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AT

WORK

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Additional criteria. In addition to three criteria to qualify for ODAM, the X research included two that are pertinent, if not required. One has been recently emphasized in ODAM, the other neglected.

5. PARTICIPATORY ERGONOMICS

Those who work in a sociotechnical system can participate in deriving human factors knowledge about the system and applying it to the design and testing of their own equipment and software, to the procedures and manuals they use, to the specification of required skills and the personnel selection methods, to the techniques for training, to the social interactions (both formal and informal) in which they engage, and to the motivational variables they encounter. In X such participatory ergonomics consisted of taking part in the two studies I have described. The participants commented at length and in detail about what they were doing and its conditions as well as performed their daily tasks without concern about being observed. Thus X showed how this kind of on-site research can differ from laboratory investigation.

6. MOTIVATIONAL VARIABLES

These have been notoriously and regrettably lacking in most human factors research and application. Though one obstacle has been the ambiguous nature of the term "motivation," this can be partly resolved by qualifying it as "motivational feedback," whether called incentives and disincentives, rewards and punishments, or reinforcers and deterrents. As in X they combine with informational feedback to influence significantly what people do in their interactions with technology's processes and products. Here ODAM is in a favorable position to open new human factors territory, since in sociotechnical systems so much of both types of feedback come from others as well as from machines. I urge macroergonomics to lead the way.

7. CONCLUSION

Finally, what was X? For those who have not already guessed it, the Chicago suburb was Hawthorne, from which the research took its name. The Hawthorne studies produced the "Hawthorne effect," to "explain" an experimental result caused by some presumed extraneous variable, such as just being in an experiment. The Hawthorne investigators never realized that the mysterious rise in productivity was most plausibly attributable to money and knowledge of results, the extraneous variable revealed through happenstance (Parsons, 1978) only many years later. Oddly, till now Hawthorne seems to have been missing in the ODAM literature.

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MORE FROM THE THIRD INTERNATIONAL ODAM SYMPOSIUM

COGNITION AT WORK, INFLUENCE OF CULTURAL AND TECHNICAL CONDITIONS

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Over the last 15 years, research has been able to clear up certain negative aspects of

technology transfers. The importance of economic and social factors has been highlighted, particularly in terms of the industrial and social fabric (Wisner, 1984).

The social fabric (Rubio, 1990) acts directly on the physiological condition of workers who arrive tired at the plant (Meckassoua, 1986; Ferreira, 1988) and on their psychological condition linked to the fear of too frequent actions (Aw, 1988). But on the contrary, in certain cases, the success of the undertaking can be explained by the good quality of the social fabric which provides a suitable level of general instruction and even skills, and familiarity with modern technologies (data processing) through school and even daily life (Rubio, 1990).

As such, highly varied degrees of success can be distinguished in technology transfers in a single country (Abrahao, 1986, Wisner et al. 1988, Wisner and Rubio, 1988), from complete shutdown of a company after vain operating tests to enhancements which improve operation of the transferred system, including operation in downgraded mode and the mastery of normal operation.

The previous considerations can be deduced from sociological or economic type observations. However, for an ergonomist, these approaches are not sufficient. He has to know what workers and their managers really do in order to see to what extent some of these vast problems can be treated or at least improved by work organization itself. In many unfavorable cases, mention is made of aspects which are specific to the culture of the country to which the transfer is made, in order to explain the failures.

But what is the cognition of the workers who have to operate the new machine? And aren't there obstacles in the system itself which could explain the workers' difficulties and the poor production of results?

In order to appreciate the differences in operating a production system in a seller country and a buyer country, the differences in intellectual levels from one country to another are often mentioned. We now know that this explanation is not valid. There is probably a random distribution of intellectual possibilities among newborn humans [babies]. As long as intelligence tests are homogeneous in regard to the culture of children or adults in each country, we find similar results, for example, for the appearance of successive stages of intelligence (Piaget, 1961). The major discordances noted by certain authors are usually linked to the fact that the methods used too often correspond to schooling tests (Rogoff, 1984).

ERGONOMIC WORK ANALYSIS (EWA) COURSE OF ACTION STUDY (CAS), THE INTERPRETANTS OF PEIRCE.

In order to know the cognitive activities at work and possibly change them through the ergonomic modification of the technical system, the transformation of job aids and improved work organization and/or additional training, it is vital to have an efficient tool: this tool is ergonomic work analysis (EWA.).

EWA is familiar to french-language authors since the book by Ombredane and Faverge (1955) which shows the interest of studying the real work activity of operators, often very different from the activity specified by the organization. The list of differences between real activities and specified activities is extremely useful for finding out that which is difficult or even impossible to do in the specified work, or that which is badly understood. In any event, the lists suggests different forms of work improvement.

The EWA methodology has been gradually improved and systematized and has taken the form of the Course of Action Study (CAS). CAS was designed and developed by Theureau (1990) and Pinsky (1990). After the ergonomist has become familiar with the technical, economic, and social situation of the company, and, more particularly, with the production system to be studied, a very detailed study is made of the critical phases of those operations where problems or difficulties will probably arise. All the behavior is noted, whether this is behavior concerning the action (control of the system), observation (glances, for example), or communication. Obviously, among the different sorts of communication behavior speech is essential but it is different from other types of behavior since it involves the complexity of the linguistic code. At this stage, the behavior constituted by speech is part of the work activity and is not provoked by the observer. On the basis of these data, the ergonomist tries to reconstitute the cognitive activities which took place during the period observed. Very often, certain

aspects remain obscure: why press that button, why look at that index, why ask a workmate that question? It is often worthwhile confronting the operator with his own activities. "Self-confrontation" can be done through notes made by the observer. It is [even] more effective if we can present the operator with his behavior recorded on a videocassette. Often the explanation requested is given spontaneously; in other cases, the worker is surprised to see himself checking such a point or neglecting another. Sometimes the operator cannot give any explanation for a certain aspect of his behavior.

Certainly, this methodology is open to criticism if we limit it to a strict definition of the scientific demonstration in the field of Human Factors, since no numerical data can be given at this stage of the study. However, these field observations can be complemented by experiments in the laboratory or by statistical investigations. As we see it, we cannot avoid the type of observation proposed by EWA since the S-R model cannot be used to understand the diversity of operators' responses to the same situation and the same signal. This is why Theureau and Pinsky propose to leave aside the dyadic model and choose the triadic model.

Peirce (1982-1986) has long suggested an element of interpretation between the signal and the sign. Using this model, Theureau and Pinsky show that we can thus take into account the context stressed by the text of Rogoff, mentioned previously.

To come back to the problems raised by technology transfers, we understand to what extent the concept of the interpretant is vital. In fact, it goes beyond the concept of the context. We can propose two categories of interpretant: cultural and contextual.

- cultural iterpretants correspond to that which the operator has acquired previously in his family, his games, his schooling or professional training and his previous jobs.

- contextual interpretants evoke a very old concept since it is expressed in Latin "hic en nunc," here and now. The updating of cultural attainments in specific circumstances is what the ergonomist observes and in which a signal becomes a sign leading to an action.

It is obvious that not all activity could be described in terms of the triadic model of the course of action. The simple temporal dimension enables us to distinguish at least the actions which are too short to lead to an interpretation, and those in which the concept of the interpretant is too simple and in which the reflection itself uses complex representations and takes a long time.

In any event, there would be no point in neglecting one of the fundamental aspects of human cognition at work, that which deals with the meaning given to signals, perceived in terms of the culture of the operator and the circumstances in which he finds himself.

THE CULTURAL PART OF THE INTERPRETATION, COGNITIVE ANTHROPOLOGY

In the vast field of cultural anthropology, we shall simply deal with cognitive anthropology in this case by leaving aside important question of the system of values which is the subject of much research work, particularly in the field of management (Hofstede, 1980). The relations of this part of cultural anthropology with the [concept of] organizational design and management (ODAM) are highly significant (Jaeger, 1983, 1986). They mean that a significant part should be reserved for the cultural environment in the applications of the theory of contingency in work organization.

Certainly, we could think of some of the main conclusions of structural anthropology formulated by C. Levi-Strauss (1962) in his book, ironically entitled "La pensee sauvage." For this author, there is no significant difference between the mental capacities of civilized people and primitive people. Many peoples who know nothing about writing use a style of thought in which the sensitive qualities of objects and structures (size, color, smell, etc.) are used in the construction of categories and the execution of logical operations, rather than the abstract qualities which western science considers as useful (weight, frequency, acceleration, etc.) For Levi-Strauss, the use of this style of thought is not proof of confused thought.

The logic of magical and mythical thought is as strict as that of science, since both are based on total determinism (Levi-

Strauss, 1962). The achievements of mythical thought can also be admired: the development of pottery, weaving, agriculture and the domestication of animals requires a really scientific attitude, a sustained interest and a personal desire for knowledge.

Although the work of Levi-Strauss tends to show the universality of human thought, cognitive anthropology lets us understand the diversity of use of this thought (Dougherty, 1985).

The contribution from cognitive anthropology then becomes essential for the ergonomist since it shows where the misunderstanding is located between what the designer expects and what the operator does.

The part of linguistic difficulties [that is due to] poor schooling and unreliable ability to read and write is considerable. In this field, we find good ergonomic studies by Sinalko (1975) and the vast production of linguistic ethnology since, during a certain period, cognitive anthropology was mainly based on a linguistic model.

However, many aspects of the culture which is usable in work have no school origin. These are latent skills: that which we expect from a worker without being a formal part of his qualifications, whether technical skills or social skills.

It is obvious that the infancy and youth of a worker or an employee give him different skills depending on whether he is the son of a farmer or a factory worker, whether he spent his life in the city, in a slum dwelling, the desert, the bush or rice fields. The vast cognitive field should be used in such a way that technical systems can be used and understood on the basis of these various skills. Ignoring these skills means that they will inevitably reappear, in an ill-timed way, at a critical moment in the form of the unexpected interpretation of a signal.

However, the attainments of workers are not limited to the cognitive field. Many body techniques acquired at an early stage of infancy or adolescence lead to good achievements in terms of balance, reference in space and motor coordination.

We know that intellectual knowledge is not enough to perform a practical activity, particularly that of production. This is not a repetition of old discussions about general intelligence and technical intelligence, but the fact that cognitive activities are developed and that thought models are formed in various situations: school, professional, games. The experimental situation in the laboratory is only a special case. The closer the real work situation is to the learning situation, the quicker the performance of operations and the greater the compliance with the model: this is learning in the field with, if possible, a workstation that is acceptable from the ergonomic viewpoint. The more this homogeneity exists, the more it has been long-established, the more difficult it is for the operator to change from one situation to another through analogy if he does not have sufficient theoretical schooling.

It is not sufficient for the new workstation to be ergonomic as well or for the conditions of the new activity to be taught. The previous work has to be studied and discussed with the operator so that, in a way, he can consider it over and done with and perceive the switch to another work situation. As such, the context of the cognitive activity plays a vital part in the formation and transformation of cognitive models.

All these concepts are necessary in an industrial society. They become vital when there are technology transfers to countries that are culturally different, not only through systems of values but through the concrete experience of action at work in very varied contexts. This is a vital part of anthropotechnology.

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SYSTEMS ANALYSIS APPROACH TO INVESTIGATING EMPLOYEE PERFORMANCE AND SKILL LEVEL

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A systems analysis model was used to explore poor job performance and to show how to effectively design and develop alternative training solutions based on a systematic analysis procedure.

1. INTRODUCTION

In today's highly advanced, technologically oriented societies many complex organizational problems arise. These problems often concern productivity, performance, employee job skills and development. Since organizational problems are extremely complex and multicausal, many underlying critical factors cannot be identified and assessed. Consequently, only the more obvious symptoms of the problem may be analyzed, resulting in a superficial, narrow and non-effective solution.

Traditionally, this scenario has occurred when an organizational problem in the area of work performance arises and a specialist in one or the other of the fields of industrial psychology, organizational behavior, human resources, or ergonomics is asked to analyze the problem and propose a solution.

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ERGONOMICS AND ECONOMIC DEVELOPMENT

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SUMMARY

Ergonomics is necessary at all stages of economic development. For some considerable time, it was involved in the very design of new tools and new artisanal machines without specialists appearing necessary. Indian ergonomics in the second half of the 20th century achieved world-wide fame through the attention it paid to the physical work of the most underprivileged, in particular with the Calcutta School of Work Psychology with R.N. Sen.

The spectacular development of the Indian economy led to India being classified as one of the NIC ("New Industrialized Countries") whose economic power is constantly increasing. It should be noted that, of all the different countries in the world, it is actually in the NICs that ergonomics has reached the level of the ergonomic activities of countries which were industrialized long before: India, Japan, Korea, China and the countries of South East Asia in Asia, and Brazil and Mexico in Latin America.

Problematics which differ from one country to another have appeared since ergonomics began to develop extensively in Asia. This diversity is not surprising in view of each of the civilizations on which the development of the various countries of Asia is based. Ergonomics that is strongly developed and well integrated in the Indian civilization is vital not only for India's human and economic success but also for the appearance of a modern world that is multicentred and hospitable for those who build it.

Technical developments over the last 25 years (automation, computerization) require a corresponding transformation of ergonomic knowledge and practices, as has been noticeable in all countries which suffered the same technological upheaval. In particular, the study of human thought, cognitive ergonomics, is vital in order to improve the relations between "natural" intelligence and artificial intelligence. This represents a research effort that is both significant and fascinating in order to have a better understanding of the natural intelligence in India which, like elsewhere, is an intelligence highlighted by culture. This investigation will lead to great progress in matters of answering questions raised by the transfer of foreign technologies and the creation of purely Indian technologies (Anthropotechnology).

However, the effort of adaptation to new industrial production methods should not be made at the expense of continuation of the remarkable efforts made by Indian ergonomists in regard to the poorest.

KEYWORDS: ERGONOMICS, COGNITION, ANTHROPOTECHNOLOGY, CULTURE, INDUSTRIAL DEVELOPMENT

1.0. INTRODUCTION: FOR INDIAN ERGONOMICS AND ANTHROPOTECHNOLOGY

In summary, the progress of science and technology was not a unilinear. Eurocentric march. Science has developed within the South Asian context as a relatively autonomous cultural growth - with influences from elsewhere of course. In tracing the development of what culminated in modern science, through ancient Greece, and the Renaissance to the great breakthroughs of the 17th century and after, I have indicated the tremendous cross-influences - many from South Asia - on the development of the modern scientific tradition in Europe (Goonatilake, 1984, p. 59) ... If South Asia had been the hegemonic power which developed science rapidly over the last 500 years,

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modern science would have been entirely different, with different pathways and tubes, because of the different historical and scientific presumptions from which it would have begun and the different internal debates within which it could have evolved. It would have resulted in different sciences, whether in the field of "pure" mental constructs such as those of mathematics, or in a purely observational science such as astronomy or in experimental sciences such as physics. Different areas of intellectual interest would have been emphasized because of social and other forces; different approaches and different methodologies would have been attempted and would of course have given rise to a different set of universal laws, valid for a different set of areas of reality (ibid., p. 87). Although the knowledge created in Europe had positive and liberating aspects, it also had negative aspects since, once it was adopted, large amounts of the non-European regions' valid, relevant knowledge was delegitimized. This delegitimization applied to very mundane knowledge, like that required for the cultivation of local vegetables or the identification of medicinal plants. The delegitimization also applied to highly sophisticated, formal systems of looking at physical reality (ibid., p. 88).

The passages which have just been quoted are taken from the book by Goonatilake (1984) called "Aborted discovery; Science and Creativity in the third world". It is an essay on the history of Sciences in the Third World and more particularly in India, in which the author, who is from Sri-Lank is particularly interested. The book is of tremendous interest despite the questionable Marxist developments and a tendency to describe historical developments which were possible but did not take place.

For someone attempting to understand the psychological and cultural aspects of technology transfers, the choice which Goonatilake made of studying the historical evolution of India is particularly fruitful. India actually has a long and great intellectual tradition and languages in which the work and the reflections of a long series of scientists and philosophers is clearly expressed.

An essential stage in the dispossession of this rich tradition was the choice of the British education system for India following the infamous "Minute" report written by Lord T.B. Macaulay in order to combat those in favour of oriental culture (en Sanskrit and Persian).

The dialects commonly spoken among the natives of this part of India contain neither literary nor scientific information, and are moreover so poor and rude that until they are enriched from some other quarter, it will not be easy to translate any valuable work into them. It seems to be admitted on all sides that the intellectual improvement of those classes of the people who have the means of pursuing higher studies can at present be effected only by means of some language not vernacular amongst them ... I have never found one among them who could deny that a single shelf of a good European library was worth the whole native literature of India and Arabia. The intrinsic superiority of western literature is indeed fully admitted by those members of the committee who support the oriental plan of education . It is, I believe, no exaggeration to say that all the historical information which bas been collected from all the books written in the Sanskrit language is less

valuable than what may be found in the most paltry abridgements used at preparatory schools in England ...

For "Le grand Larousse", the French dictionary considered as the authority: "The historical quality of the works of Macaulay is rather mediocre but he remains one of the masters of the English language".

Macaulay's text is particularly shocking for us because it deals with the Indian civilization and Sanskrit, the mother tongue of the other Indo-European languages. Unfortunately, in colonial literature, there are many other expressions of the contempt and self-importance of European intellectuals in regard to non-European cultures and in Europe itself for its own minority cultures.

In our own field, that of Ergonomics, and more particularly the psychological part of it, one should read the remarkable book by P. Sinha (1986); it is a report requested by UNESCO called "Psychology in a third world country, the Indian experience".

As a result [of Macaulay's report] English was introduced and it soon became the language of the Indian intelligentsia. It made them receptive to the West and opened up the vast world of scientific knowledge. But it had a detrimental influence in that scholars not only became more receptive to western knowledge but at the same time tended to neglect learning Sanskrit or Persian so that they progressively ceased to have access to the scientific knowledge and wisdom of the East. Dr. Brojendra Nath Seal (1958) in his *Positive Sciences of the Ancient Hindus* has amply demonstrated the richness of the ancient sources with regard to concepts and ideas pertaining even to the physical sciences. Along with receptivity to the West, the new intelligentsia that grew up under the British system also developed an attitude of indifference, if not contempt, towards ancient learning. As a result, the kind of psychology that came to India in the wake of westernisation was completely isolated from the Indian tradition and was alien to the local intellectual soil (Sinha, p. 1 1).

Reading Sinha's book is a serious warning for the westerner that I am when he addresses a gathering like yours.

The introduction of scientific psychology in India and other countries of the Third World is part of the general transfer of knowledge from the dominant countries of Europe and America. These countries were more advanced materially and at the same time had at their disposal a vast repertory of modern scientific knowledge. Therefore, domination over the colonial countries was not only on the economic and political planes but intellectual as well, which adversely affected indigenous development in the intellectual and scientific spheres and ultimately led to undue dependency of the Third World on the West even in the sphere of knowledge ... Further in many ways it can be regarded as a case of inappropriate transfer or knowledge, that is, something which was hard to adapt and assimilate to the new conditions. Knowledge is generated and flourishes in a socio-

cultural matrix. It is a product of the society and the genius of the people. This is particularly true of those sciences which are called social or human sciences, where it is inevitably linked with the world view of the people. Because it is deeply rooted in a particular culture, no knowledge can be transmitted in totality from one culture to another (Sinha, p. 125).

Although I agree with the ideas which are thus exposed, I agreed to speak before you for three reasons which are linked to my experience in India and other parts of the world which Sinha and lots of other people continue to call the Third World, an expression which has been somewhat aged by History. I prefer the expression "Industrially developing countries". This underlines that the development to be considered can only be industrial development and not social and cultural development. It is obvious that, from the cultural viewpoint, certain highly industrialized countries cut a poor figure when compared to certain nations that are presently very poor in economic terms, like India and China (Wisner, 1984).

We shall successively consider a scientific field in which India excels while remaining faithful to its people and its culture, that of work physiology, the contribution to be made to my own conceptions in Anthropotechnology and the role which E.W.A. (Ergonomic Work Analysis) can play in discovering the difficulties and improving the situation which workers and managements in NICs (New Industrial Countries, N.I.C., Mc Namara) might encounter when using imported technology.

2.0. THE INDIAN SCHOOL OF WORK PHYSIOLOGY

The characteristics of the Indian school of work physiology are absolutely remarkable. The researchers in this school not only have perfect mastery of the fundamental scientific aspect but also make efficient use of the main measurement methods both in the field and in the laboratory.

They usually describe work situations in such an accurate and pertinent way that, in their regard, one could speak of ethnophysiology. Finally, their concern is always to answer an important social requirement. Already, in 1953, Sen and Majumbar (1982) studied a weaving factory because it was one of the industries that employed the most workers in India. This social dimension is essential in the subsequent work of this author and his school: ergonomic study of buses in Calcutta (Sen et Nag, 1973), health and safety of workers in the jute industry which was the cause of 55% of the country's industrial accidents (Sen et Majumbar, 1982), ergonomic study of tea-leaf plucking (Sen et coll. 1981), research on the working conditions of train drivers in which the author recalls that India has the largest railway network in the world and shows that the specific environment often imposed a "highly demanding and complicated" activity (Sen et Ganguli, 1982). This same social preoccupation is found in the investigations of Nag et coll. (1992) who studied workers on sewing machines and recalled that there were around 700,000 sewing machines in India in 40,000 companies employing 1,500,000 workers, mostly women. When auxiliary industries are

taken into account, the clothing industry employs around 2,300,000 persons. These workers on machines suffer considerably from their repetitive and fast work in the form of musculo-skeletal disorders. The recent thesis of S.K. Mitra (1996) reveals the same social orientation in Indian work physiology. This author studied workers in brickworks and indicated that there were around 4,000 of these companies in the state of West Bengal alone. Indian physiologists have published in-depth studies of the handicapped, in particular paraplegics, and proposed judicious ergonomic advice concerning manual-propulsion wheelchairs (Goswani et coll., 1984).

Due to the considerable work done by Indian work physiologists and ergonomists, India is the only industrially developing country where one could attempt to give an in-depth description of the anthropometric characteristics of the population and its sources of variation (Wisner, 1989). It is true that India is both a large economic power and a country with a high scientific development level. 44 references, over half of which come from R.N. Sen and his student P.K. Nag have been taken into consideration by Wisner (1989).

For complex reasons, the samples studied are often small and there is no guarantee of their representativeness in terms of the population studied. The people studied in the samples are probably in better physical condition than the average population since it is often stated that young and apparently healthy workers were examined. This act obviously rules out the unemployed, the elderly and the sick. In most cases, the significance of the results is increased to a considerable extent by the fact that the study includes a job analysis of the people studied and a description of their living standards and the conditions under which measurements were taken (mostly in Northern India). The male Indian farmer (usually a poor farmer) has an average height of 157 cm and a mean weight of 39 kg. There is a slight tendency for the young (20-29 years) to be 1-2 kg heavier (Nag, 1981). The Indian industrial worker bas an average height of 164 cm and an average weight of 55 kg (Sen and Sarkar, 1979). This indicates a considerable difference compared to poor farmers. In industrialized countries, the difference is usually only 1-2 cm. The explanation for the large variation in India could be due to genetical differences linked to the caste system, but is more likely because of the standard of living and, in particular, the nutritional level in large industrial cities in the North. An indication of the comparative nutritional well-being of workers is the fact that in one sample studied older men (aged 40-45) had a higher average weight (62 kg) than younger men (20-29) who only weighed 54 kg.

Workers outside urban industry are not so fortunate. For instance, railway track repairmen are 163 cm tall and weigh 48 kg (Nag et al., 1985) and Dhanbad miners are 161 cm and weigh 49 kg (Chakraborty et al., 1979). It should be noted that in South Africa, Strydom recommends that no miners under 50 kg should be hired (Strydom et al., 1971

Heavy workers in various parts of the country (vehicle pushers or pullers, porters) are the same height as factory workers (164 cm), but are lighter (50 kg) (Datta et al., 1983).

In better-off social classes, people are taller. In various student groups, the average height is 167 cm and the weight 53 kg (Bandopadhyay and Chatopadhyay, 1981). The difference in height between workers and students is similar to that found in industrialized countries. The average

height of a group of female students is 155 cm and the weight 49 kg (Oberoi et al., 1983). In India, as in many industrially developing countries, soldiers constitute a privileged group : H - 168 cm and W - 59 kg (Sengupta et al. 1977).

Pheasant (1986) states 164 cm as the average height of the Indian male and 151.5 cm for the Indian female based on certain work done by R.N. Sen. The values are right for workers but are too high for farmers and too low for the middle classes. These remarks have consequences from the ergonomic viewpoint depending on whether equipment is designed for use by poor farmers, workers or those who are well off.

Happily, these anthropometirc considerations are complemented by the results obtained by Indian physiologists in the field of aerobic power. For Wyndham et coll. (1963), young workers in industrial countries have a "maximum V02" of between 3 and 3.3 litres/minute. But Asia and South East Asia, which have a third of the world's population, "have mostly ill-fed and undernourished inhabitants". As such, the maximal V02 is quite different in South and South Asia where a total maximum V02 over 3 l/min is only reported in Himalayan Sherpas (total maximum V02 = 3.9 l/min). This high value is obtained despite a low weight (54 kg) through intensive training at high altitude. Pugh (1964) reported the drop in Everest climbers maximal V02 in terms of increasing altitude. Conversely, men like Sherpas who have been trained as carriers since childhood in villages at an altitude of 5000 metres can reach maximal V02/kg values 30% higher than those they would reach at sea level and can reach or exceed a maximum V02/kg of 70 ml/kg/min (Nag and Sen, 1978; Nag et al., 1978).

In India, a high maximum V02 is quite exceptional since only one group of well-trained soldiers achieved 2.7 l/min (Sengupta et al., 1977). Students reach 2.5. l/min (Maïtra, 1979).

Industrial workers (Sen and Sarkar, 1979) and porters (Samanta and Chatter jee, 1981) are between 2 1 and 2.5 l/min. Farmers (Nag, 1981), miners (Chakraborty et al., 1979a), railway maintenance workers (Nag et al., 1985) hardly exceed 2 l/min. In particular, it should be noted that miners have a mean weight (49 kg), below the recruitment exclusion level in South Africa and have a total maximum oxygen uptake (VO2) of 1.9 l/min, 25% below that considered as minimal in South African mines.

In fact the muscular capacity expressed by the maximum V02 /kg is similar in Africa and Asia and is between 40 and 45 ml/kg/min as in any young, thin, trained man. It may be noted that the maximal V02 /kg values obtained by dividing the total weight are proportionally lower for Indians since they are thinner than Africans (12-17% body fats) (Lange-Andersen, 1972; Ojikutu et al., 1972). The body fat rate is between 5 and 10% in India for farmers (Nag, 1981) and porters (Nag and Sen, 1978) with an average of 7%. In Indian women, body fats are between 13 and 19% (Nag et al., 1978b). What mainly distinguishes Indians and South-east Asians from Africans or people elsewhere in the world is their low weight which is around 43 kg in poor farmers, 49 kg for miners and railway workers, 50-55 kg for industrial workers and porters, 53 kg for students and 60 kg for soldiers. Most of the populations of IDCs have tropical climates. Their actual working

capacity is limited by heat (Sengupta et al., 1977); a study of professional soldiers with an average weight of 59 kg shows the comparative drop in total V02 and V02 /kg with heat. Sen and Sarkar (1979) produced comparable results. This shows to what extent physical activity in a warm country can be reduced in terms of the heat environment, especially in people with a low capacity and in the case of substantial efforts in people with a normal capacity. The results obtained by Nag (1981) on the reduction of capacities through *age* in an Indian village are significant.

The 8% loss in the 30-39 year age bracket and the 19% loss in the 40-49 year bracket are almost fully explained by weight reduction when lean weight is taken into account since body fats increase with age. Sen and Sarkar (1979) obtained more favourable results in Indian industrial workers.

There are less Indian data on *women* than on men. Yet these studies give an evaluation of Indian women's capacities at a low level. This level is linked to the low weight both in female villagers (39 kg) (Nag et al., 1978b) and in female students (45 kg) (Maïtra, 1979; Oberoi et al. 1983). It is also linked to the rather low level of the muscular capacity expressed by maximal V02 /kg: between 30 and 35 ml./kg./min in female villagers as in female students. As such, a total maximal V02 of between 1 and 1.3 l/min is reported in poor village women and 1.5 l/min in female students.

Indian physiologists (Nag et al., 1982; Goswani et al., 1984) made an extensive study of the physical capacities of *disabled* persons, especially paraplegics. With an average weight of 40 kg, the paraplegics examined had a maximal V02 of between 1 and 1.3. l/min. It is known how significant these data are for the design of motorless wheelchairs since an excessive and sustained effort could provoke heart failure.

This questionable description of a limited number of Indian data seems to show that ethnic differences have less influence on anthropometric and physiological differences than the social and economic situation, the sex, the age, the climate or the altitude. The large and fast change in the characteristics of the Japanese population over the last 40 years of prosperity shows that human populations don't have an unalterable character.

My interest in these questions is closely associated with my links with the Indian school of ergonomics and work physiology but also with my participation in the examination board for the thesis of P.M. Nag, A. Goswami and, more recently, S.K. Mitza.

2.0. THE INDIAN ORIGINS OF ANTHROPOTECHNOLOGY

In 1970, I met Professor R.N. Sen for the first time and, thanks to him, Indian ergonomics and work physiology. He went on to organize the first post-graduate course in 1971 in Calcutta and prepared the first Indian ergonomics seminar which was held in 1972 with an excellent exclusively Indian participation. In 1974, again in Calcutta, R.N. Sen organized the international satellite symposium on ergonomics and work physiology during the 26th Congress of Physiological Sciences.

I improved my knowledge of the Indian school during stays in Calcutta in 1975 and in Bombay in 1976 thanks to the B.I.T. which asked my to prepare part of the P.I.A.C.T. (International Programme for Better Working Conditions). One of my main concerns was that of understanding the share of responsibility of technology-exporting countries in the too numerous technology transfer failures, the scale of which is constantly increasing. These failures were explained, at the time, by statements like those of Macaulay. In order to grasp the mechanisms of these failures, I started examining the anthropological, economic and social causes of these difficulties of technology transfers by trying to constitute an interdisciplinary field of knowledge which I called Anthropotechnology (Wisner, 1976). I was also helped in this reflection by the participation of C.N. Daftuar at the Oosterbeck seminar (1972) whose work was published in 1979 by A. Chapanis under the title "Ethnic variables in Human Factors Engineering".

The work of Sen, like that of Daftuar and my visits to Indian companies in 1975 and 1976 helped to rid me of my uneasiness in regard to the fundamental orientation of the Oosterbeck meeting where the main concern was that of showing that the difficulties between the centre and the periphery was explained by the ethnic particularities of the countries of the periphery in question, like anomalies compared to the single view of NATO countries, representing the general tendency of global industry. As we shall see later on, my present reading of the situation is that of a pluricentric industrial world.

In my visits to various Indian companies, I was struck by the obvious opposition between a Tata textile factory in Bombay and an electronics plant, a branch of a European multinational, in Calcutta. The former was an old factory (probably dating from the First World War), evidence of the age of Indian industry. Two facts among lots of others were representative of the Indian situation: first of all, there had been a recent strike in order to have the canteen closed so that the workers could share the money corresponding to this advantage with their families, while the international recommendations of the time were to feed the workers in the company abundantly so that they could reconstitute their working strength. Secondly, half of the factory's infirmary was dedicated to a surgical unit where they practised ligature of the spermatic tubes of fathers with large families, like the example of Mr. Tata, in return for a reward.

Apparently, in the foreign electronics plant in Calcutta, the situation was far removed from that city still overwhelmed by migration linked to the recent war of independence in Bangladesh. Although the management, the engineers, the managers and the workers were all Indian, all the machines and the entire organization were European. The analogy of the posture and the attitudes of Indian workers was striking in comparison with their European counterparts. At a meeting with the managers, I learned that everything, including the professional pathology, was similar to that of Europe (visual and postural disorders and depressive tendencies). Considerable efforts had been made at a great cost in terms of selection, health, housing and training in order to create a group

comparable to what could be found in Europe, but without preventing the specific professional pathology. However, two aspects of Indian social pressure were visible: medical care was not reserved just for the workers but for the enlarged family. In addition, wherever possible, a female worker who left the company was replaced by a member of her family. For me, this situation was the prototype of what I subsequently called the "anthropotechnological island" which is found all over the world when the management wants to obtain results that satisfy international criteria in regions are not favourable to it.

Without being able to observe the facts, later I studied with great interest a dramatic event which took place in India and I was struck by the violent conflict between requirements which came from elsewhere and the characteristics specific to the country. I refer to the disaster which took place in Bhopal in 1984 in a plant set up through a joint venture between the state of Madya-Pradesh and the multinational firm of Union Carbide. An essential source of information and reflection concerning the Bhopal disaster was the book published by L. Surendra (Area, Asian Regional Exchange for new alternatives, 1985) consisting of a collection of 31 articles published in the Indian press (19 publications) by 19 journalists. Most of the articles were of a very high scientific and professional level, which is a credit to the Indian press. In particular, the four articles by Praful Bidway published in the Times of India (December 1984) should be noted.

The source of the difficulties which led to the disaster was linked to an industrial decision to build a plant for the production of insecticide - Sevin or Carbaryl - which belonged to a category whose sales were declining and, especially, the choice of the site of Bhopal for the industrial-scale production of one of the components of carbaryl - alphanaphtol - using a process which, previously, had only beeen tested at a semi-industrial level. And yet the switch from a semi-industrial level to an industrial level is always a very risky operation in a region which, at the time, wasn not a great scientific and industrial centre. From the outset, the failure of this operation created a serious financial situation for the plant. It was condemned to lose money each year. It was also a political setback for the state of Madya Pradesh. It appeared vital to make savings which would lead to deterioration of the technical and human situation: the total lack of thermometers and pressure gauges and shutdown of the refrigeration circuit of the tanks of MIC, a product that is explosive at high temperature in the presence of impurities. Maintenance was considerably reduced: the safety circuits and alarms had been cut off "to avoid disturbing the neighbourhood"; purchases of supplies and spare parts had stopped and bonuses offered for voluntary redundancy led to the departure of the best workers and managers. Trade union persecution completed the reduction of the possibilities of alerting the population and political risks paralysed most of the inspection authorities. Finally, the secrecy concerning toxic products delayed the application of efficient treatment.

It would be wrong to believe that such a structure of causes is particular to India, except perhaps as regards the overpopulation around the plant. Previously, in Italy, there had been the Seveso

disaster, that of Mimata in Japan and, since then, we have witnessed the Three Miles Island incident in the USA and the Chernobyl disaster in Russia.

We know that we must fear other dramas if we don't take care with complex and dangerous systems (Wisner, 1996). What was characteristic of Bhopal was the fact that it was the first disaster that was studied so carefully and with such great honesty thanks to the Indian press. However, the book by Arena very quickly disappeared from circulation.

In any event, as far as I'm concerned, the Indian study of the Bhopal disaster showed the importance of the anthropotechnological study of technology transfers by not limiting research to the ergonomic study of the system (on which a lot could be said in the Bhopal case). The study should also include errors in technical decisions and in the installation of plants; there are the cases of mismanagement mentioned by the N.R.C. (Nuclear Regulatory Commission) which assessed the condition of certain American nuclear power stations.

4.0. ERGONOMIC WORK ANALYSIS

4.1. Indian contribution to psychological ergonomics

D. Sinha (1986) distinguishes four sections of the history of Indian psychology: before independence, after independence, then the period of orientation towards the country's problems and, finally, the phase of indigenization. His underlining of the importance of the last two phases is all the more valid since he himself is specialized in social psychology and, to a lesser extent, in clinical psychology, two branches of psychology which are both deeply rooted in the culture and history of society and its spiritual convictions. This shows to what extent the numerous works published by Indian researchers over the last 30 years have been useful in Anthropotechnology. Mention could be made, for example, of the "nurturant task leader" (J.B.P. Sinha, 1980), the result of the "Guru-Chela" (preceptor-pupil) relationship. Certain French authors' interest in the Indian management style have shown the interest of this specifically Indian approach (Mathieu, 1987).

Despite his reserves in regard to the psychological research done in India during the period following independence, Sinha indicates the work of Ergonomics and Human Engineering of Adiseshiar in the fifties in the field of national defence. For ergonomists who are familiar with international literature, it is surprising to note the lack of any text by C.N. Daftuar who, in particular, directed two reviews on the subject of Indian ergonomics. One was published in the most widely-read Ergnomics review (Human Factors) under the title "Human Factors Research in India" (1971). In this text, Daftuar indicates 36 Indian ergonomic references. The other review of the matter is entitled "The role of Human Factors Engineering in Underdeveloped Countries with special reference to India" and constitutes a chapter of the book by Chapanis (1975) mentioned previously.

Among the multiple works of Daftuar, those which are relative to linguistics interest me in particular because this is an essential matter in Anthropotechnology and more particularly in India which, alongside English, has some 15 main languages of which Hindi is the predominant one. For example, Daftuar compares the legibility, for Indians, of numbers written in Roman, Arab and Devenagari (Sanskrit) characters with the legibility of characters in the Roman, Devengari and Bengali alphabets. Daftuar (1977) also experimentally demonstrated the different success levels of an Indian intelligent test written in Hindi and translated into English for Thai students at the University of Gaya (Bihar), according to whether the questions were asked by an Indian or a Thai. The check-test confirms the first results when the English version of the test is given to Indian students by a Thai and then by an Indian. As such, one of the major questions raised by common languages like English, French, Spanish or Chinese is that of their pronunciation and the accent of the speakers alongside that of the content of the local vocabulary (pidgin).
D. Sinha points our the existence of Indian research on cognition and stresses the specific aspects of the intellectual development of the child on the importance of the

"context of an elaborate system of rituals and practices which characterise the Indian society" (Basu, 1975) "of the modalities of interplay between the universal processes of human development and the specific forces of Indian social reality surrounding the growing child that comprise mainly religious ideals, historical traditions and social institutions that are not only unique but probably exclusive to the Indian scene" (Kakar, 1978).

D. Sinha insists on the fact that

"Evidence from comparatice cross-cultural researches shows how habits of perceptual inference, use of cognitive strategies, linguistic and motivational are conditioned by cultural and ecological factors".

On the basis of this, Sinha insists on the necessity of creating research methods which enable the work situation to be explored in its social and cultural context while maintaining a solid, theoretical anchorage.
It could be considered that this concern was similar to that of French-speaking ergonomists when we proposed Ergonomic Work Analysis (E.W.A.). They applied it to anthropotechnological questions and came closer to the theoretical context offered by American cognitive anthropology (Wisner, 1995).

4.2. Methodology of ergonomic work analysis

In principle, this methodology includes an analysis of the request, an examination of the technical, economic and social conditions, an analysis of the activities - the central element of the study - the

diagnosis, recommendations, simulation of the work on the modified system and evaluation of the work in the new situation. Such a methodology is extremely cumbersome if it is followed up in full. In reality, the complete work analysis process is rarely necessary.

The central and original part of ergonomic work analysis is the analysis of activities. Here it will be presented in its most comprehensive form, constituted progressively by different authors (1992) including Theureau (1992).. The concern for obtaining objective and comprehensive data leads the analyst to study the behaviour of the operator with a tendency towards exhaustiveness. This leads not only to the behaviour of action in the tool or machine being taken into account - in the style of "time and motion study" specialists - but also the behaviour of information collection (in particular, movements of the head and eyes) and communication behaviour (gestures and speech). The latter obviously have a particular status owing to their symbolic character. Naturally, these various types of behaviour may be the subject of recordings, measurements and statistics, but the most beneficial grouping of these behavioural data is that of "histories", which may be easy to isolate and are situated in a short space of time, like the correction of a typing error or changing a tool on a machine tool. Sometimes, in complex activities, "histories" consist of several episodes separated by other activities, like an attempt to solve a quality problem through the repeated adjustment of a machine, or the preparation, execution, dispatch and receipt of the results of a biological examination by a hospital nurse. Several "histories" may be mingled in a given period of activity.

The behaviour observed, even when grouped in "histories", does not always give an understanding of the cognitive activities that explain them. That is why specialists in ergonomic work analysis complement the observation of behaviour with an approach that is very different from the. epistemological viewpoint; self-confrontation.

Self-confrontation

In principle, the self-confrontation interview avoids any judgement of value, any concept of disobedience of recommendations or incorrect procedures. The questions are asked on the basis of what the ergonomist has noted or recorded; confrontation with the videotape recording is often instructive. The operator is seen to be surprised by the fact that he neglected an indicator that he thought he was monitoring and that he very often observed part of the technical system to which he did not think he attached such great importance. He easily gives an explanation for certain types of behaviour that surprised the observer, but may have to think for some time before recalling the explanation for why he behaved in an unusual way. It is obvious that self-confrontation, which is very often beneficial, should be treated with great caution since the a posteriori reconstitution of a fictional rationality is a permanent risk. However, this risk is limited to a certain extent by the fact that the interview is always closely linked to the facts. In any event, this procedure is much safer than an interview with no prior in-depth observation of behaviour.

The major interest of self-conformation is probably that it highlights elements of the cognitive unconscious. This plays an essential part in heuristic activities that enable problem building. Thanks to Kohler (1927), since the start of the century it is known that man is far from grasping the integrality of observable facts. He uses unconscious processes to select certain elements that are grouped in structures *(Gestalttheorie)* and neglects the rest, especially when he does not consider them to be directly pertinent. These phenomena play an important part in recall, which is closely linked to previous activities and to culture (Ohlsson, 1985).

In other words, the subject does not reason in terms of the proposed situation, but in terms of a personal representation of it. An elegant demonstration of this reality was given by Ochanine (Ochanine and Zaltman, 1973) who asked operators to design the various elements of the chemical production systems on which they worked, as well as the links between these elements. Ochanine often observed a very deformed image of the system, but considered this representation as functional and gave it the name *of operating image.* In this way, many aspects of reality are modified in the representation, but the massive reduction of information and the selection made as such are indispensable in view of the limited character of human cognitive capacity.

4.3. Analogies and differences between the study of situated action and ergonomic work analysis

4.3.1. Contributions from cognitive anthropology

One of the bases of modern ethnology was expressed by Boas (191 1) who thought that each culture should be understood from its own premises, while Malinovski (1922) insisted on the need for extensive field work. Goodenough (1957) then defined culture as cognition, as a system of knowledge. He studied the mental phenomena that should be taken into account in order to understand human behaviour; these mental phenomena are considered as complex and rational and are able to be studied thanks to strict methods that lead to reproducible results.

Casson (1981) insisted on the fact that the approach of cognitive anthropologists was closely linked to empirical reality.

"The picture of the individual emerging from current perspectives in cognitive anthropology is simultaneously as a learner and creator of culture. An individual represents his understandings of experience as cultural knowledge in various forms and reapplies this knowledge as it is seen to be contextually appropriate. Both representations and reapplication simultaneously reinforce experienced patterns and contain the elements of cognitive reorganization and creativity in behaviour and understanding" (Dougherty 1985: 8).

One can see to what extent cognitive anthropology is close to it the principles that are the basis ergonomic work analysis. One has to understand the operator's cognition (and not give him ours or that of the designer). This can be done through long, detailed field studies. The models are based on a hypothesis of operators rationality.

Anyway, our position is that of an ergonomist and a cognitive psychologist who is attempting to grasp cognitive phenomena in the field and who is not afraid of including, in the situation treated by the operator the context, the environment, the operator's prior knowledge and his/her relations with others, as done by Neisser, 1976; Cole and Scribner, 1974; Rogoff and Lave, 1984; Scribner, 1984; Sternberg and Wagner, 1986.

Defining such a position does not answer any question. It simply amounts to acknowledging a fact; the extreme diversity and variability of real work situations in which the actions of operators and users are situated. The main aim of EWA is to find out how operators constitute the problems of their work (situation and action) in a stable or variable way and, to a lesser extent, how they solve them. As such, it is close to the position of authors favourable to situated action. However, it also has a more ergonomic aim, that of identifying pragmatic obstacles, the elements of the situation that hinder an easier constitution and resolution of the problem.

4.3.2. Technical, economic and social constraints and anthropological treatments

The ergonomics of technology transfers was called anthropotechnology in order to underline the fact that knowledge that is useful when dealing with difficult questions of the transfer belonged to collective human sciences and not to individual human sciences, as is the case for ergonomics.
With 20 years experience in various countries (Algeria, Brazil, Canada, the Central African Republic, India, Indonesia, the Ivory Coast, Japan, the Philippines, Senegal, Singapore, Thailand, Tunisia, Zaire, etc.) thanks to personal studies and international collaborations, it is possible to conclude that there are problematics specific to each country. This is linked to the tremendous diversity of situations noted in the countries and regions that acquire foreign technologies and attempt to implement them with various degrees of success. Owing to the main differences observed in the installation and the results of identical technologies, according to the location of the company, it is necessary to study the geographic, historical and, in particular, the ethnological dimensions, as underlined by the title of Chapanis's book (Chapanis, 1975). However, the common points in the economic development of the most diverse countries are too numerous for major socio-economic components to be ruled out.
Anthropotechnological methodology: The orientation of anthropotechnology is similar to that of ergonomics. It is aimed at solving particular problems using general methods, reducing the risks of workers (professional illnesses; work accidents and disorders linked to industrialization which are more common in IDCs), improving the characteristics of production (quantity and quality) and reducing the deterioration of production facilities.
The general methodology is also similar to that of ergonomics. However in a similar way to what is generally practised in engineering, a comparative method is proposed (Wisner, 1976). First of all, prior to the technology transfer a study is made of the technology presently in operation in order to highlight its defects and correct them in a new design.

In anthropotechnology, this stage is done through the EWA of the critical points of the technical system in the seller countries, thus avoiding a situation where the system is necessarily considered satisfactory and ergonomic. The method also includes a study of the critical aspects of a similar technical system operating in the buyer country or in a country that has similar characteristics.

Justification of the use of EWA in a technology transfer is still more convincing than that of its use in ergonomics. The factors that influence work are too numerous for a forecast to be made, from the outside, of those that constitute determining obstacles in the particular situation considered and which may be removed thanks to the means at the disposal of the company or its partners. However, in anthropotechnology, a search for the origin of the difficulties encountered is made and a tree of causes is constructed that is not limited to the technical and organizational aspects that are closest to the workstation. For example, it could be discovered that the air-conditioning system of a continuous process control centre is not working in a subtropical country because the foreign trade inspection department has not listed argon as a priority import product. In an oil mixing plant (Langa, 1994; Langa and Wisner, 1994), it was difficult to organize production owing to the uncertain arrival of oil tankers, overloading of the railway line linking the port to the plant and the lack of storage tanks for unprocessed and finished products. In this case, it is understandable that the first two causes are beyond the scope of the company's actions. However, an increase in the number and dimension of the tanks could be an acceptable cost and the decision is the sole responsibility of the company that owns the mixing plant. In another situation (Abrahao, 1986), among multiple causes of the low production level of a sugar cane alcohol distillery, the most significant and the easiest to modify was the rigid organizational, hierarchized and centralized design of the company's management, a design that was incompatible with the realities of a continuous process plant. Finally, in a phosphates mine (Sahbi, 1984), the large number of very expansive hydraulic props out of order was an essential dimension of the financial difficulties while the maintenance department was insufficient and totally uninformed of the unsuitability of the repairs it made to the props in regard to their age and their use down the mine.

4.3.3. Ergonomic work analysis and the refusal of a priori explanations of transfer difficulties

Anthropotechnology, which makes a comparative study of the use of technology in the buyer country, situates the work activity in the context of the society where it takes place. This point of view is evoked by those who, in line with Vygotsky (1934 [1962] and the Russian school, attach great importance to society in the construction of cognition (Wertsch et al., 1984). In this research context those who claim kinship with Vygotsky and Ochanine move away from a simplistic version of the theory of reflection in order to consider an instance of interpretation and deliberation where the importance of anthropology appears between the technico-economic data and the way in which situations are treated by individuals and communities (Magaud and Sugita, 1993). The technology and the social conditions do not produce a detailed determination of the

activities of individuals or groups and the result of their work. Only a meticulous analysis of their behaviour and their situated activities is capable of starting from reality to arrive at the remote, multiple causes of the difficulties. As such, the bottom up approach of EWA constitutes a sort of guarantee in regard to a dogmatic interpretation of the operating defects in exported technical systems and enables the creation of spaces situated at various levels in order to solve the difficulties noted. The reason why ergonomic work analysis turns out to be determining is that, in a industrially developing country the real work is even more distant from the prescribed work according to the vocabulary of French-speaking ergonomists. In effect, the poor comprehension of the fact that electronic control systems are necessary to obtain production quality, the difficulty in purchasing spare parts and the lack of experts too often provoke permanent operating anomalies in the technical systems of industrially developing countries which may go as far as deterioration or waste. Owing to this, operators have to construct their tasks under special circumstances that depend on the type and extent of the anomalies. The operators' comprehension is not helped either by instructions written in the most academic form of a foreign language. Sinaïko (1975) made a very good analysis of this type of question. Operators may even have difficulties in communicating with engineers trained, like all engineers, according to a logic of design and not a logic of use. Furthermore, these engineers are trained in a vehicular language but are unable to translate the principles into vernacular language so that it may be understood by operators (Madi, 1994). It is wrong to think that these operators always have a low education level. Sometimes they are more educated than their counterparts in industrialized countries but they have to construct their problematics in regard to a more or less downgraded system, without the benefit of a technical manual that they can understand and without the help of supervisory staff able to express themselves in the sense of their problems. Social distances that are increased by substantial wage differences and sometimes class, caste, religious and political differences may create conflict situations in the company that further complicate the comprehension of and the solution to technical difficulties. It can be seen that the concept of cognition in a situation then takes on a great significance and that EWA is the least that can be done to approach reality.

4.3.4. The operator, iterative creator of his task. The grasp of foreign technology.

Considering the operator as the repeated creator of his task, a position that might appear audacious at first glance thus becomes a necessity since he cannot execute a program that does not correspond to the technical reality which, in addition, is transmitted to him in an obscure and unsuitable language. This considerable work of the operator enables him in an obscure and unsùitable language. This considerable work of the operator enables him to progressively turn from a farm labourer into an efficient worker in a work team according to modalities of the type evoked by Garfinkel (1967) in regard to ethnomethodology. Such a representation of the activity of operators and their managers working on the same technical system imported from abroad has the advantage of demonstrating clearly that a technology purchased cannot be used unless it is understood in depth, taking into account the realities of all sorts specific to the country. This clearly corresponds

to the double relation that Vygotsky saw between the person and society which, first, provides him with technologies and, second, acts through its social organisation.

5.0. CONCLUSIONS

The determination to create work physiology, scientific physiology, ergonomics and - perhaps - anthropotechnology that is specifically Indian is an enterprise that is difficult but has already been successful to a great extent after an age-old effort. The immediate stakes are obvious, that of contributing to the successful agricultural and industrial development of India. But there are other stakes which interest the future of international development.

Contrary to what is affirmed by many authors, in particular economists, as far as we can see there is no convergence towards a single industrialized civilization based on the American model; what we are heading for is the maintaining and development of several major industrial civilizations. In fact, the various industrial civilizations of Western Europe have never been identical to each other and have always differed from the industrial civilization that developed in the United States. Since the 19th century, we have seen the appearance of at least two other major industrial civilizations: Russia and Japan. I think it is obvious that the 21st century will witness the affirmation of at least two other major industrial civilizations: India and China, and probably Brazil (Wisner, 1985).

The success of the Japanese industrial civilization has been the subject of many studies. Some, like that of Ekwan (1996) were limited to an exalted proclamation. But others provided an in-depth analysis of this phenomenon according to the Weberian model (Morishima, 1982).

As such, the effort in which Indian ergonomists are participating is useful for India but also for the blossoming of the multiple industrial civilizations which will characterize the forthcoming historical period.

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