol is the amplitude increase of the positive d.c. response (see Figs. 5—7) which has been shown to build up te *b*-wave (Knave *et al.* 1972). Since increase of the positive d.c. response appears to represent a release of the activity of cells in the inner nuclear layer from an inhibitory action exerted from the horizontal cells, the increase of the *b*-wave appears to be a sign of this disinhibitory effect. The decrease of the *a*-wave appears to be secondary to the *b*-wave

increase, all the more as it was shown in the present study that administration of alcohol had no effect on the isolated receptor potential (see Fig. 6).

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The use of ergonomics in the design of new industries

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The author presents the case for considering ergonomics factors as well as social and environmental considerations when designing new buildings and industrial plants. After considering the design processes currently being used in Sweden for houses, offices and industrial buildings, he reviews the type and presentation of the data required, followed by an outline of the application of the proposed system to the design of a large and a small industrial development.

It has often been stated, and often as a result of hindsight, that social, human factors and environmental (SHE) considerations should be taken into account right from the start when new buildings and industrial plants are being planned and designed. In other words, the problems which arise concerning the needs of both man and nature in new buildings and industries, and in domestic housing and the whole area of urban development, must be predicted and solved before the first brick is laid. This also implies a sound judgement of the technical means that are available to solve these problems.

So much is self-evident, and sounds almost trite. But sadly enough, it is very seldom that this ideal exists in practice, despite the fact that discussion and controversy about human factors and environmental problems are currently so fashionable. The main reasons for this are two-fold:

1. The people with knowledge and experience in the human factors field are not those doing the designing and planning.
2. A more serious problem at the present time is that the information available in the fields of human factors (eg. ergonomics, occupational and environmental health) is mainly of a diagnostic and research-oriented character.

Experience, although limited in the use of this "diagnostic" information in Sweden and the USA, shows that it is not directly applicable to the processes of design and planning. It requires some effort for a non-specialist to search the literature, for example, for a relevant fact which should be used in a design, and many aspects cannot be considered at all. What is needed is a 'data-bank' of knowledge, which can be used directly in the design and planning processes and routines.

These routines, which are in current use in the design of new domestic and industrial buildings, have achieved a high level of development and complexity, while the actual time allowed for these stages has been steadily reduced. This in turn means that many design activities have to be performed in parallel, and complex rules for information flow between experts in different fields and for decision-making tasks have been formulated. It is thus even more difficult to break into these processes with new types of information.

There are thus two needs: (1) to obtain SHE data in such a form that they can be used easily in the design process; (2) to attempt to change the design process itself so that this new type of information can be assimilated more easily.

The body of this paper is divided into three main sections:

1. A discussion of the design processes currently being used in Sweden for houses, offices and industrial buildings.
2. The type and presentation of the SHE data which are required for planning and design processes.
3. Applications of the proposed system as experienced in the architectural design of a large industrial plant and in a smaller factory building.

The author's main experience in this field has been gained in the design of industrial plant and shopping areas, but the systematic approach to be described is applicable to all other building projects.

The design and planning process

In Sweden today there are basically two models which are being used in the design of buildings:

The first model uses classical and well-tried techniques, and is divided into three phases: analysis, design and construction (these are also analogous with the methods used in the USA). This means that the design consultants are producing the complete design and can follow it through from the initial stages to the completion of the bid package. They are responsible for producing detailed design drawings and descriptions of all parts of the system. The bid package is made up of sub-packages covering heating and ventilation, electrical installations, sanitation, interior design and so on, and they also cover the industrial process and the machinery to be used. This kind of design and planning process is becoming less common in Sweden nowadays.

The second model relates to the modern tendency for the consultant designers to provide just the basic framework for the design, and leave the detailed design work to the different contractors. In this case, the bid package consists of functionally oriented specifications couched in much more general terms than in the first model. The contractors are then free to produce the detailed design in ways which fit in with their own particular construction methods. There are two main philosophies behind this:

1. The contractor should be able to produce a cheaper product because he can use processes and techniques with which his company has had the most experience and has optimised in terms of time and cost.

2. The design process should take less time, as the contractors know more about their techniques, materials and construction methods than do the consultant designers.

There is an inherent risk in the use of the second model that the customer does not end up with the building or plant that he originally envisaged. It is difficult to be specific when talking in general and functional terms, and it is still more difficult to evaluate the bids produced by the contractors and to be able to compare them in relation to the original specifications when they are phrased in such general terms. Last, but by no means least, is the difficulty of checking later whether the contractors have fullfilled the specified requirements.

Fig 1 shows a diagram of a generalised design process, which is applicable to both of the models mentioned above. In the first model, the consultant designers are involved in all stages of the process, wheras in the second model they are only concerned in the first phases.

In parallel with the building process are shown the steps in the design of the industrial process, although, of course, if buildings with other purposes than industrial are being constructed the details of each phase will be different. However, the basic steps in this systematic approach will be the same whether the building is an industrial plant or, for example, a goods distribution centre for retail shops or an administrative office block.

In a central position in the diagram are indicated the SHE factors. These are discussed in the next section.

Integration of SHE factors in a design process

Information required

SHE information must be considered at each of the following points in the design process:

First, the aims and whole raison d'etre of the building in question must be examined from a SHE viewpoint, in addition to considering the purely commercial aspects.

Second is the determination of a site for the building. Factors which must be considered here are air and water pollution, waste disposal problems, positioning of the building in relation to others on the site and aesthetic problems of fitting the building into the general environment.

Third is consideration of the internal design of the building and the relevant work processes which will be

PHASE	0	1	2			3	4	5
Production process	Definition of system objectives and general criteria	Function analysis	Layout and selection of processes and machinery	Design of hardware and purchase specifications		Analysis of bids and the purchasing processes	Installation and construction	Operation
S H E factors		Definition of operation requirements for S H E	Design assistance					Evaluation and testing
Building		Analysis	Design: Function design	Physical design	Detailed design			In use
Examples of S H E factor activities	Definition of activities —Selection of site —Studies of other plants and buildings	To give requirements on: —Noise —Light —Thermal environment —Ventilation —Waste : —gases —liquids —solids —Social norms —Social space —Communication flows —Job principles	—Selection of machinery —safety —vibration —lay-out —instruments —Selection of building techniques —acoustics —lighting —ventilation plan —physical communication —Development of —control routines —information programs —organisation				Advice to management and personnel departments on —selection —training —safety programmes	

Fig 1 An example of a design process in which the social, human and environmental factors are considered

carried out in it. The layout of the interior must be natural to, and easily understood by, its occupants. Environmental problems such as lighting, noise levels, air conditioning and gas and dust removal must be considered, also the degree of automation needed and the job principles, etc. Ergonomics questions of importance are the amount of monotony allowable in a man's job, information flow, communications and understanding of the process (also selection and training of personnel in the first place).

Experts' contribution

Involvement of SHE experts in the design process may be divided into four phases:

1. Development of specifications
2. Design work and technical advice
3. Evaluation of bids
4. Evaluation and inspection on the fulfilment of the original specifications and the operational requirements.

These four phases may be seen to be similar to the four design phases listed earlier, and may similarly be applied to both design models. In the first model, the SHE experts involved can be much more directly in touch with details of the design. In the second model, the customer must rely on the contractor having qualificated SHE experts in his design team, and this will only been achieved if the customer himself has a highly qualified (and tough) SHE group. The jobs of such a group would be:

1. To examine the process or function of the building and determine the necessary SHE factors which must be taken into account.
2. Interpret and formulate these factors into simple rules which the contractors must follow and incorporate into the bid package.
3. Establishment of norms of how the bid package should be presented, so that it may be compared readily with bids from other contractors as regards compliance with the rules mentioned in (2).
4. Specifications of the techniques and instrumentation needed for testing, inspecting and examining whether the original requirements have been fulfilled.

The quality of the bid package provided by the contractors would be much increased by these steps, and it will be easier to question and check the information given. On the other hand, it will be easier for the contractors to produce a bid package according to this simple series of guide lines.

Available information

The information which is available at present in the SHE field is seldom in a form in which it can be used directly in the design process, as mentioned in the introduction. One example of what is needed, and how the SHE information can be presented in a form where it is directly usable by designers, is that concerned with the acoustic environment. One can specify exactly what noise levels and which frequencies will cause damage to the hearing, and which will cause social and behavioural disturbances. Standardisation has been achieved on methods for noise measurement and instrumentation, and methods and materials for noise reduction are also well-documented.

Other information, however, tends still to be found only in bits and pieces in the masses of research reports and papers that are produced. It is all very well for the SHE group to have access to the relevant information, but unless it can be presented in a useable form to the designers it is worthless. This implies two points; that the SHE experts must be able to talk the same technical language as the designers, and that a 'data-bank' of all the knowledge and information in the areas where the SHE experts are involved is needed. This would not, of course, obviate the need for the SHE experts, but would provide valuable guidelines in the basic requirements for the designers. Typical questions which should be specified more closely are the optimum degree of automation in industries of different types, information flow patterns, and the social contacts and relationships (or opportunities for them) within the working environment.

Some experiences in the use of these methods

The methods discussed in this paper have been used several times in Sweden, and two examples in which the author was involved are discussed here. One concerns a small textile factory in the north of Sweden, where the methods were necessarily applied in a fairly elementary way, and the other is a sizeable oil refinery built on a site where a more sophisticated application was possible.

Textile factory

In this case, the more traditional form of bidding and design procedure was used (akin to Model 1), which meant that the work of the SHE experts was well-integrated with that of the other consultants in the design team. The author acted as the social, human factors and environmental expert throughout for the design stages. He was called in during the preliminary stages in the design process, before selection of the site for the factory, but after the main decision had been taken that a factory should be built.

The design work had to be completed within a period of six months and a number of outside consultants were used at various stages. The general requirements were defined by the author, but for the detailed design of the different process plants and buildings specialists in, for example, acoustics were called in to carry out the technical calculations necessary. Experts on ventilation plants and lighting equipment were also consulted at the relevant stages.

In retrospect, one can see that many of the possible SHE problems were foreseen and avoided, but due to the short time period and the work-load involved some problems could not be solved at the time and had to be corrected later in the traditional and much more expensive way. It is always difficult to analyse the costs and benefits of complying with SHE requirements, but one can easily estimate that the cost of forseeing the problems in the design stage is between one fifth and one tenth of the cost of correcting mistakes afterwards. The increase in the design costs in this type of job would be between 10% - 15% of the total design costs.

Oil refinery

In this plant, the more modern design and building processes were used, similar to Model 2. In this case, the author was also called in at a very early stage in the design, and he acted as co-ordinator of all the SHE factors work. Later in the design the general environmental problems which concerned the community (eg, air and water pollution) were handed over to another group of specialists; and in the final phases these problems, and those concerning safety on the plant, were taken over by the newly-recruited permanent staff of the refinery who would be responsible for them in the future.

In the same way that specifications (eg, for piping and building construction) were produced by the designers, a special SHE factors specification was also produced, and this had to some extent a higher status than other specifications. This meant that in the case of any conflict of interest or information, the SHE specification would have priority.

The specifications dealt with all the various areas mentioned above such as acoustic, visual and thermal environments, water and air pollution, waste disposal and safety problems.

As already indicated, some of the specifications were relatively easy to produce, while great difficulty was experienced with others. To take noise as an example, the four steps of basic requirements, design rules, norms to be complied with, and testing and inspection specifications, could be specified in great detail. Even so, it proved to be expensive to comply with all the legal requirements for just this one factor. Other sections of the specification were necessarily somewhat simpler.

Conclusions

Much work still has to be done, especially on standardisation, in this field, and also applied research into the kind of information which it is necessary to provide for designers of these and similar systems. Much of the present-day SHE factors research is not directed in such a way as to give this type of information because its aim is usually explorative in a general sense. Apart from this applied research, there is also a great need to assemble the data which have already been provided by researchers into a usable and useful form (the 'data-bank'), and to make this available to the designers and planners as soon as possible. With the new design techniques mentioned becoming more and more common, these needs are rapidly becoming more urgent.

In the autumn of 1972, a new course in Social, Human and Environmental factors has been given in Stockholm for engineers involved in building services. This course is a short introduction, based on the concepts outlined in this paper, to present such information as can be used by them in normal design work. Similar courses will probably also be organised for architects and interior designers at a later date.

There may also be a research project starting in Sweden which will aim to specify and detail the information and standards necessary for rational design routines, which include social, human factors and environmental criteria. It would be most useful and interesting to make contact with anyone else who is working in this field, and the author would be glad to hear from anyone engaged in similar research.

The future

There are a few instances in Sweden where the design approach outlined here has been used with success in buildings other than factories; eg, in the design of shopping-centres. This approach can also be used in the design of living accommodation, and in urban development in general. One can foresee that this approach could probably be most successful in the design of complete new towns, where one is able to consider all the main aspects of man's life, ie, both the working (industrial) life and the leisure and domestic life. As in all complex systems, such as a new town, the various parts are inter-dependent in different ways. This is especially true in the relation between a man's work and home, and if these could be designed in an integrated fashion it may well be possible to alleviate some of the problems caused by the present-day patterns of living.

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Convective heat emission and awareness of draught in human beings

Lars-Olof Glas, Toni Ivergård & Georg Lewin

National Swedish Building Research Summaries

R26:1972

Complaints about draughts are common both in the home environment and in different working environments. Report No R26:1972 describes a study which was carried out in order to establish the effect of different parameters on the "draught threshold" and to study the relationship between the convective cooling of electrically heated test objects and the subjective reactions of people while being cooled convectively. The study is divided into an ergonomic section in which the subjective reaction to cooling by air jets was studied, and an engineering section in which cooling was measured by physical means on test objects, similar in size to parts of the human body, which were subjected to air streams of different velocities.

Method of investigation — ergonomic section

In addition to the test subjects who took part in a preliminary investigation in which minor corrections of the investigation method were made, nineteen people participated in the investigation. The test subjects lay on their backs on a bunk with the upper parts of their bodies bare. Air was blown onto their backs from two separate pipes the bunk. The test subjects had to determine the pipe through which the air was being blown. There were 4 possible air velocities (0.08, 0.14, 0.2 or 0.3 m/s) and the air flow had a duration of 0.3 or 18 seconds. There were thus 16 different combinations: two positions (2 different pipes), 4 velocities and two air flow durations.

Method of investigation — engineering section

Seven different test objects (three cylindrical, three cubical and one flat) were placed into a duct which was arranged so as to give even air velocity distribution around the bodies. The test objects were electrically heated, the power being different for the three test series. Temperature differences of approx. 5, 10 and 30° were obtained between the object and the ambient air at air velocities below 0.05 m/s.

The surface temperature was measured by means of thermocouples. The temperature measurement points were placed on the cylindrical and cubical test objects as shown in FIG. 1. The measurement surfaces on the bodies were separated from one another by heat insulation.

Results

It was found as a result of the ergonomical investigation that an increase in the duration of the air flow from 0.3 to 18 seconds caused a statistically significant increase in the awareness of draugt. The shorter air flow was on the whole insufficient to permit reliable observations with regard to the sensation of draught experienced. FIG. 2 shows for the different air jet velocities the probability that the air jet will be distinguished by the test subjects. This applies to the longer duration of 18 seconds. At a velocity of 0.15 m/s the air jet is distinguished with a certainty of 50 %.

As shown in FIG. 3, it is evident from the engineering investigation that an increasing cooling effect is obtained at air velocities greater than 0.05 and 0.2 m/s respectively, depending on the size of the test object and the placing of the measurement points. When these were placed on the front of the object (the side facing the air stream), the thermal transmittance was higher than when the measurement point was placed on the rear of the object. The smaller test objects had an obviously higher thermal transmittance than the lager ones. There was a cooling effect, i.e. a clear increase in the thermal transmittance, on the front of the objects even at low air velocities (approximately 0.05—0.06 m/s).

There was on the other hand no appreciable increase in thermal transmittance on the rear of the test object until the air velocity had exceeded 0.2 m/s.

Conclusions

One conclusion that can be drawn from this investigation is that most of the awareness of draught probably depends

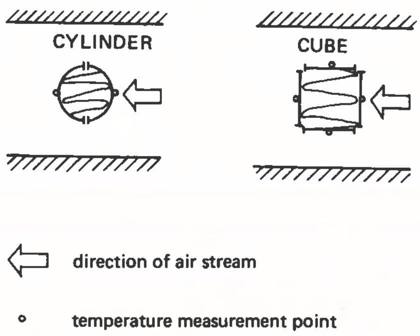

FIG. 1. Placing of measurement points on a cylindrical and a cubical test object.

Key words:

convective heat emission, awareness of draught, laboratory study

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on the convective heat emission and not on the contact effect due to the air flow, since no significant differences could be demonstrated for air flows of short duration as regards the sensation of draught which was experienced at different air velocities.

In investigations of the awareness of draught, engineering studies by means of measurements of the convective heat emission should therefore in many instances be a perfectly satisfactory alternative to tests on people. Care must, however, be exercised in evaluating the results of the investigations, since their validity is dependent on a number of different factors. It is particularly important in the engineering investigations to bear in mind the part of the body to which the draught studies are to apply, since the convective heat emission is very largely dependent on the size of the object and the direction of flow of the air stream. In the case of larger body surfaces such as the back, with the air stream parallel to the surface, it is to be expected that air velocities will have no effect on the sensation of draught until they have exceeded approximately 0.2 m/s.

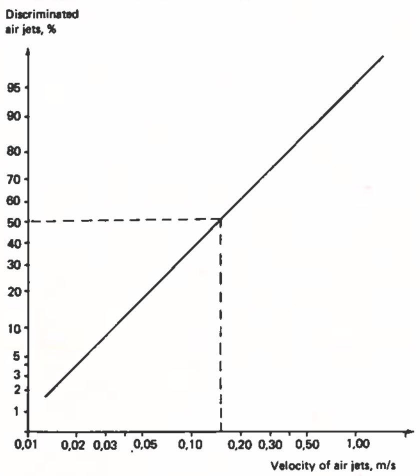

FIG. 2. Relation between detection of air flows of 18 seconds duration and the velocity of the air stream

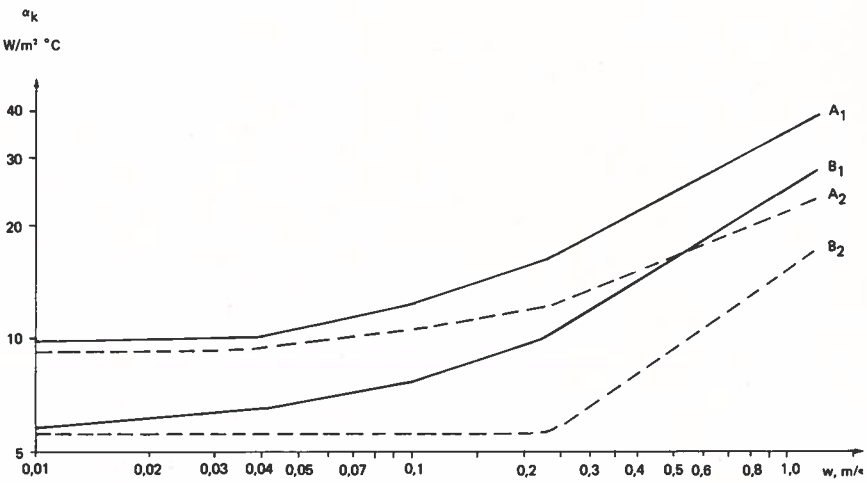

FIG. 3. Effect of thermal transmittance α_k at different air velocities w

A_1: Measurement point at the front of a cylinder of diameter ∅ = 23 mm and length = 35 mm

A_2: Measurement point at the rear of a cylinder of diameter ∅ = 23 mm and length = 35 mm

B_1: Measurement point at the front of a cylinder of diameter ∅ = 100 mm and length = 155 mm

B_2: Measurement point at the rear of a cylinder of diameter ∅ = 100 mm and length = 155 mm

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Causes of accidents involving children in their homes or the immediate vicinity – a method study

Tomas Berns, Helene Broms, Tony Ivergård & Gerd Svensson

National Swedish Building Research Summaries

R66:1973

Key words:
accidents involving children, home, method study

Accidents are the commonest cause of death amongst children over the age of 12 months. Most accidents involving children under school age take place at home. Only a few of the previous studies of accidents involving children have aimed at establishing the technical causes.

The principle aim of this study was to develop a method whereby it would be possible to evaluate the risk of accidents occurring with children in their home environment. It is particularly important to be able to isolate the technical causes of accidents.

The study was divided into two parts. It began with a detailed review of previous research in this field and then with this as a basis went on to make a practical assessment of two different methods of establishing the technical causes of accidents involving children.

Previous research

The review of literature is divided into six sections (What is an accident?, Classification of accidents, Commonness of accidents, Methods, Research, and Product Safety in the USA) and confirms that most studies up to now have been in the form of outline surveys in which accidents are classified and grouped according to their consequences and manner of occurrence. The few studies which have concentrated on the manner in which accidents have been caused have been far too general to be of any real practical value in preventive measures. A review of the existing literature revealed a need for detailed studies of technical functions.

The study

The statistical material which can be obtained about accidents causing serious physical injuries is far too limited to be of any use in establishing their technical causes. This is particularly true if we seek a method of evaluating the risk involved in individual buildings or types of buildings within a limited period of time. We have therefore instead chosen to consider two different methods of studying accident risk.

The first method involves the use of journals and open interviews. 24 families kept a record of all the occasions on which their children almost had an accident or something approaching an accident at home over a period of 23 days. These 24 families plus a further 12 were also interviewed in detail on all the accidents which had occurred earlier.

The second method consisted of two phases. In the first phase the most important risks were established with the aid of a detailed questionnaire. This was followed by a second phase involving detailed studies at the scene of an accident. The questionnaire was sent out to 198 families, 67 of which replied.

Results

The theoretical part of the study shows that in the dwellings studied, which are not representative of Swedish homes as a whole, the following items were most often the cause of accidents of various types; playground equipment, doors, furniture, bicycles, stairs and cookers. This shows good agreement with the products found to be most frequently involved in children's accidents and those leading to hospital attention in the United States.

The study also shows that it is possible to trace certain types of accident back to the design of the dwelling or to the design of products in it. Certain types of accident were common when the cooker was situated alongside a heavily used passage in the kitchen. Accidents with chopping boards occurred only in those kitchens where the chopping board was adjacent to a passage. A lighted lamp in a hot oven with a glass front encouraged children to play with the oven, subsequently leading to accidents and even burns.

Evaluation of the method

The method of using a questionnaire followed by detailed studies was judged to be the best for future evaluation of the technical causes of accidents involving children. The main reason for this choice was that practical difficulties were encountered with the method involving diaries and interviews; it was extremely difficult to persuade the persons in charge of the children to do something as demanding as keeping a diary.

Despite the scope of the questionnaire used, a relatively satisfactory level of response was achieved. The follow-up studies were easier to carry out than the open interviews following the keeping of the diary. One of the reasons for this was that the follow-up studies could concentrate on questions of a specific and concrete nature.

It should thus be possible in the future to evaluate individual buildings and types of buildings and thus to provide a basis for standardization of items made safe for children.

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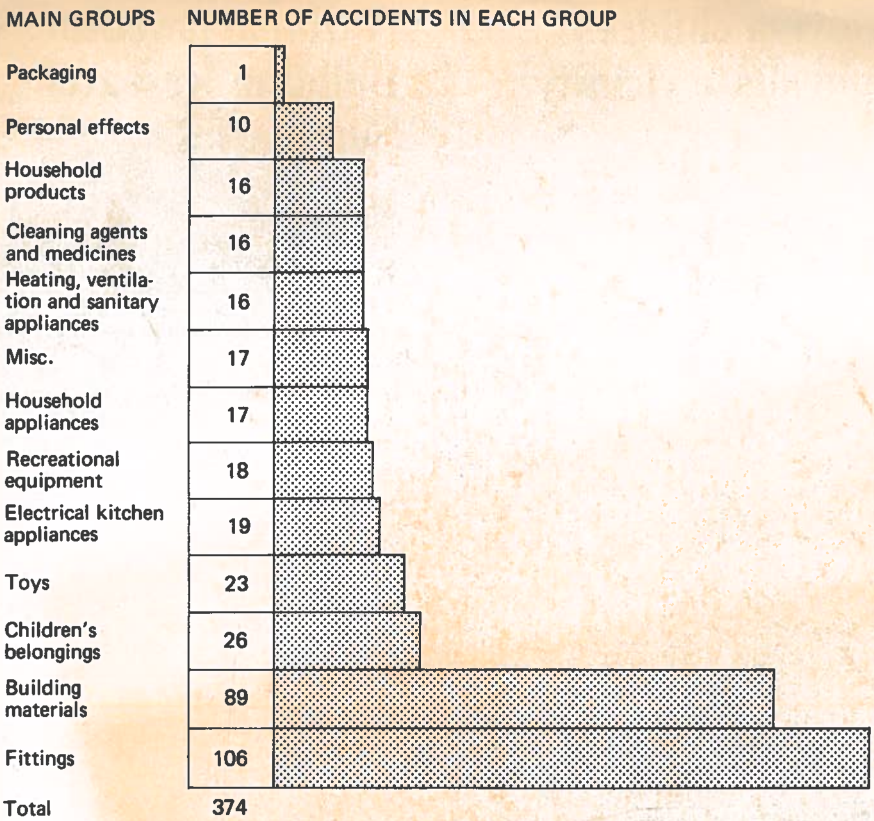

FIG. 1. Main groups of items which caused or contributed to accident risks.

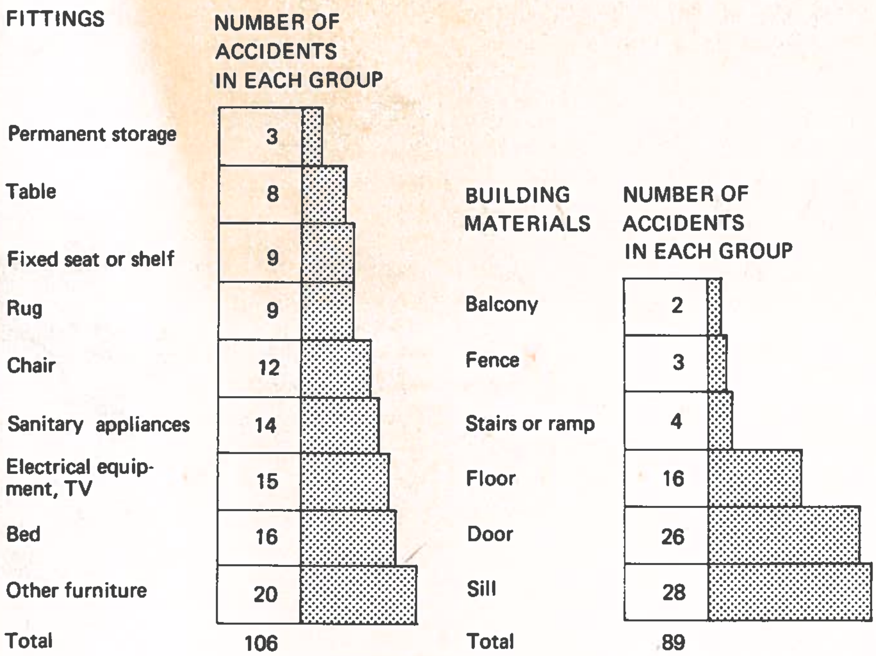

FIG. 2. Sub-division of the groups "Fitting" and "Building materials" to indicate the objects which caused or contributed to accident risks.

UTGIVARE: STATENS INSTITUT FÖR BYGGNADSFORSKNING

Rotobeckman Stockholm 1973

Act of December 7. 1956
respecting the Protection of Workers with amendments, latest of December 15. 1972, and with the addition of an amendment of June 16. 1972, which will come into effect later.

Annex

The Act of December 7. 1956 respecting the protection of workers, as last amended by the Act of Descember 15. 1972[1])

Chapter 1. SCOPE OF ACT; REGISTRATION OF ESTABLISHMENTS

§ 1:

§ 1. *Establishments covered by Act.*

(1) Save as otherwise expressly provided hereinafter, this Act shall apply to every establishment which employs workers or which uses mechanical power of 1 horsepower or more.

The following shall be exempt from the operation of the Act:

(a) maritime navigation, whaling, sealing, etc., and fishing, including the treatment of the catch on board ships;

(b) air navigation;

(c) agriculture and other activities to which the Act respecting the conditions of employment of agricultural workers is applicable.

The Crown shall decide whether and to what extent government service shall be exempt from the operation of this Act on account of general or public interests.[2]) The Crown* shall also decide to what extent an undertaking operated by a public authority shall be deemed to be a government service.

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[1]) Se pages 39–42 with the act of June 16. 1972 no. 58, which will come into effect later, and which amends the sections 54, 54 a, 55, 55 a, 60, 63, 70, 71.

[2]) cf. Royal Decree of December 19. 1958.

*) The Royal Ministry of Local Government and Labour (Decision of November 4. 1961).

(2) The Crown may direct that machinery and other technical installations and plant shall be subject to inspection in accordance with this Act, even where they are not used in an establishment covered by this Act. The same shall apply in the case of work that is not covered by this Act, if it is carried on in conditions involving particular danger to life or health.

§ 2:

§ 2. *Definition of "employee".*

In this Act the term "employee" means any person who performs work outside his own home in the service of another.

If an establishment is operated by a number of persons jointly on their own account, only one of such persons shall be deemed to be the employer for the purposes of this Act, and the other persons shall be deemed to be employees. The inspectorate shall be notified immediately of the name of the person who is to be considered the employer.

§ 3:

§ 3. *Compulsory registration of establishments.*

Every establishment covered by this Act shall be registered in writing with the Labour Inspectorate (cf. Chapter VII), if it has not been registered with the Labour Inspectorate previously in accordance with section 3 of the former Act respecting the protection of workers of 19 June 1936.

If the establishment is in operation at the date of commencement of this Act, it shall be registered within fourteen days of the said date. If is it put into operation at a later date, registration shall take place at least fourteen days before operations commence.

Registration shall also take place when an establishment intends to start using a new permanent workplace, whether in connection with removal or otherwice. Registration shall take place at least fourteen days before such workplace is put into use.

If the construction plans for the establishment are submitted to the Labour Inspectorate in accordance with the first paragraph of section 16, registration may be postponed up to a maximum of fourteen days after the establishment is put into operation or the new workplace is put into use.

When registration takes place, particulars shall be given of the nature and situation of the establishment, the nature and size of the motive power, and the number of employees.

Unless the Department* directs otherwise, establishments to which the provisions of Chapter III do not apply shall be exempt from compulsory registration.

*) The Royal Ministry of Local Government and Labour.

§ 4:

§ 4. *(Repealed by Act No. 2 of May 10. 1968.)*

Chapter 2. MEASURES FOR ENSURING HEALTHY AND SAFE WORKING CONDITIONS

§ 5:

§ 5. *Protection against accidents and injury to health.*

The employer shall ensure that the establishment is so installed and maintained and that the work is so arranged and carried out that the employees are protected against danger to life and health as effectively and as suitably as the circumstances permit.

The employer shall pay particular attention to the following:

(1) When employees are engaged, regard shall be had to their age, their skill and other qualifications affecting their ability to carry out the work in a safe and proper manner. The employer shall ensure that employees are informed of the dangers involved in the work and that they receive such guidance and practice as are necessary to avoid such dangers.

(2) In the workrooms there shall be good lighting, sufficient air space and proper ventilation. The air shall as far as possible be suitably warm and humid, and free from dust, unpleasant odours, smoke, gas and steam. The workplace shall be kept clean and tidy and have the necessary open and safe passageways. Noise and vibration shall be suppressed as far as possible and the work shall be arranged in such manner that it is not unnecessarily tiring.

(3) Power generators, transmission gear, working machinery, lifting appliances, means of transport and other mechanical installations shall be fitted with the necessary safety devices and shall in other respects be properly constructed, installed, maintained and supervised.

(4) The necessary precautions shall be taken to ensure as possible that employees are protected from injury caused by falls, falling objects or slides, the handling of objects, electricity, radiations or dazzling lights, or by explosive, inflammable, hot, corrosive poisonous or other injurious substances. Where poisonous or other injurious substances are manufactured, packed or utilised in a manner that may involve a danger to health, the containers and packings used for such substances shall be clearly marked with the name of the substance and a suitable warning. As far as possible such dangerous substances shall be replaced by less dangerous substances.

(5) Adequate personal protective equipment shall, where necessary, be provided for the employees, of this may reasonably be expected and no other precautions can be taken to ensure adequate protec-

tion against accidents or injury to health. It shall be the duty of every employee to use and take good care of such equipment.

(6) At or near the workplace there shall be safe and wholesome drinking water, water for washing, facilities for washing and drying and an adequate number of lavatories. Where necessary there shall be a heated dining room and a suitable room for changing, storing and drying clothes. Where the nature and size of the establishment render it desirable, the employees shall be given facilities for having baths.

Housing accommodation provided by the employer for his employees shall be properly constructed, equipped and maintained. The employees shall take good care of such accommodation.

(7) The necessary measures, adapted to the size and situation of the workplace, the nature of the work and the conditions in which it is carried out, shall be taken to enable first aid to be given in the event of accidents or illness.

The employer shall ensure order and good conduct in the establishment.

§ 6:

§ 6. *Workplaces with two or more employers.*

Where employees in the service of different employers are employed at the same workplace–

(a) each employer shall ensure that his own sector of activity is so arranged and that the work of his own employees is so organised and carried out that the other employees are also protected in accordance with section 5;

(b) each employer shall, if necessary for the protection of his own employees, assist the other employers in taking the necessary safety measures in accordance with clause *(a)*.

§ 7:

§ 7. *Co-operation of employees in giving effect to protective measures, etc.*

The employees themselves shall co-operate in giving effect to the measures taken for the purpose of protecting them against accidents and injury to health. They shall comply with the instructions of the employer and the inspectorate, use the prescribed protective appliances, take due care and in every other way co-operate in preventing injury to life and health.

The employees shall observe order and good conduct in the establishment.

§ 8:

§ 8. *Medical supervision.*

Where necessary to the life and health of the employees the employees the Directorate of Labour Inspection shall have power to

order that a medical practitioner be attached to an establishment in accordance with approved rules or that medical supervision be exercised in some other approved manner.

§ 9:

§ 9. *Co-operation in hygiene and safety matters.*

In order to ensure healthy and safe working conditions at the workplace the employer shall organise systematic hygiene and safety measures and carry out such measures in co-operation with the employees. The employer may delegate the organisation of hygiene and safety measures to a deputy. In hygiene and safety matters he shall co-operate with the hygiene and safety delegates chosen by the employees from among themselves.

The employer shall at all times keep the inspectorate informed of the names of the persons appointed or chosen as hygiene and safety delegates (cf. sections 10 and 11).

§ 10:

§ 10. *Hygiene and safety delegates.*

At workplaces where there are few employees one of the union representatives elected by the employees shall be the hygiene and safety delegate. At workplaces where more than twenty persons are employed the employees shall elect one or more hygiene and safety delegates from among themselves. In building and civil engineering undertakings the hygiene and safety delegates shall be chosen from among the elected union representatives. The name of every hygiene and safety delegate elected shall be communicated to the employer and shall be made known to the employees by means of notices posted in the establishment.

Where necessary the Directorate of Labour Inspection shall lay down detailed rules governing the election and term of office of hygiene and safety delegates.

Hygiene and safety delegates shall work for the promotion of healthy and safe working conditions. If a hygiene and safety delegate discovers irregularities or deficiencies in the hygiene and safety measures taken by the establishment or considers that new hygiene and safety measures should be taken, he shall notify the employer. It shall be the duty of the employer to reply to the hygiene and safety delegate. If no action is taken on the notification within a reasonable time, the hygiene and safety delegate shall inform the inspectorate.

Hygiene and safety delegates shall acquaint themselves with the hygiene and safety rules in force and the instructions, orders and recommendations made by the inspectorate, and shall co-operate in ensuring that they are put into effect.

Hygiene and safety delegates shall be protected in accordance with section 43 against unwarranted dismissal, irrespective of their age or length of service.

§ 11:

§ 11. *Hygiene and safety committee.*

At workplaces where 100 or more persons are regularly employed there shall be a hygiene and safety committee composed of representatives of the employer and the hygiene and safety delegates. Where desirable a hygiene and safety committee shall also be set up at workplaces where there are fewer than 100 employees. The committee shall meet regularly to discuss hygiene and safety measures.

The hygiene and safety committee shall work for the promotion of healthy and safe working conditions. In the discharge of its duties it shall aim at ensuring–

(a) that newly engaged employees are instructed in the dangers inherent in their work and in the manner of avoiding such dangers;

(b) that conditions which may involve danger to life or health are rectified;

(c) that the causes of accidents and occupational diseases are traced and that an opinion is formed as to how these may be prevented;

(d) that training is given in the prevention of accidents and injuries to health.

The provisions of the fourth paragraph of section 10 shall apply, *mutatis mutandis,* to members of hygiene and safety committees who are not hygiene and safety delegates.

§ 12:

§ 12. *Boilers, tanks and pipes.*

(1) Boilers, tanks and pipes that are under steam pressure shall be properly manufactured, equipped, installed and maintained. They shall not be brought into use until the inspectorate has given permission. They shall be registered, tested and inspected in the manner prescribed by the Crown.

The owner shall be bound to make the preparations prescribed for such tests in the regulations and shall give such other assistance as may be necessary.

The inspectorate may require that the person in charge of a boiler be in possession of at certificate approved by the inspectorate to the effect that he has the necessary skill. The Crown* may direct that the person in charge of a boiler shall have the qualifications to be prescribed in detail by the Crown.

(2) The Crown may lay down rules respecting the public inspection of tanks and pipes under pressure other than those mentioned in subsection (1).

*) The Royal Ministry of Local Government and Labour.

§ 13:

§ 13. *Special hygiene and safety measures.*

In the case of establishments, parts of establishments or operations that are considered particularly strenuous or particularly dangerous for the lives and health of the employees, the Crown* may order special hygiene and safety measures, *inter alia,* that no establishment may be set up, and no machine or working appliance put into use without permission, or that the hours of work shall be shorter than those prescribed elsewhere in this Act.

If any such order is to apply to an establishment where the employees or the employer belong to a national industrial association, such association shall be given an opportunity to state its opinion.

§ 14:

§ 14. *Testing of substances and materials.*

If the Directorate of Labour Inspection considers that any substance or material produced or used by an establishment in its operations may expose the employees to the danger of accident or injury to health, it may, for the purpose of determining whether such danger is present, require the employer to carry out a test or furnish samples for testing. The cost of such tests shall be defrayed by the employer, unless a fee is charged under clause *(e)* of subsection (2) of section 62.

§ 15:

§ 15. *Obligations of persons manufacturing, transferring or assembling machines or other technical equipment.*

Every person who manufactures a machine, tool or other technical equipment and every person who sells, rents or lends such equipment shall ensure when he delivers it for use or for display with a view to sale or advertisement in Norway that it is fitted with the necessary safety devices and is in other respects properly safeguarded against the danger of causing an accident or injury. He shall also ensure that it is accompanied by the nesessary written instructions for use and supervision.

Any person who undertakes on his own account the assembly of any of the equipment mentioned in the first paragraph shall ensure that it is set up and assembled in a manner satisfying the requirements of this Act respecting safe working conditions.

§ 16:

§ 16.[1]) *Observations of inspectorate on plans for establishments, etc.*

Any person intending to construct a building or undertake building work which is notifiable under the building legislation currently in force and which will be used or is likely to be used for an establishment

[1]) Act of June 18. 1965 no. 7 § 121.

covered by this Act shall submit the building plans to the labour inspectorate before the work begins. Details shall be given of the nature of the establishment and the plans shall indicate the type and location of any machinery and technical equipment.

The right to submit plans to the inspectorate for an opinion on whether their execution is consistent with this Act shall also be enjoyed, in cases not covered by the first paragraph of this section, by any person intending to construct, start operations in or convert an establishment coming or likely to come within the purview of this Ac. The same shall apply to any person intending to bring any new or modified equipment or process into use or to introduce protective measures.

The provisions of the preceding paragraph respecting the right to obtain the opinion of the inspectorate shall apply, where appropriate, to persons who manufacture, transfer or assemble any of the equipment mentioned in section 15.

§17:

§ 17. *Reporting of employment accidents and occupational diseases.*

(1) *Obligation of establishment.* If[1]) an employee sustains an employment accident that causes death or serious injury, the employer shall immediately and with all possible dispatch report the injury to the inspectorate and to the nearest police authority. The employer shall confirm the report in writing.

If[2]) the establishment is not obliged to file reports pursuant to section 18 – 2 of the National Insurance act., less serious employment accidents shall also be reported to the inspectorate in writing as soon as possible and within three days at the latest, if it appears likely that the employee, as a result of the accident, will be incapacitated for work for at least three days.

The provisions of the preceding paragraph respecting employment accidents shall also apply in the case of diseases that the employer knows or should know to be occupational diseases.

(2) *Obligation of medical practitioner.* If[2]) a medical practitioner is attending an employee who is suffering from an occupational disease that is considered equivalent to an occupational injury under section 11 – 4 of the National Insurance Act, he shall report the disease in writing to the inspectorate.

The Department shall issue detailed regulations respecting such matters. It may direct that notification shall also be compulsory in the case of other diseases that may be deemed to be caused by the nature of the work or the conditions obtaining at the workplace.

1) Act of June 13. 1969 no. 33 I.
2) Act of January 29. 1971 no. 29.

Chapter 3. HOURS OF WORK

§ 18:

§ 18. *Work not covered by the provisions respecting hours of work.*

This Chapter shall not apply to–

(1) work of a managerial or supervisory nature. This shall not be deemed to include the work of foremen and others in similar positions who, during the hours of work, accompany the persons they are appointed to direct or supervise;
(2) work of a particularly confidential nature other than that specified in the first sentence og clause (1);
(3) the work of representatives, agents and commercial travellers, in so far as it is carried on outside the permanent workplace of the establishment;
(4) forestry, timber measuring and lumber floating, exclusive of work at permanent sorting booms where the work is performed wholly or partly with machinery;
(5) salvage work and diving operations;
(6) work at theatres and other shows and performances;
(7) educational and training establishments, as regards the educational and training personnel;
(8)[1]) workers covered by the Act respecting hours of work in bakeries.

The Crown* may wholly or partly exempt work in a public administrative service from the provisions of this Chapter, where the special nature of the work renders the application of the said provisions difficult.[2])

§ 19:

§ 19.[3]) *Night work, etc.*

The normal hours of work shall fall between 6 a.m. and 9 p.m.

Work between 9 p.m. and 6 a.m. shall be deemed to be night work and may be performed only in the cases specified in this section and the following section.

The following kinds of work may be performed at night:

(a) work that must be performed at night in order to ensure the normal working of the establishment, such as the lighting, heating, cleaning, maintenance and repair of workrooms, machinery and other work appliances, stocktaking and the making up of accounts. Where serious reasons so warrant, such work may also be carried out at night for the purpose of ensuring the regular working of another establishment;

1) Act of June 18. 1965 no. 8 § 16.
*) The Royal Ministry of Local Government and Labour.
2) Cf. Royal decree of December 19. 1958.
3) Act of November 28. 1958 no. 1.

(b) work necessary to prevent damage to plant, machinery, raw materials or manufactured goods;
(c) the work of watchmen and caretakers, and the care of animals;
(d) work in shops;
(e) transport operations and the necessary loading, unloading and storage connected therewith, the despatch of mail, telegrams and telephone calls. Work that must be performed at night to ensure the operation of means of transport or satisfy the needs of passengers shall be placed on the same footing as transport operations;
(f) building and civil engineering work;
(g) work organised in two day-shifts falling between 6 a.m. and midnight;
(h) work in hospitals and nursing homes and work in residential establishments attached to educational and training establishments;
(i) work in hotels and catering establishments, where it is necessary for the serving of patrons;
(j) work which by reason of its nature or character cannot be interrupted.

Any trade union enjoying the right of nomination prescribed in subsection (1) of section 11 of the Act of 5 May 1927 respecting labour disputes may conclude a collective agreement specifying that certain work shall be done at night, even if it is not suh as to be included among the exemptions mentioned under clauses *(a)* to *(j)* of the preceding paragraph. A collective agreement may also provide for a scheme of shiftworking or contain other provisions for dividing the hours of work. With the Department's permission an employer may, in any establishment to which such an agreement applies, extend its provisions as to night work and the division of hours of work to employees not covered by the agreement.

§ 20:

§ 20.[1]) *Special permission or agreement relating to night work.*

The Directorate of Labour Inspection may, subject to specified conditions, grant permission for night work to be carried out in an establishment or part of an establishment–

(a) where there is pressure of work at regularly recurring times of the year;
(b) where unexpected or exceptional pressure of work has arisen;
(c) where acts of God, accidents or other unpredictable occurrences have upset or threaten to upset the normal ourse of operations; or
(d) where general considerations so warrant or night work is deemed to be necessary for special economic reasons.

[1]) Act of May 10 1968 no. 2.

Before permission is granted, the employees shall be allowed to state their opinion through their union representatives. Reasons for the opinion shall be given.

Permission shall not be necessary for the first four days if it is imperative that night work should commence immediately and if application is made to the inspectorate without delay.

In the case of an establishment bound by a collective agreement the employer may conclude an agreement in writing with the employees' union representatives for night work to be done for not more than two successive weeks, and in any event for not more than three months in all in any calendar year, if such work is necessary for any of the reasons given in clauses *(a)* to *(d)* of the first paragraph. If the agreement is binding on the majority of the employees, the employer may extend its application to all persons employed in the establishment on similar activities to those covered by the agreement.

Notice of an agreement reached under the fourth paragraph of this section shall as far as possible be given to the district inspectorate before the night work is introduced and otherwise without undue delay.

§ 21:

§ 21. *Work on Sundays and public holidays, etc.*

(1) Work shall be suspended from 6 p.m. on Saturdays and the eves of public holidays until 10 p.m. on the day preceding the next working day. Work shall be suspended from 3 p.m. on the eves of Christmas, Easter Sunday and Whit Sunday until 10 p.m. on the day preceding the next working day.

The following kinds of work may be performed on Sundays and public holodays:

(a) work that must be performed on Sundays and public holidays in order to ensure the normal working of the establishment, such as the lighting, heating, cleaning, maintenance and repair of workrooms, machinery and other working appliances, stocktaking and the making up of accounts. Where serious reasons so warrant, such work may also be carried out on Sundays and public holidays for the purpose of ensuring the normal working of another establishment;
(b) work necessary to prevent damage to plant, machinery, raw materials or manufactured goods;
(c) the work of watchmen and caretakers, and the care of animals;
(d) work in shops;
(e) transport operations and the necessary loading, unloading and storage work connected therewith, and the despatch of mail, telegrams and telephone calls. Work that must be performed on Sundays and public holidays to ensure the operation of means of transport or satisfy the needs of passengers shall be placed on the same footing as transport operations;

(f) work in hospitals and nursing homes and work in residential establishments attached to educational and training establishments;
(g) work in hotels and catering establishments, where it is necessary for the serving of patrons;
(h) work which by reason of its nature or character cannot be interrupted.

(2) An employee who has performed work on a Sunday or public holiday under clauses *(a)* to *(f)* of subsection (1) shall be released from work on the following Sunday or public holiday in accordance with the provisions of the first paragraph of subsection (1). The Directorate of Labour Inspection may authorise exeptions from this provision in urgent cases.

(3) Employees performing work covered by clause *(g)* of subsection (1) shall, as far as possible, be granted the weekly day of rest (cf. subsection (3) of section 28) on a Sunday or public holiday every second week. At least every fourth week the weekly day of rest shall fall upon a Sunday or public holiday.

In hotels and catering establishments which by reason of their situation find it particularly difficult to provide accommodation for their employees the Directorate of Labour Inspection may authorise exceptions from this provision, so, however, that the weekly day of rest is granted on a Sunday or public holiday at least once every six weeks.

(4) In the case of the work mentioned in clause *(h)* of subsection (1) there shall be a weekly change of shifts in accordance with a shift schedule. The provisions of the second and third paragraphs of subsection (3) of section 23 shall apply, *mutatis mutandis,* to the schedule.

The change of shifts shall be effected in a manner ensuring that as far as possible the employees obtain the Sunday and public holiday rest prescribed in the first sentence of subsection (2) and have at least every third Sunday off on average over the shift period.

§ 22:

§ 22.[1]) *Special permission for work on Sundays and public holidays.*

(1) If public or general interests or other important considerations render it imperative, the Directorate of Labour Inspection may grant permission for work to be performed on a Sunday or public holiday to the extent necessary in the circumstances.

A permit for Sunday or holiday work shall not cover the hours between 3 p.m. on the eves of Christmas, Easter Sunday or Whit Sunday and 10 p.m. on the day preceding the next working day, or the hours between 6 p.m. on Wednesday in Holy Week and 10 p.m. on Good Friday, unless this is expressly stated in the permit.

(2) Work which, by reason of its nature or in virtue of an exemption order, is performed on a 24-hour basis, but not on every day of the

[1]) Act of May 10 1968 no. 2.

week, and work organised in two day-shifts under clause *(g)* of section 19 may, with the permission of the Directorate of Labour Inspection, be continued until 10 p.m. on a Saturday or the eve of a public holiday.

(3) Before an exemption is granted under subsection (1) or (2), the employees shall be allowed to state their opinion through their union representatives. Reasons for the opinion shall be given.

§ 23:

3 23.[1]) *Normal hours of work.*

(1)[2]) The normal hours of work of an employee shall not exceed nine a day or 42½ a week.

Hours of work shall normally be spread over six days a week, without prejudice, however, to any agreements that may be made with the object of distributing the hours over a shorter period.

The normal hours of work may be fixed by means of a written agreement at a maximum of 42½ a week on the average in the course of a given year, so, however, that no single week exceeds fifty-one hours. The agreement shall stipulate in which weeks during the year the normal hours of work will be either more or less than 42½. When an agreement is made with a trade union or with the employees' union representatives and the majority of the employees are bound by it, the employer may extend its application to all persons employed in the establishment on similar activities to those covered by the agreement.

(2)[2]) In the case of work done for the purpose of serving patrons by employees remunerated on a percentage basis in hotels and restaurants and in the case of staff employed in railway dining cars the normal hours of work may be distributed otherwise than as prescribed in subsection (1), on condition that they have been fixed by written agreement and that the timetable is displayed in the workplace, as provided in section 52: Provided that such hours shall not exceed 42½ a week on average over the period stipulated in the contract of employment, or one year in any circumstances.

Timetables shall be prepared by agreement between the employer and the employees or their representatives. Where the parties cannot reach agreement, the timetable shall be fixed by the Directorate of Labour Inspection in accordance with the provisions of this Act, after consultation with the parties.

The provisions mentioned in the last sentence of the third paragraph of subsection (1) shall apply, *mutatis mutandis.*

(3)[3]) In the case of work carried out at night under clause *(j)* of section 19 and in the case of work carried out both at night under the said clause and on Sundays and public holidays under clause *(h)* of subsection (1) of section 21, the normal hours of work specified in the

[1]) Act of November 28. 1958 no. 1.
[2]) Act of May 10. 1968 no. 2.
[3]) Act of May 5. 1972 no. 23.

shift schedule shall not exceed 40 a week on average calculated over the shift period.

In the case of work carried out both at night under clause *(j)* of section 19 and on Sundays and public holidays under clause *(h)* of subsection (1) of section 21, the shift schedule shall either be approved by the Directorate of Labour Inspection or be drawn up in accordance with the provisions of the third paragraph of this subsection. When deciding whether to approve the shift schedule, the Directorate shall have special regard for the wishes of the majority of the employees.

In the case of an establishment bound by collective agreement the employer may conclude an agreement in writing with the employees' union representatives on the use of a shift schedule approved by the parties to the collective agreement. The agreement may provide for different schedules to be used over the year, so that the normal hours of work may exceed 40 a week on average over a given shift period, on condition that they are proportionately less over other shift periods. If the agreement mentioned in this subsection is binding o n the majority of the employees, the employer may extend its application to all persons employed in the establishment on similar activities to those covered by the agreement.

(4) The normal hours of work of persons employed underground in mines shall not exceed forty a week on an average calculated over a period of three weeks. Agreements may be made to cover a longer period, on condition that they are approved by the inspectorate. Winding time shall be included in the hours of work. The provisions mentioned in the last sentence of the third paragraph of subsection (1) shall be applicable, *mutatis mutandis.*

The provisions of the first paragraph of subsection (1) of section 21 respecting shorter hours of work on Saturdays and the eves of public holidays shall not apply to a week in which there are one or more holidays other that Sunday: Provided that work shall cease not later than 3 p.m. on the eves of Christmas, Easter Sunday and Whit Sunday.

(5)[1]) The normal hours of work in the driving of mountain tunnels and the blasting of galleries underground shall not exceed nine a day or forty a week.

Provision may be made by written agreement for the normal hours of work to be so distributed that over a period not exceeding one year the represent an average of forty a week, but not more than forty-five in any given week. The agreement shall specify the times of year at which the longer or shorter hours of work than forty are to fall. The provisions of the last sentence of the third paragraph of subsection (1) shall apply, *mutatis mutandis.*

The provisions of the first and second paragraphs of this subsection shall not apply to the construction of tunnels whose total length from

[1]) Act of April 13. 1962 no. 3.

mouth to mouth does not exceed 50 metres or to galleries not more than 25 metres deep, measured from the entrance.

(6)[1]) Any trade union enjoying the right of nomination prescribed in subsection (1) of section 11 of the Act of 5 May 1927 respecting labour disputes may conclude a collective agreement governing the distribution of the normal hours of work, notwithstanding the limits provided for in subsections (1) to (5) of this section. The conclusion of such an agreement shall require the consent of the parties. With the Department's permission an employer may, in any establishment to which such agreement applies, extend its provisions as to hours of work to employees not covered by the agreement.

§ 24:

§ 24.[2]) *Hours of work in special circumstances.*

(1)[1]) If the nature of the establishment or work requires an irregular distribution of the hours of work, the normal hours of work of all or certain categories of the persons employed in the establishment may, with the permission of the Directorate of Labour Inspection, be so arranged that they average 42½ a week over a period not exceeding six weeks. Before the Directorate takes a decision in such cases, the employees concerned or their organisations shall be allowed to state their opinion.

(2)[1]) If in any occupation or establishment a considerable pressure of work occurs at regularly recurring periods because of the season, the climate or other circumstances, the normal hours of work for such occupation or establishment may, with the permission of the Diretorate of Labour Inspection, be so arranged as to average 42½ a week over a period not exceeding one year, so, however, that the normal hours of work do not at any time exceed ten a day and fifty-four a week. Before the Directorate takes a decision in such cases, the employees concerned or their organisations shall be allowed to state their opinion.

(3) In the case of government offices and the construction, operation and maintenance of means of communication operated by the State, including postal, telegraph and telephone services, the Crown* may prescribe an arrangement of the hours of work of the kind specified in subsections (1) and (2), after the organisations of the public employees concerned have been given an opportunity to negotiate with respect to the arrangement in question.

(4) If the normal working of an establishment cannot be ensured unless certain employees begin their work before or finish their work after the other employees, the normal hours of work of such empløyees may be increased by a maximum of two a day.

Customers may continue to be served up to half an hour beyond the hours of work permitted under subsection (1) of section 23.

[1]) Act of May 10. 1968 nr. 2.
[2]) Act of November 28. 1958 no. 1.
*) The Royal Ministry of Local Government and Labour.

(5) If, by reason of the nature of the establishment or the work done, the work of certain employees or categories of employees is interrupted by periods during which little or no work is done, but it is impossible for the employees in question to leave the workplace, the normal hours of work of such employees may be increased by a maximum of two a day.

The Directorate of Labour Inspection may allow the normal hours of work to be extended on a given day beyond the figure given in the preceding paragraph, on condition that the work is properly organised. Before the Directorate takes a decision in such cases, the employees concerned or their organisations shall be allowed to state their opinion.

(6)[1] In the case of qualified pharmacists in dispendaries and in other cases where the employee's duties consist wholly or in part in remaining in the establishment and being available for work if necessary, but where the employee is not required to work or be on the alert except during short or occasional interruptions, the Directorate of Labour Inspection may authorise exceptions from the provisions respecting the normal hours of work.

§ 25:

§ 25. *Overtime.*

(1) If any employee is employed beyond the time fixed for his normal hours of work under sections 23 and 24 (cf. sections 13 and 29), the work done outside the normal hours of work shall be treated as overtime.

Overtime shall not be worked except in the following special cases:

(a) where an unforeseen occurrence or the absence of one or more employees has interrupted or threatens to interrupt the normal working of the establishment;

(b) where overtime is necessary to prevent damage to plant, machinery, raw materials or manufactured goods;

(c) where there is unexpected or exceptional pressure of work;

(d) where overtime is warranted by public or general interests or other considerations: Provided that the employer must obtain the inspectorate's permission if overtime is introduced for such reasons and continues for more than one day;

(e) in state transport undertakings, including the Post Office and the Telegraph Office, if the higher authority considers overtime necessary on account of conditions in the undertaking. The working of overtime in such cases shall be governed by the rules issued from time to time by the state authorities.

(2) Before introducing overtime the establishment shall as a rule discuss the need for such action with the employees' union representatives.

[1]) Act of May 10. 1968 no. 2.

(3) Employees who work overtime shall be paid a supplement in addition to the wage agreed upon for corresponding work performed by them during their normal hours of work. Such supplement shall be not less than 25 per cent.

The supplement payable in the case of piece work shall, in the absence of a special agreement, be calculated on the basis of the weekly, monthly or hourly wage fixed for the employee in question.

§ 26:

§ 26.[1]) *Duration of overtime.*

(1) Overtime may be worked for a maximum of twenty hours in any two consecutive weeks and shall as far as possible be evenly distributed over two or more working days.

(2) In the case of an establishment bound by a collective agreement the employer and the employees' union representatives may conclude an agreement in writing in particular circumstances providing for overtime to be worked for a maximum of thirty hours in any two consecutive weeks. If the agreement is binding on the majority of the employees, the employer may extend its application to all persons employed in the establishment on similar activities to those covered by the agreement.

(3) In particular circumstances or for a period not exceeding six months at a time the inspectorate may permit individual employees to work overtime up to a maximum of thirty hours in any two consecutive weeks.

(4) The overtime worked by an individual employee shall in no case exceed 250 hours in any calendar year.

(5) In the case of establishments that require longer hours of work at particular periods of the year on account of the nature of the goods produced or for other reasons the Directorate of Labour Inspection may lay down other rules for overtime than those contained in subsections (1), (3) and (4). The employees shall be given an opportunity to state their opinion through their union representatives before effect is given to such rules. Reasons for the opinion shall be given.

§ 27:

§ 27. *Wage lists.*

Wage lists shall be kept in such a manner as to indicate the amount of overtime worked by each individual employee. They shall be available for examination by the inspectorate.

The management of the establishment shall allow employees' union representatives to inspect the overtime kists, if they so reuqest.

[1]) Act of May 10. 1968 no. 2.

§ 28:

§ 28. *Rest breaks and weekly rest period.*

(1) Where the normal hours of work exceed five-and-a-half a day, there shall be at least one rest break during working time. The employer and the employees or their union representatives shall fix the rest break by agreement, so, however, that the rest break or aggregate of rest breaks shall amount to at least half an hour if the hours of work exceed eight a day. If the parties fail to reach agreement, the matter shall be decided by the inspectorate. The inspectorate may order an arrangement other than that agreed to where this is necessary to protect the health of the employees.

During rest breaks the employees shall not remain in the workrooms without the permission of the inspectorate, unless work in the rooms has completely stopped. The employees shall not be permitted to work during rest breaks, but the time of the rest break may be varied where the circumstances make it necessary to do so.

(2) In the case of 24-hour shift work and contunuous shift work, and whenever the nature of the operations renders it necessary, the employer may, in lieu of granting a rest break within the meaning of subsection (1), allow the employees to take their meals during breaks granted while the work is in progress, the employees being required in such cases to remain at the workplace the whole time, if necessary. Where the employer puts such an arrangement into operation, the rest break shall be included in the hours of work.

Questions as to whether the employer is entitled to avail himself of the provisions of subsection (2) shall be decided by the Directorate of Labour Inspection.

The inspectorate may permit arrangements for the granting of rest breaks different from those prescribed in subsections (1) and (2).

(3) The normal hours of work of every employee shall be so distributed as to ensure that he has an uninterrupted rest period of at least twenty-four hours each week. As far as possible the rest period shall coincide fith a Sunday or public holiday and shall be granted at the same time for all the persons employed in the establishment.

In[1]) the case of work carried out under an approved shift schedule in accordance with subsection (4) of section 21 and in other special cases the Directorate of Labour Inspection may prescribe a different distribution of the weekly rest period, so, however, that the employees receive a continuous rest period averaging not less than twenty-four hours a week during the shift period or some other specified period.

The Directorate of Labour Inspection[1]) may also authorise other exceptions from the foregoing provisions where it is disproportionately difficult to ensure reliefs or the amount of work required by the service is insignificant.

[1]) Act of May 10. 1968 no. 2.

§ 29:

§ 29.[1]) *Exemptions from provisions respecting normal hours of work.*

Work that is necessary to prevent danger or damage to life or property resulting from acts of God, accidents or other unforeseen occurrences may be carried out at any time of the day notwithstanding the provisions of the first paragraph of section 19 and the first paragraph of subsection (1) of section 21. Such work may also be carried out during rest breaks notwithstanding the provisions of the second paragraph of subsection (1) of section 28. The limitations prescribed in subsections (1) to (4) of section 23 and subsection (3) of section 28 shall not apply during the first four days.

§ 30:

§ 30. *Definition of "day" and "week".*

In this Act the word "day" means the time between midnight on two successive days, and the word "week" means the time between midnight on two successive Saturdays.

The day and the week may be deemed to begin at other hours under a collective agreement or in virtue of any other arrangement that cannot be altered unilaterally by either of the parties to an employment relationship.

Chapter 4. SPECIAL PROVISIONS RESPECTING THE EMPLOYMENT OF WOMEN

§ 31:

§ 31. *Maternity protection.*

(1) A woman shall be entitled to leave of absence for the first six weeks following the birth of a child. She may claim leave of absence for a further period of not more than six weeks, which may be taken wholly or in part before or after her confinement. The employer shall have the right to demand that the presumed date of her confinement be certified by a medical practitioner or midwife. He shall be given at least three days' notice of a woman's absence from work before confinement. If the woman is able to prove by means of a medical certificate that she is suffering from a disease caused by pregnancy or confinement, she shall be entitled to claim leave of absence for an additional period of not more than six weeks before or after her confinement.

(2) A woman who is absent from work in virtue of the provisions of subsection (1) shall not be dismissed if the employer is aware that her absence is due to this reason, or if she informs him without delay that she is absent for this reason. If she has already been given notice of dismissal to terminate on a date within the period mentioned in sub-

[1]) Act of November 28. 1958 no. 1.

section (1), the dismissal shall be valid but the period of notice shall be extended by the length of the said period.

The provisions of this subsection shall not apply to a contract of employment for a specific job of a temporary nature if the job has been completed before the woman again reports for work.

(3) Any woman who becomes indigent during absence from work under subsection (1) shall be entitled to claim public assistance in accordance with the legislation is force at the time.

(4) A woman who breast-feeds her child shall be entitled to claim the time off necessary for this purpose, which shall amount to at least half an hour twice a day.

Chapter 5. SPECIAL PROVISIONS RESPECTING CHILDREN AND OUNG WORKERS

§ 32:

§ 32.[1]) *Definition of "child" and "young person".*

In this Act–

(1) the word "child' means a person under 15 years of age;

(2) the expression "young person" means a person between 15 and 18 years of age.

§ 33:

§ 33. *Employment of children.*

No child shall be employed in an establishment to which the provisions of Chapter 3 are applicable: Provided that children over 12 years of age may be ecployed to dry peat and to dry fish in the open air and to deliver goods, sell newspapers and serve as messengers, in so far as such work is not prejudicial to their health, school attendance and morals, and subject to such other conditions as may be prescribed by the Department.

The Department shall have power to decide whether and subject to what conditions children may be employed in work not covered by Chapter 3 (cf. section 18).

§ 34:

§ 34. *Employment of young persons.*

Young persons shall not be employed to mind steam boilers or machines the operation of which demands particular caution.

Young persons shall not be employed underground in mines or quarries.

[1]) Act of May 10. 1968 no. 2.

No[1]) child or young person who is attending school shall be employed unless he or she has at least four weeks' holidays a year, of which at least two weeks must be in the summer holidays.

In the case of establishments or operations that are deemed particularly strenuous or dangerous to the lives and health of young persons, or where it is necessary for other reasons, the Crown* shall have power to order that special hygiene and safety measures be taken (cf. section 13), *inter alia,* that a young person's total hours of work and school attendance (where he is attending an evening technical or trade school) do not exceed a specified number in any one day or that the employment of young persons be absolutely prohibited.

§ 35:

§ 35. *Medical examination of children and young employees.*

No child or young person under 16 years of age shall be employed in any establishment to which this Act applies unless it is established by a medical examination conducted prior to his engagement that there is no medical reason why he should not enter employment.

Children and young persons under 16 yrars of age who are in employment shall be medically examined at regular intervals and not less than once a year until their sixteenth birthday.

If the work or the establishment is particularly strenuous or dangerous to the lives and health of young workers, the provisions of the first and second paragraphs shall apply, *mutatis mutandis,* to persons who are over 16 years of age but have not yet attained the age of 19 years.

The Directorate of Labour Inspection shall prescribe detailed rules for the carrying out of such medical examinations.

The Crown shall have power to direct that the age-limit prescribed in the first and second paragraphs shall be raised from 16 to 1 8years and that the age-limit prescribed in the third paragraph shall be raised from 19 to 21 years.

The Crown shall issue rules respecting the manner in which the expenses relating to the medical examinations shall be defrayed, so, however, that neither the children and young workers who are examined nor their partents or guardians shall be required to defray any part thereof.

§ 36:

§ 36. *Employment of young persons at night.*

(1) In industrial establishments, transport operations, civil engineering and building operations the hours of work of young persons shall be so arranged that every young worker has at least twelve consecutive hours off between any two spells of work.

[1]) Act of May 10. 1968 no. 2.

*) The Royal Ministry of Local Government and Labour.

In the case of young persons under 16 years of age the rest period mentioned in the first paragraph shall include the hours between 9 p.m. and 6 a.m.

In[1]) the case of young persons over 16 years of age the rest period mentioned in the first paragraph shall be so arranged as to include at least seven consecutive hours between 10 p.m. and 7 a.m.: Provided that it shall be unlawful to employ such young persons after 11 p.m. without the permission of the Directorate of Labour Inspection.

For[1]) purposes of vocational training the Directorate of Labour Inspection may grant permission for a young person over 16 years of age to be employed during the hours at which he should be free in virtue of this subsection, subject to such conditions as are necessary to protect his health and on condition, moreover, that he is guaranteed a rest period of at least thirteen consecutive hours between who spells of work.

Young persons over 16 years of age may, notwithstanding the provisions of the first, second and third paragraphs, be employed between 9 p.m. and 6 a.m. where exceptional occurrences of the kind mentioned in section 29 render it imperative.

(2) The Crown may direct that this section shall also apply to establishments or operations other than those specified in subsection (1).

§ 37:

§ 37. *Employment of young persons on Sundays and public holidays.*

(1) In industrial establishments and in civil engineering and building operations young persons shall not be employed on Sundays or public holidays: Provided that this shall not apply in the case of young persons over 16 years of age where the work to be done is necessary to prevent damage to plant, machinery, raw materials or manufactured goods, or where exceptional occurrences of the kind mentioned in section 29 render it imperative.

Where[1]) it is necessary for the vocational training of a young worker, the Directorate of Labour Inspection may grant permission for a young person over 16 years of age to be employed on Sundays and public holidays, subject to such conditions as are necessary to protect his health.

(2) The Crown may direct that this section shall also apply to establishments other than those specified in subsection (1).

§ 38:

§ 38.[2]) *Hours of work of children and young persons.*

The normal hours of work of children and young persons in employment to which the provisions of Chapter 3 are applicable shall not

[1]) Act of May 10. 1968 no. 2.
[2]) Act of November 28. 1958 no. 1.

exceed those prescribed in the first paragraph of subsection (1) of section 23.

When[1]) the normal hours of work are changed in accordance with the provisions of the second and third sentences of the third paragraph of subsection (1) of section 23 or subsections (1) and (2) of section 24, the normal hours of work of young persons shall not exceed nine a day or forty-eight during any one week without the permission of the Directorate of Labour Inspection, which shall be required in every individual case.

The provisions of subsections (4) to (6) of section 24 respecting the extension of normal hours of work shall not be applicable to young persons: Provided that this limitation may be waived in the case of young persons serving patrons for a maximum of half an hour beyond the permitted hours of work and on condition that the limits fixed in the second paragraph of this section concerning the daily and weekly hours of work are observed.

Children and young persons shall not be employed on overtime.

The hours of work of children and young persons shall be so arranged that they do not prevent attendance at school, in so far as is necessary for their training.

§ 39:

§ 39. *List of children and young persons.*

The Department may direct that employers shall keep a list of the children and young persons whom they employ.

Chapter 6. WAGES, DISMISSAL, EMPLOMENT RULES, ETC

§ 40:

§ 40. *Wages.*

(1) Wages shall be paid in legal tender, unless an agreement has been made for payment by cheque, bank bill or postal transfer account. They shall be paid at or near the workplace during the hours of work or as soon as possible thereafter.

If an hourly, daily or weekly wage has been agreed to, wages shall be paid at least once a week. In the case of piece work the settlement may be postponed until the work is completed, so, however, that a suitable advance shall be paid weekly in respect of the work that has already been performed. Other time limits for settlement may be fixed by agreement.

[1]) Act of May 10. 1968 no. 2.

In the absence of any agreement to the contrary employees remunerated by the month or year shall be paid at least twice a month.

(2) No deductions shall be made from wages otherwise than in pursuance of an agreement in writing, except deductions authorised by law or deductions in respect of pension fund and sick fund contributions prescribed by law or compensation for damage that the employee has caused wilfully or through gross negligence.

(3) Either at the time of payment or immediately thereafter the employee may demand a written statement setting forth the amount of the wages, the method of calculation and any deductions made.

§ 41:

§ 41.[1]) *Period of notice.*

(1) Except as otherwise agreed in writing or provided in a collective agreement or employment rules–

(a) the period of notice for employees who are paid by the hour, day or week or at piece rates and are not covered by subsections (2) or (3) below shall be at least fourteen days;

(b) the period of notice for employees who are paid by the month or year and are not covered by subsection (3) below shall be at least one month and shall expire on the last day of a calendar month.

The provisions of this subsection shall not apply to employees who are expressly engaged for a specified period of probation or for the performance of a specified piece of work of a temporary nature. Except as otherwise following from the employment relationship, the employment may be terminated at one day's notice before the expiry of the period of probation or the completion of said specified piece of work.

(2) Employees who have been employed for four years or more without interruption in the same establishment after attaining the age of 21 years shall be entitled to at least one month's notice to expire on the last day of a calendar month.

(3) Employees who have been employed for ten years or more without interruption in the same establishment shall be entitled to at least two months notice to expire on the last day of a calendar month if the employee has attained 50 years of age, and at least three months' notice if he has attained 60 years, at the time the notice is given.

(4) The period of notice shall be the same for both parties.

§ 42:

§ 42. *Dismissal in event of unforeseeable occurrences.*

(1) If accidents, acts of God or other unforeseeable occurrences cause a total or partial stoppage of operations and the employees are dismissed for that reason, the period of notice for employees engaged on the work that must be stopped may be reduced to seven days reckoned from the date of the occurrence or, in the case of fire,

[1]) Act of June 13. 1969 no. 33 I.

fourteen days reckoned from the date of the fire. Where the period of notice in force at the time is shorter than that prescribed hereinbefore, the latter period shall be observed.

(2) The period of notice shall not be reduced under subsection (1) in the event of the death or bankruptcy of the employer or a stoppage of work that is due, through no fault of the employee, to workrooms, machinery, tools, materials or other equipment that the employer is bound to provide being unfit for use.

§ 43:

§ 43. *Protection against unwarranted dismissal.*

(1) The employer shall be liable to pay compensation if he dismisses an employee who has been employed for two or more years without interruption in the same establishment after attaining the age of 20 years and if dismissal is not warranted by the circumstances of the owner of the establishment, the employee or the establishment.

Subject to the same conditions an employer who has dismissed an employee may, where it appears reasonable and reinstatement is claimed by the employee, be ordered to reinstate him in the establishment either in the same post or a post corresponding to his former post. The court shall decide to what extent the employee shall also be entitled to compensation in respect of the period during which he has been deprived of his work in the establishment.

A notice[1]) of dismissal which is to take effect before the employee attains 70 years of age and which is exclusively due to the employee having attained pensionable age under the National Insurance Act of 17 June 1966, shall not be regarded as warranted. On receiving a written enquiry from the employer, the employee is obliged to declare whether he wishes to continue in his position after attaining said pensionable age. The employee shall give such declaration not later than six months before attaining pensionable age, provided he receives the enquiry a reasonable time in advance. If the employee receives the enquiry later than stated in the preceding sentence, he shall submit the declaration within a reasonable time after having received the enquiry.

The employee[1]) shall not be entitled to claim compensation or reinstatement if he has been dismissed as a result of pressure exerted by the other employees in the establishment or by an organisation and the employer had reason to believe that he would sustain loss or damage if he did not dismiss the employee.

(2) In assessing the compensation payable under the first and second paragraphs of subsection (1) regard shall be had to the employee's loss of earnings, length of service, remuneration, prospects of obtaining new employment in the same or in another occupation, his personal circumstances, and all other circumstances that it is reasonable to take into account. The compensation awarded shall not exceed one-

[1]) Act of December 15. 1972 no. 78 I.

half of the employee's last annual earnings in the establishment: Provided that, if the employee has been employed in the establishment for ten or more years without interruption after attaining the age of 20 years, the compensation awarded may be equal to his last annual earnings in the establishment. If he has been so employed in the establishment for twenty years, the compensation awarded may be equal to hos earnings in the establishment over the last three years.

If dismissal is cancelled, the provisions of the final sentence of the second paragraph of subsection (1) shall apply, *mutatis mutandis*.

(3) Proceedings against the employer must be brought within six weeks of the receipt of a written intimation of dismissal specifying the time allowed for bringing proceedings. If a verbal intimation is given or the intimation does not specify the time allowed for bringing proceedings, the time allowed shall be three months.

§ 44:

§ 44. *Dismissal of sick employee.*

An employee who has been employed for two years or more without interruption in the same establishment after attaining the age of 20 years and who is incapacitated for work by an accident or illness may not be dismissed on such grounds during the first three months of incapacity for work, unless he has incurred the illness wilfully or through gross negligence or fraudulently concealed the fact that he was suffering from the illness when he was engaged.

An employee who wishes to avail himself of the foregoing provisions respecting protection against dismissal shall notify the employer in good time, by means of a medical certificate or in some other manner, that his absence is due to illness. If the establishment so requests, a medical certificate shall be furnished in respect of the entire period of absence due to illness.

Where a person has been employed in the establishment for ten years or more without interruption, the prohibition of dismissal on the ground of incapacity for work shall apply for a consecutive period of one year.

Notwithstanding the foregoing a sick employee may be dismissed with the usual period of notice if, by reason of repeated absence or a reduction of working capacity due to illness, he is so unfit for work in the establishment that dismissal is deemed to be lawful under section 43.

§ 44 (a):

§ 44 (a).[1]) *Work for elderly employees and for employees who are not fully fit for work.*

If an employee has been partially disabled for his vocation as a consequence of accident or of a disease which he has undergone, the employer shall at the request of the employee examine whether the

[1]) Act of December 15. 1972 no. 78 I.

conditions in the establishment are suitable for providing the employee with work for which he is vocationally and medically fit, if necessary after suitable retraining.

When an employee who has attained pensionable age under the National Insurance Act of 17 June 1966 so requests, the employer shall in consultation with the employees' union representatives examine whether the conditions in the establishment are suitable for setting up a work schedule for the employee which is suitable for his age.

§ 45:

§ 45. *Testimonial.*

Every employee who leaves his employment after receiving lawful notice may request a written testimonial from the employer. Such testimonial shall set forth the employee's name, date and year of birth, the nature of the work he has done and the dates on which he entered and left employment.

The foregoing shall not limit the employee's right to request a more detailed testimonial in employment relationships where this is customary and the collective agreement contains no provision to the contrary.

§ 46:

§ 46. *Exceptions.*

The provisions of sections 41 to 45 shall not apply–

(1) in the case of employees who can be dismissed without notice under the statutory provisions in force at the time or under the employment rules;

(2) in the case of persons covered by the Public Servants Act of February 15. 1918 or public officials.

The provisions[1]) of subsection (2) of section 41 and sections 43–45 shall not apply to dismissal under the Act of May 5. 1927 respecting labour disputes, or under the Act of July 18. 1958 respecting public service disputes. In such cases the provisions of subsection (1) of section 41 shall apply to the employees mentione din subsection (2) of section 41.

§ 47:

§ 47. *Employment rules.*

In[2]) industrial and commercial establishments and offices the employer shall, if there are more than ten employees or if, irrespective of the number of employees, the inspectorate thinks fit so to order, draw up employment rules for employees not holding managerial or supervisory posts. The employment rules shall contain the necessary disciplinary provisions, provisions respecting the organisation of the work, the conditions for engagement, the giving of notice of dismissal and dismissal, and provisions respecting the payment of wages.

[1]) Act of June 19. 1969 no. 74 II.
[2]) Act of May 10. 1968 no. 2.

The employment rules shall not prescribe fines for infringements of the rules.

The Department may direct that employment rules shall be drawn up for establishments and employees other than those specified above.

§ 48:

§ 48.[1]) *Preparation of employment rules.*

(1) Where the provisions of subsection (2) do not apply, employment rules shall require the approval of the Directorate of Labour Inspection to be valid. Draft rules shall be prepared by the employer, who shall discuss the provisions of the rules with the employees' representatives. If the establishment is bound by a collective agreement, he shall discuss such provisions with the employees' union representatives. Otherwise all employees over 18 years of age working in the establishment shall elect five representatives over 21 years of age, with whom the employer shall discuss the provisions of the rules.

If the employees' representatives submit different proposals for the rules, such proposals shall be attached when the employer submits the draft for approval. If the employees' representatives fail to discuss the rules, the employer shall mention the fact when he submits the draft for approval.

(2) In the case of an establishment bound by a collective agreement the employer and the employees' union representatives may draw up employment rules by agreement in writing. If the agreement is binding on the majority of the employees, the employer may extend the application of the rules to all persons employed in the branch or branches of activity in the establishment covered by the agreement.

The employer shall send a copy of the rules to the Directorate of Labour Inspection.

§ 49:

§ 49.[1]) *Time limit for submission of employment rules.*

Where an establishment is of such a kind and size that it is required in pursuance of section 47 to have employment rules, the employer shall transmit the draft referred to in subsection (1) of section 48 or the rules drawn up by agreement in terms of subsection (2) of section 48 to the Directorate of Labour Inspection within six weeks after the establishment begins its operations.

If the inspectorate orders an establishment to have employment rules in terms of section 47, the draft referred to in subsection (1) of section 48 or the rules drawn up by agreement in terms of subsection (2) of section 48 shall be submitted within four weeks of the order given by the inspectorate.

[1]) Act of May 10. 1968 no. 2.

§ 50:

§ 50.[1]) *Validity of employment rules.*

To be valid, employment rules must be drawn up in accordance with the law and shall not contain provisions that are contrary to law.

Where the draft mentioned in subsection (1) of section 48 contains provisions that are contrary to law or prejudicial to the employees or where it has not been drawn up in accordance with the law, the Directorate of Labour Inspection shall refuse to approve it.

Where employment rules drawn up by agreement in terms of subsection (2) of section 48 contain provisions that are contrary to law, the Directorate shall draw the parties' attention to the fact and ensure that the provisions are corrected.

§ 51:

§ 51.[1]) *Amendment of employment rules.*

The provisions of sections 48 and 50 shall also apply where employment rules are to be amended or supplemented.

§ 52:

§52. *Posting of notices.*

All rules and provisions issued under this Act that concern a particular establishment shall be posted up in an easily legible form at one or more conspicuous places in the establishment.

The same shall apply as regards the rules respecting hours of work and rest periods in the establishment, any exemptions that are granted, and the employment rules, where employment rules must be drawn up under section 47. A copy of the employment rules shall be issued to every employee to whom they apply.

§ 53:

§ 53. *Invariability of provisions of Act.*

Employees may not give valid consent to departures from the provisions of this Act otherwise than as expressly authorised in the Act.

Chapter 7. LABOUR INSPECTORATE

§ 54:

§ 54.[1]) *Supervision of observance of Act; Labour Inspection Council.*

(1) Supervision of the observance of this Act shall be exercised by the Labour Inspectorate, which shall consist of the State Labour Inspectorate and the commune labour inspectorates. In relation to inflammable substances covered by the Fire Risks Act such supervision shall be exercised by the inspectors referred to in that Act. The Crown shall have power to prescribe how inspection work is to be carried out

[1]) Act of May 10. 1968 no. 2.

in the case of government offices and transport undertakings operated by the State, including the Post Office and the Telegraph Office.

In particular circumstances and special cases the Department may engage experts not belonging to the Labour Inspetorate to carry out inspection work.

(2) The Labour Inspectorate shall be directed by a Council consisting of seven members and their personal substitutes appointed by the Crown for four years. Employees and employers shall each have two representatives on the Council. At least one of the employees' representatives and his personal substitute shall be appointed on the recommendation of the General Confederation of Trade Unions in Norway and at least one of the employers' representatives and his personal substitute on the recommendation of the Norwegian Employers' Confederation.

The Crown shall appoint a chairman and vice-chairman from among the other members. One of these latter members and his personal substitute shall have legal training.

The chairman may co-opt experts to advise in the consideration of particular matters.

(3) The members of the Council and any experts who have been co-opted or engaged shall be entitled to travelling and maintenance allowances in accordance with the regulations applicable to public servants. They shall also be entitled to such emoluments as may be prescribed.

§ 54 a:

§ 54 a.[1]) *State Labour Inspectorate.*

The State Labour Inspectorate shall consist of the Directorate of Labour Inspection and the district inspectorates.

The Crown shall appoint the Director and such other officials as are remunerated in accordance with the scale for senior civil servants. Other officials shall be appointed in accordance with provisions to be laid down by the Department.

The Director shall be responsible for the day-to-day management of the Directorate. He shall attend meetings of the Council but shall not have the right to vote. A Deputy Director shall be appointed by the Department.

§ 55:

§ 55. *Commune labour inspectorate.*

(1) A commune labour inspectorate consisting of not less than four members and a like number of personal substitutes shall be set up in every commune.

(2) The members of the commune labour inspectorate and their substitutes shall be elected by the commune council for the council's term of office.

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[1]) Act of May 10. 1968 no. 2.

At least one member of the commune labour inspectorate shall be an employee. At least one of the members shall be a woman. A medical practitioner practising in the locality should also be a member. When the election takes place, care shall be taken to ensure that at least one of the persons elected has expert knowledge of machinery and the operation thereof and that the members of the inspectorate include persons with experience in the most important sectors of industrial activity in the commune.

The commune council shall choose the chairman and vice-chairman from among the members. In communes where it is necessary a permanent chairman may be appointed. As a rule the observations of the Directorate of Labour Inspection shall be obtained before a permanent chairman is appointed.

In so far as is necessary the commune may appoint inspectors and other permanent personnel for the commune inspectorate.

Not less than one month before the election of the inspectorate the commune council shall announce how many of the members must be employees and shall invite the persons employed in establishments situated in the commune to submit candidates for election as employee members and substitutes.

(3) A person who has been a member for four years shall be entitled to refuse re-election for the ensuing term of four years.

(4) If a commune inspectorate has less than six members, three members shall constitute a quorum. Otherwise two-thirds of the members shall constitute a quorum. Resolutions shall be adopted by a simple majority. In the event of an equality of votes the chairman shall have a casting vote.

The power of the commune inspectorate to grant exemptions may, in urgent cases, be exercised provisionally by the chairman, who shall submit the matter in question to the inspectorate as soon as possible.

§ 55 a:

§ 55 a.[1]) *Additional provisions as to the organisation and operation of Labour Inspectorate.*

Detailed provisions supplementing those of sections 54, 54 a and 55 as to the organisation and operation of the Labour Inspectorate, the operation of the Council and the relationship between the Council and the Directorate shall be laid down by the Crown. The Crown may also lay down provisions as to the relationship between the Labour Inspectorate and the other inspection authorities.

The Crown may lay down provisions as to the delegation by the Directorate of Labour Inspection of its authority under this Act to the district inspectorates and the commune labour inspectorates.

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[1]) Act of May 10. 1968 no. 2.

§ 56:

§ 56.[1]) *Decisions of inspectorate; appeal against decisions.*

(1) The inspectorate shall issue the general and special regulations, recommendations and instructions necessary for the administration of this Act.

Instructions shall be given in writing and, where they concern alterations or improvements for the purpose of preventing employment accidents and ensuring healthy working conditions, a suitable time limit shall be fixed for compliance. The inspectorate may, if imminent danger so warrants, require that the necessary measures be taken immediately.

If the inspectorate's instructions have not been complied with and a new time limit is fixed for compliance, and if such time limit is exceeded, the inspectorate may order the total or partial cessation of work in the establishment until the conditions complained of have been remedied.

(2) Exemptions from the provisions of this Act shall not be valid unless they have been granted in writing or by telegram.

(3) An appeal against any particular decision shall lie to the next higher inspection authority. An appeal against a decision by the Directorate of Labour Inspection shall lie to the Labour Inspection Council and against a decision by the Council to the Department. The Crown shall have power to lay down special provisions for the procedure for appeal to the Chief Inspector of Boilers. For the purposes of this subsection the expression "decision" includes a ruling on an appeal.

The time limit for an appeal against an order shall be three weeks, unless the order provides for a longer period.

(4) The employees' union representatives shall be informed of the recommendations, instructions and other decisions of the inspectorate.

§ 57:

§ 57. *Access of inspectorate to establishments.*

The[1]) members of the Labour Inspection Council, the officials of the inspectorate, and the experts engaged in accordance with the last paragraph of subsection (1) of section 54 or co-opted under the last sentence of the first paragraph of subsection (2) of section 54 shall have access at any time to any workplace which is coreted by this Act or which it is proposed to bring within the scope of this Act. The same shall apply as regards the housing accommodation mentioned in the second paragraph of subsection (6) of section 5. The person concerned shall produce his credentials if required to do so.

It shall be the duty of the employer, the employees and every other person connected with the establishment to furnich all the information considered necessary for the carrying out of the inspection.

In carrying out an inspection at the workplace the officials of the

[1]) Act of May 10. 1968 no. 2.

inspectorate shall consult the hygiene and safety representatives of the employer and of the employees.

In establishments that have a staff doctor officials of the inspectorate shall, in carrying out an inspection, consult the staff doctor.

§ 58:

§ 58.[1]) *Inspection register.*

The inspectorate may require establishments to keep an inspection register. The Directorate of Labour Inspection may issue detailed regulations respecting the manner in which the inspection register is to be drawn up, kept up to date and preserved.

§ 59:

§ 59.[1]) *Obligation to preserve secrecy.*

The members of the Labour Inspection Council, the officials of the inspectorate and experts shall, unless their duties otherwise require, preserve secrecy respecting the operational and business circumstances that come to their knowledge in the exercise of their functions and shall not make drawings of the equipment or proessess of an establishment without its permission.

If any circumstance contrary to his Act is reported to the Labour Inspection Council or the inspectorate, the name of the person reporting it shall not be divulged unless he expressly consents to be named or the report is found to be groundless.

§ 60:

§ 60.[1]) *Relations between inspectorate and establishments.*

(1) Public employees in the State Labour Inspectorate and officials appointed to the commune labour inspectorates shall not operate on their own account or on behalf of another person, have considerable financial interest in, or hold a post in, any establishment subject to their inspection or undertake any business on behalf of any such establishment in return for remuneration. In special cases where it is unlikely to be prejudicial to the service the Department may authorise exceptions from the foregoing prohibition.

(2) No employer, manager or foreman may take part, as a member of a commune inspectorate, in inuqiries or inspections relating to an establishment which he himself operates, or in which he has considerable financial interests, or holds a post, or an establishment of the same kind as his own. No employee may take part, as a member of a commune inspectorate, in inquiries or inspections relating to the establishment in which he is employed, unless with the Department's permission.

§ 61:

§ 61. *Labour Inspection Council.*

(Repealed by Act No. 2 of 10 May 1968.)

[1]) Act of May 10. 1968 no. 2.

§ 62:

§ 62. *Liability to pay fees.*

(1) Establishments which are covered by this Act and are liable to insurance under the legislation respecting accident insurance for industrial employees, etc., shall pay an annual inspection fee to the Treasury.

The owner or user shall pay a fee to cover expenses incurred in the inspection and testing of boilers, tanks and pipes under steam pressure.

The Crown shall prescribe detailed rules respecting the payment of fees, which shall be enforceable by distraint.

(2) The Crown shall have power to impose–

(a) a normal inspection fee under the first paragraph of subsection (1) in the case of establishments covered by this Act but not covered by the legislation respecting accident insurance for industrial workers, etc.;

(b) a fee payable by owners or users of machines, technical equipment or plant to cover the expenses incurred in inspections ordered under the first sentence of subsection (2) of section 1;

(c) a fee payable by owners or users of tanks and pipes within the meaning of subsection (2) of section 12 to cover the expenses incurred in inspections ordered under the said subsection;

(d) a fee payable by the owners or users of machines, technical equipment or plant to cover the expenses incurred in inspections and tests ordered under the first paragraph of section 13;

(e) a fee payable by each establishment concerned where it is found that the expenses incurred in inspections and tests ordered under section 14 should be shared by two or more establishments.

The Crown shall issue detailed rules respecting the fees mentioned in subsection (2). Payment of the said fees may be enforced by distraint.

§ 63:

§ 63. *Expenses of commune labour inspectorate.*

The expenses incurred in the functioning of the commune labour inspectorate shall be defrayed by the commune.

The commune council shall fix an annual allowance for the chairman, which shall be reasonably proportionate to the work done.

Travelling expenses and subsistence allowances for the chairman of the inspectorate shall be defrayed by the Treasury, but advances may be claimed from the commune.

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[1] Act of May 10. 1968 no. 2.

Chapter 8. PENALTIES

§ 64:

Subject to any heavier penalty provided for in the General Penal Code an employer or owner of an establishment shall be liable to a fine if he–

(1) contravenes the provisions of this Act as to healthy and safe working conditions or the regulations, rules or instructions issued thereunder;

(2) contravenes the provisions of this Act as to night work, work on Sundays and public holidays, hours of work, rest breaks, rest periods and the special protection of women, children and young persons or the regulations issued thereunder;

(3) fails to make the registrations, post up the notices or keep the lists required by this Act or to prepare employment rules;

(4) contravenes the provisions of section 40 as to the settlement of employees' wages.

§ 65:

The provisions of this Act as to employers shall also apply to persons managing an establishment in the employer's stead.

§ 66:

Subject to any heavier penalty provided for in the General Penal Code an employee shall be liable to a fine if he is guilty of an offence of the type referred to in clause (1) of section 64.

§ 67:

The provisions of sections 64, 65 and 66 shall not apply to officials, public employees and conciliation officers in the public service.

§ 68:

A parent or guardian allowing a child to be employed in contravention of this Act shall be liable to a fine.

§ 69:

Subject to any heavier penalty provided for in the General Penal Code a person shall be liable to a fine if he–

(1) removes a prescribed safety device or causes damage to it either wilfully or through gross negligence;

(2) owns or uses machinery, tools or other technical equipment and contravenes any provision or instruction contained in or issued under this Act for the prevention of accidents or injuries in connection therewith;

(3) manufactures, sells, rents or lends machinery, tools or other technical equipment and delivers it for use or for display with a view

to sale or advertisement in Norway, if it fails to comply with the provisions of the first paragraph of section 15 of this Act or the regulations made thereunder;

(4) undertakes on his own account to assemble machinery, tools or other technical equipment and assembles it otherwise than in accordance with the provisions of the first paragraph of section 15 of this Act or the regulations made thereunder.

§ 70:[1])

Subject to any heavier penalty provided for in the General Penal Code a person shall be liable to a fine if he hinders an inquiry undertaken by the Labour Inspection Council or any inspection service or fails to give the assistance he is reuqired to give or supply the information deemed necessary for inspection purposes.

§ 71:[1])

Any person who is attached to the Labour Inspection Council or an inspection service shall be deemed to be a public official for the purposes of the General Penal Code.

§ 72:

Proceedings for offences under this Act shall be instituted by the public prosecutor: Provided that proceedings for offences under section 40 shall be instituted only on application by the injured party.

Chapter 9. COMMENCEMENT AND TRANSITIONAL PROVISIONS

§ 73:

(1) This Act shall come into operation on July 1. 1957: Provided that the provisions of clause *(b)* of subsection (1) of section 23 shall come into operation on February 3. 1957, and the provisions of the final paragraph of subsection (1) of section 1 (cf. the final paragraph of section 18 and section 35) shall not come into operation until January 1. 1959.

(2) On the date on which this Act comes into operation the Act of June 19. 1936 respecting the protection of workers, as subsequently supplemented, shall be repealed: Provided that the provisions of section 1 of the said Act respecting government offices and the decisions taken by the Crown thereunder shall continue to apply until January 1. 1959. In addition, the instructions and regulations issued under subsection (2) of section 1 and sections 7, 9, 27 and 43 of the said Act and under sections 3, 9, 17 and 18 of the Act of September 18. 1915 respecting the protection of workers in industrial establishments, as subsequently supplemented, shall continue in force until further notice.

[1]) Act of May 10. 1968 no. 2.

Act of June 16. 1972 No. 58 respecting amendments in the provisions concerning the local labour inspection in the Act of Descember 7. 1956 No. 2 respecting the protection of workers.

I.

The act of Descember 7. 1956 no. 2 respecting the protection of workers is amended as follows:

The heading and subsection (1) of section 54 shall read:

§ 54:

§ 54. *Supervision of observance of the Act. Labour Inspection Council.*

(1) Supervision of the observance of this Act shall be exercised by the Labour Inspectorate. The Crown shall have power to prescribe how inspection work is to be carried out in the case of government offices and transport undertakings operated by the State, including the Post Office and Telegraph Office.

In special cases the Department may engage experts not belonging to the Labour Inspectorate to carry out inspection work.

Section 54 a shall read:

§ 54 a:

§ 54 a. *Directorate of Labour Inspection.*

The everday management of the Labour Inspectorate pertains to the Directorate of Labour Inspection.

The Crown shall appoint the Director and such other officials as are remunerated in accordance with the scale for senior civil servants. Other officials shall be appointed to the Directorate in accordance with employment rules laid down by the Crown.

The Diretor shall attend meetings of the Council but shall not have the right to vote.

Section 55 shall read:

§ 55:

§ 55. *Local agencies of the Labour Inspectorate.*

The local labour inspectorate consists of regional offices and divisional offices. Each regional office and the pertaining divisional offices are directed by a regional superintendent.

Officials of the regional and devisional offices are engaged in accordance with employment rules laid down by the Crown.

Section 55 a shall read:

§ 55 a:

§ 55 a. *Additional provisions as to the organisation and operation of the Labour Inspectorate.*

The Crown will lay down further provisions regarding the organisation and operation of the Labour Inspectorate, including relations between the Council, the Directorate, the regional offices and divisional offices.

The Crown may moreover lay down provisions regarding the delegation of authority within the Labour Inspectorate and regarding the relations between the Labour Inspectorate and other authorities.

Section 60 shall read:

§ 60:

§ 60. *Relations between Inspectorate and establishments.*

Officials of the Labour Inspectorate shall not for their own or other's account operate or have any considerable financial interest in or hold a post in any establishment subject to their inspection, nor shall they undertake any business on behalf of any such establishment in return for remuneration.

In special cases where it is unlikely to be prejudicial to the service the Department may authorize exceptions from the foregoing prohibition.

Section 63 is repealed:

A new chapter 7 a is to have the following heading and content:

Chapter 7 a. COMMUNE WORKER PROTECTION COMMITTEES.

§ 63:

(1) In each commune there shall be a workers protection committee of at least 3 members with personal deputies.

(2) The committee is appointed by the commune council for the council's term of office.

At least one of the committee members shall be a member of the commune council. Employees and employers shall each have at least one representative on the committee; the are appointed at the recommendation of, respectively, the Federation of Trade Unions in Norway and the Norwegian Employers Association. It is desirable that both sexes be represented on the committee.

A person who has acted as member of the committee for an election period may refuse to be re-elected for the next period.

(3) The committee forms a quorum when at least two thirds of the members are present. Resolutions are adopted by simple majority. In the event of a tie the chairman has the casting vote.

(4) The committee shall

(a) promote protection of workers in the commune;

(b) assist in enforcing the provisions of the Act regarding hygiene and safety measures (see §§ 9, 10 and 11);

(c) furnish advice regarding the provisions of this Act and transmit inquiries to the Labour Inspectorate about questions which the committee itself is unable to answer;

(d) promote information on the rules for the protection of workers and hygiene and safety measures;

(e) assist the Labour Inspectorate by reporting any matter which may be contrary to the legislation regarding protectio nof workers or its enforcement.

(5) The access of committee members to the establishments, their obligations of secrecy and their other relations with the establishments are subject to the provisions of §§ 57, 59 and 60 of this Act.

The committee shall insofar as possible report in advance to the Labour Inspectorate any forthcoming visits to establishments.

An employer, supervisor or foreman who is a member of the committee shall not take part in investigations of an establishment which he personally operates, or in which he has considerable financial interests or holds a post. Nor shall he take part in investigations of or visits to establishments of the same kind as his own.

An employee who is a member of the committee shall not take part in investigations of the establishment in which he works, unless the Department consents thereto.

(6) The costs of the committee's activities will be paid by the commune.

(7) The Department may decide, after having invited the opinion of the communes concerned, that instead of commune committees a joint inter-commune committee shall be appointed for all or part of a divisional office's area. Such an inter-commune committee shall consist of at least one representative of the employees and at least one representative of the employers appointed by the Department on the recommendation of the Federation of Trade Unions in Norway and the Norwegian Employers Association, and one representative from each commune, appointed by the commune council from among its members. Moreover, the Department may appoint additional members, if appropriate also the chairman of the committee. In other respects, the provisions of commune workers protection committees will similarly apply.

Section 70 shall read:

§ 70:

Subject to any heavier penalty provided for in the General Penal Code a person shall be liable to a fine if he obstructs investigations conducted by the Labour Inspectorate or a commune or inter-commune workers protection committee, or if he fails to furnish the assistance he is required to give or fails to supply the information deemed necessary for inspection purposes.

Section 71 shall read:

§ 71:

Any persons who is attached to the Labour Inspectorate or to a commune or inter-commune workers protection committee shall be deemed to be a public official for the purposes of the General Penal Code.

II.

This Act shall come into force from the date decided by the Crown.
The Crown may resolve to let the Act come into force at different times in the carious counties or communes.

Flisa Boktrykkeri

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L'ORGANISATION MONDIALE DE LA SANTE DESIGNE UN LABORATOIRE SUEDOIS SUR LE STRESS POUR ETRE SON PREMIER CENTRE INTERNATIONAL DE RECHERCHES ET D'ENSEIGNEMENT SUR LES FACTEURS PSYCHOLOGIQUES ET LA SANTÉ

par Richard J. Litell

Ces douze dernières années, l'équipe du Laboratoire de Recherches sur le Stress Clinique de l'Institut Karolinska a été occupée par des recherches dont le but était de parvenir à une meilleure compréhension de la réponse de l'homme aux stimuli psychologiques.

Sous la direction énergique du Dr. Lennart Levi, le laboratoire a également organisé une série de symposia internationaux annuels qui allaient amener chaque printemps à Stockholm, l'élite des chercheurs dans le domaine des problèmes relatifs au stress.

L'importance des contributions apportées par ce laboratoire a été telle que l'Organisation Mondiale de la Santé a récemment décidé de le désigner comme son premier centre international de recherches et d'enseignement sur les facteurs psychologiques et la santé. (Il constitue de ce fait le deuxième centre de recherches et d'enseignement de l'Organisation Mondiale de la Santé en Suède; l'autre, qui fait aussi du point de vue administratif, partie de l'Institut Karolinska, est consacré à la reproduction de l'homme).

Lors de la nomination officielle à Stockholm, le Dr. Thomas Lambo qui vient d'être nommé Directeur Général Adjoint de l'OMS, déclara que la recherche sur le stress est plus avancée en Suède que nulle part ailleurs au monde. C'est pourquoi il dit qu'il était logique de choisir le laboratoire de Stockholm comme premier centre de stress de l'OMS. Dans quelques années on assistera sans doute à l' installation de centres analogues en Amérique du Nord et en Asie.

Le Dr. Bror Rexed, Directeur Général de la Direction Nationale de la Santé Publique et de la Prévoyance Sociale, attira l'attention sur les effets néfastes des maladies relatives au stress. Peut-être, dit-il, que le produit national brut (PNB) n'est plus la mesure idéale du progrès et de la prospérité d'un pays. Peut-être que nous devrions tenir compte du bonheur de l'homme et essayer à la place, d'obtenir un bien-être national brut (BNB) élévé ou une satisfaction nationale brute (SNB). Le Dr. Rexed ajouta que l'honneur fait au laboratoire par un organisme aussi respecté que l'OMS, ne manquerait pas de rassurer les autorités, facilitant de ce fait l'obtention d'aide économique.

La nomination du nouveau centre, dit le Dr. Lambo, fait partie d'un programme proposé par l'OMS pour l'amélioration des services de santé qui profiteront des développements récents dans le rapport de la santé mentale, sociale et physique avec le bien-être psycho-social absolu, dont la notion fut incorporée à la charte de l'OMS il y a de cela 25 ans.

"Cet objectif principal, dit-il, aura le soutien des efforts qui seront faits pour coordonner et concentrer la recherche ainsi que pour expérimenter les hypothèses relevant de la question; pour évaluer les actions sanitaires; pour comprendre ce que cela implique pour le personnel médical et pour donner des résultats obtenus une traduction acceptable et accessible à ceux qui sont dans le besoin."

<u>Les fonctions du centre</u>

Les fonctions du nouveau centre seront:

- d'effectuer des recherches sur les effets que produisent sur la santé les facteurs psychologiques, pour permettre que les actions sanitaires s'appuyant alors sur une base plus large puissent contribuer à améliorer la qualité de la vie;

- de donner dans cette perspective une formation à des scientifiques de divers pays - et de faciliter les études transculturelles (un fait d'une importance spéciale dans le cas des pays en voie de développement, comme le souligne le Dr. Lambo);

- de coordonner, de documenter et de conseiller sur la recherche partout ailleurs;

- de coopérer avec d'autres institutions dans la marche des études;

- de mettre au point une méthodologie, et

- de mettre au point des façons de divulger l'information sur les questions de santé publique.

Tant que les programmes n'auront pas été établis dans le détail, les activités du nouveau centre ne diffèreront pas sensiblement de celles qui sont couramment menées au laboratoire du stress, disent les docteurs Levi et Lambo. Il arrivera cependant que l'on insiste de plus en plus sur des problèmes importants pour les pays en voie de développement qui sont nombreux à opérer une transformation technologique et sociale accélérée. On espère pouvoir épargner à ces nations quelques-unes des douleurs de croissance qu'a connues le monde industriel.

Qu'est-ce que le stress?

Par stress physiologique, on entend le plan général de l'organisme humain pour s'adapter à un vaste registre d'influences. Le but général de ce plan, que nous possédons en commun avec nos ancêtres non-civilisés d'il y a des millions d'années, de même qu'avec de vastes sections du royaume animal, est de préparer l'organisme à l'activité physique. Lorsqu'il se trouve en présence d'une menace, le plan général aide à élever l'état de préparation de l'organisme de façon à ce qu'il soit prêt, tel qu'il le serait pour le combat ou pour la fuite.

Le concept du stress psychologique (détresse) est identique sous plusieurs aspects. Tous deux peuvent être occasionnées par pratiquement n'importe quel type de sur-stimulation ou de sous-stimulation. En conséquence, le bombardement de nos organes sensoriels caractéristique de la vie urbaine moderne ainsi que la monotonie et le manque de contact devant une chaîne de montage dans une usine, constituent tous deux un "stresseur".

Que ces stimuli et d'autres soient en réalité inducteurs ou non de réactions de stress physiologique, d'un sentiment de détresse et/ou d'un comportement défensif et de changements dans l'exécution, dépend dans une large mesure de la façon dont la personne apprécie la situation et des mécanismes qui lui permettent de se mettre à la hauteur de celle-ci. La même musique pop qui est source d'un intense bien-être chez un adolescent, peut occasionner une intense détresse chez les parents de celui-ci; cela dépend de l'appréciation.

Le stress psychologique s'accompagne habituellement de stress physiologique. D'un autre côté, il peut y avoir stress physiologique sans qu'il y ait la moindre détresse psychologique. En fait, même des états émotionnels extrêmement agréables d'où sont absentes toutes marques de détresse, peuvent s'accompagner de réactions de stress physiologique assez prononcées, dans le cas de l'enthousiasme, de forts sentiments d'engagement, de joie ou d'excitation sexuelle.

Le stress est-il nocif?

En règle générale, les réactions de stress ont une fonction définie dans les situations qui demandent une activité musculaire. Pour l'athlète ou le laboureur, il est important que le "carburant" soit lâché dans le système sanguin, que la circulation s'accélère (battements de coeur rapides), que le sang soit mieux oxygéné (respiration plus rapide) et que le sang avec son "carburant" soit transporté là où il est le plus nécessaire, à savoir, les muscles.

Les nombreuses influences sociales, psychologiques et financières qui s'exercent fréquemment sur l'homme moderne, n'exigent pas ou ne permettent pas de réactions sous forme d'activité musculaire. Le corps est cependant "programmé" pour réagir aussi bien dans ces cas-là avec du stress. Qu'il s'agisse, par exemple, d'un refus d'augmentation, d'une remarque blessante, d'une irritabilité croissante dans les encombrements de la circulation ou d'une querelle avec l'époux (ou l'épouse). Si de telles situations se répètent souvent ou si elles sont prolongées, elles peuvent laisser échapper des réactions de stress d'une telle force et d'une telle durée, que la fonction et la structure mêmes du corps s'en trouvent endommagées. On peut dire à ce moment-là que l'on a affaire à une maladie du stress.

Cette succession d'événements a été étudiée par de nombreux chercheurs à travers le monde. On a démontré qu'une exposition prolongée, intense ou souvent répétée à des "stresseurs" psycho-sociaux accroît le risque de maladie psychiatrique ou psychosomatique. De plus, des expériences faites sur des animaux corroborent cette preuve.

On estime qu'à peu près un tiers de la totalité des journées de maladie enregistrées dans les pays industrialisés ont un rapport étroit avec les réactions de stress dont il a été question.

<u>Le facteur "humain" et "inhumain"</u>

L'expression facteur "humain" signifie que le corps est "programmé" par l'éducation et autres influences, de telle sorte que même des environnements et des influences soit-disant normaux, peuvent être générateurs de stress. Une personne qui a appris à se méfier de tous et de toutes sera très facilement sujette au stress.

Réciproquement, il y a des environnements auxquels la grande majorité des gens éprouvent des difficultés à s'adapter, indépendamment de la façon dont ils peuvent être "programmés". La raison peut en être par exemple, que ces environnements ont été désignés sans tenir compte des lois psychologiques et biologiques qui gouvernent les possibilités et les besoins humains. On peut, dans ces cas-là, parler de facteur "inhumain".

Le problème le plus important pour notre époque et pour l'avenir, est que les divers environnements de l'homme - la famille, le lieu de travail, etc. - sont presque exclusivement planifiés à partir de considérations économiques, technologiques et politiques, aux dépens des aspects psychologiques et médicaux. Comme résultat, on peut se trouver face à un environnement social général qui est en désaccord total avec la "construction" biologique de l'homme.

Des miracles de la science pourront peut-être dans l'avenir permettre la reprogrammation de l'homme pour l'adapter à un environnement hostile. Mais l'alternative logique est, bien sûr, de s'efforcer d'adapter l'environnement social aux capacités et aux besoins mentaux et biologiques humains fondamentaux.

Une approche interdisciplinaire

La preuve que les stimuli environnementaux physiques sont cause de maladie est convaincante pour grand nombre de maladies. Mais le rôle des stimuli psycho-sociaux intrinsèques n'est pas tout aussi clair. Comme le dit le Dr. Levi, il y a de fortes indications, mais pas de preuves. L'action de tels stimuli sur les mécanismes corporels et sur les précurseurs de maladie est mieux comprise, quoiqu'encore de façon assez rudimentaire. Il y a aussi le fait que l'on soupçonne de plus en plus que des facteurs psycho-sociaux et des facteurs physiques intervenants pourraient empêcher certains mécanismes, précurseurs et maladies, dit le Dr. Levi.

Avant de pouvoir pratiquer la prévention sur une grande échelle, nous devons apprendre davantage; ce qui signifie, davantage de recherches. Le Dr. Levi maintient qu'une approche interdisciplinaire est essentielle. Au nouveau centre de l'OMS, on étudiera très peu, si toutefois étude il y a, de projets purement médicaux, psychologiques ou sociaux. Mais on insistera plutôt sur l'interaction de tous ces aspects dans quelque zone de problèmes donnée que ce soit.

L'approche "pain, beurre et confiture"

Selon Aubrey R. Kagan qui a été auparavant à l'OMS à Genève et qui est maintenant professeur de passage au nouveau centre, ce centre suivra ce qu'il appelle une approche "pain, beurre et confiture". Il s'efforcera de combiner l'évaluation des actions sanitaires et sociales (le pain) considérées comme importantes par la société, en termes de sécurité, efficacité et coût, avec des études dont le but est de tester des hypothèses clés (le beurre). De ce fait, on comprendra mieux les évaluations et les découvertes trouveront un champ d'application élargi.

Tout en évaluant les actions sanitaires et en testant les hypothèses clés, il pourra être possible de mener des observations sur les relations mutuelles de plusieurs facteurs considérés comme importants, mais pour lesquels on n'a pas étudié de relation de cause à effet. La connaissance retirée de cette tentative pourra faire fonction de confiture, dit le Dr. Kagan.

"Nous pensons que si nous pouvons établir des corrélations quantifiées dans une quantité de divers types d'études, nous aurons une chance raisonnable d'être en mesure de produire un modèle simulé d'une situation donnée, de telle sorte que nous pourrons dire, en manipulant un facteur non expérimenté, ce qui va se produire à la sortie," dit-il. "Nous serons en mesure de tester ce modèle et de le modifier à partir de l'évaluation de l'action sanitaire et du test de l'hypothèse."

Il dit que l'on pouvait s'attendre à des résultats 100 % sûrs des évaluations de l'action sanitaire, dans une période de temps raisonnablement courte. Le test de l'hypothèse est, d'un autre côté, plus spéculatif et il peut prendre davantage de temps. Mais simuler l'ensemble du système est un procédé hautement speculatif et il demanderait bon nombre d'années pour obtenir, le cas échéant, des résultats concluants.

Pour ce qui est de l'avenir, le Dr. Kagan dit, "nous attendons le pain, nous comptons sur le beurre et nous serions très heureux d'avoir la confiture."

<u>Projets courants</u>

Au laboratoire du Dr. Levi, les projets courants sont centrés sur l'environnement des enfants et sur celui du travail. Les enfants ne disposant pas de syndicats pour plaider leur cause, dit-il, il est important de déterminer la façon dont ils réagissent aux divers "stresseurs". Pourquoi tombent-ils malades? Quels environnements sont bons ou mauvais? Quel type d'enfant est le plus vulnérable aux situations de stress? Comment empêcher les maladies du stress chez les enfants?

De la même façon, pourquoi les gens tombent-ils malades au travail? Pourquoi restent-ils chez eux? Pourquoi leurs situations les laissent-elles insatisfaits? Cette année, le quatrième des cinq symposia sur "la société, le stress et la maladie", organisé par le Dr. Levi, patronné par l'OMS et l'université d'Upsal et financé par le Groupe d'Assurances Trygg-Hansa, sera consacré précisément à ce type de problème. Le thème en sera "les Facteurs du Stress dans l'Environnement du Travail, le Développement Technologique et l'Urbanisation des Populations".

De précédents symposia dans ces séries se concentrèrent sur l'environnement psychosocial et les maladies psychosomatiques (1970), l'enfance et l'adolescence (1971) et sur les rôles et les relations de l'homme et de la femme (1972). Le cinquième et dernier symposium dans les séries (qui se tiendra en 1975), considèrera l'environnement des personnes vieillissantes et les problèmes psychologiques. L'année dernière, un symposium international en dehors des séries, fut consacré aux "Paramètres de l'Emotion".

Dans une étude qui est sur le point de commencer, Marianne Cederblad, psychiatre pour enfants, travaillera avec 100 enfants de trois ans dans les crèches de jour, et s'efforcera de déterminer le type d'activités le plus favorable ainsi que la quantité maximum idéale du personnel.

Expériences types

Les quelques enquêtes types déjà effectuées au laboratoire du Dr. Levi, donneront peut-être un exemple du genre de résultats des recherches auxquels on peut s'attendre de la part du nouveau centre de l'OMS.

Dans une étude, on présenta, plusieurs soirs de rang, un film d'une heure et demie à 20 jeunes employées de bureau. On trouva que le calme et la tranquillité d'esprit amenés en regardant des films de paysages naturels paisibles, étaient accompagnés d'une baisse significative de l'excrétion de catécholamine. Des films provoquant trouble et agression, d'un autre côté, aussi bien qu'une comédie, amenèrent tous un accroissement significatif de l'excrétion d'adrénaline. L'interprétation des résultats de cette étude soutient la non spécificité dans les réactions physiologiques, comme postulé par le père du concept du stress, Hans Selye. Les réactions de stress étaient obtenues par des "stresseurs" aussi bien agréables que désagréables.

Une autre étude appuya l'hypothèse de Kinsey selon laquelle les hommes sont plus portés à être excités sexuellement par des stimuli visuels. On montra à 53 étudiantes et 50 étudiants un programme de films d'une heure et demie qui consistait en quatre films courts et muets choisis pour causer surtout une excitation sexuelle agréable. L'excrétion d'adrénaline et de noradrénaline augmenta de manière significative dans les deux groupes pendant la projection. L'excitation sexuelle était la réaction subjective prédominante rapportée par les deux sexes, mais les valeurs atteintes suivant leur propre jugement et les accroissements d'excrétion étaient significativement plus élevés dans le groupe des hommes.

Dans encore une autre étude, 12 facturières en bonne santé furent placées dans des conditions présentant une grande similitude avec celles de leur routine quotidienne, mais qui comportaient des quantités de stimuli physiques et psychosociaux étrangers, gardés sous contrôle. Des salaires aux pièces, hautement progressifs, furent introduits le premier et le troisième jour; ils eurent pour résultat d'accroître le rendement de façon importante, mais aussi la précipitation, la fatigue, les sensations d'inconfort physique, les excrétions d'adrénaline, de noradrénaline et de créatinine ainsi que la production d'urine. En conséquence, raisonnèrent les auteurs, les conditions quotidiennes au travail peuvent modifier d'une manière significative les réactions physiologiques d'une façon qui <u>peut</u> avoir une importance pathogénique sur l'organisme humain.

La coopération de la Suède avec l'OMS

Pour conclure ses remarques dédiées au nouveau centre de l'OMS, le Dr. Lambo souligna le fait que l'OMS avait au préalable cherché et obtenu une aide considérable de la part de la Suède sur de nombreuses questions ayant trait à la santé. Les contributions apportées par ce pays, ont été, déclara-t-il, spectaculaires et remarquables tant en quantité qu'en qualité, tant pour fournir des ressources matérielles qu'humaines.

"Je suis sûr, par la qualité invariablement élevée de la réponse que nous (l'OMS) avons reçue (de la part de la Suède), ainsi que par ma connaissance personnelle de ceux qui sont concernés en cette occasion, que le nouveau pas qui est fait par l'OMS et par la Suède l'année du 25ème anniversaire de l'organisation, sera un jalon dans notre approche pratique de l'amélioration de la qualité de la vie chez les peuples du monde, et qu'il fera honneur à la sagesse perspicace de ceux qui ont été à l'origine de la charte de l'OMS ainsi qu'à l'aide continue que ce pays procure à l'organisation," dit le Dr. Lambo.

Les opinions énoncées dans cet article n'engagent que la seule responsabilité de l'auteur.