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Situated cognition and action: implications for ergonomic work analysis and anthropotechnology

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After a short history of the study of work activities, the methodology of Ergonomic Work Analysis (EWA) is described and the diversity of practices is underlined. The methodology of analysis of activities involves exhaustive checks of the behaviour of operators in critical situations and confronts the operator with his own behaviour in order to obtain pertinent explanations and evoke the cognitive unconscious. Ethnological work may constitute a contribution as regards the choice of the operator(s) whose behaviour is the most significant for the problem posed. In the same way, ethnologists using recording tools that are similar to those of ergonomists offer interesting frameworks for discussion of the qualities of these tools and the posture and balance aspects of behaviour. Moreover, interpersonal communications lead to beneficial exchanges with the ethnographic experience. Although the American school of situated cognition (cognitive and psychological anthropology) is very useful to know for activity analysts, it should not be confused with EWA which, by definition, is directed towards an objective: knowing and transforming obstacles of all types that hinder and prevent satisfactory activities. First of all, EWA has to show, from the viewpoint of operators, how they build problems in order to be able to solve them. Ergonomists and ethnologists note how difficult this problem building may be in view of the variability of the technical system and of the state of operators' knowledge. The technology transfer situations studied by anthropotechnology need EWA even more in view of the frequent degradation of technical systems and the heterogeneous character of the two cultures present in the mind of the operator: his own culture and that which has inspired the imported technology. From this viewpoint, here and there the operator may be considered not as a performer but as the iterative creator of his task.

1. Introduction: A short history of the study of work activities

One of the reasons for the present difficulties concerning ergonomics stems from the modesty of theoretical and epistemological studies of the discipline, with the exception of some notable examples (Meister 1989). Many ergonomists maintained a rather positivistic conception of the science, which led to claims of their attachment to experimentation and a priori modelling. However, in order to succeed in their professional practice, they are concerned with what happens in reality and they try to understand the reasons for the behaviour of operators in real situations. As such, they provoke an epistemological slide that is both substantial and partly hidden. However, for more than 40 years, French-speaking ergonomists Pacaud (1949) and Ombredane and Faverge (1955) have made a clearer choice by creating Ergonomic Work Analysis (EWA). There are few theoretical texts that give an account of this practical method.

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Only the efficiency of EWA appears to justify its existence, thus ruling out the possibility of dialogue with specialists in neighbouring disciplines. It is true that, at the time of creation of EWA, the dominant paradigms were those of behaviourism and laboratory experimentation, the results of which were supposed to be applicable in real situations. Certain ergonomists felt uneasy about the contradiction between what they saw in the field and the experimental results obtained (Wisner 1972). However, in the literature they found no conceptual aid, only the same concern (Bartlett 1932, 1958).

Some anthropologists and psychologists, most of whom were working in the USA, felt uneasy in the theoretical contexts of the period, in particular that of cultural anthropology: hence, they created cognitive anthropology. Cognitive anthropology, which was first of all directed towards the relation between cognition and language (Sapir 1958 and Whorf 1956) sought generative grammar of thought, inspired by Chomsky, the theoretical study of which played an essential role at the time. Gradually, thanks to a group of psychologist and anthropologist authors, a collection of works led to the creation of a new field: thought and action in situation, *situated cognition*, which was very close to what EWA was analysing (Resnick 1976, Casson 1981, Rogoff and Lave 1984, Dougherty 1985). It might be interesting to see to what extent theoretical studies of situated cognition, which appeared 30 years after EWA, are able to shed light on the epistemological problems raised by the latter. Very few ergonomists, even French-speaking ones, with the notable exception of Theureau (1992) and Pinsky (1990, 1992) established the link between EWA and the American school of situated cognition. This paper will attempt to examine the possible relationship. This attempt involves risks for those who cling to the division of human sciences that were proposed a hundred years ago by Durkheim (1895, [1986]), leaving the study of thought mechanisms to psychologists and the study of thought content to sociologists (and anthropologists). This arbitrary division raised protests for some considerable time (Malinowski 1922, Vygotsky 1934, [1962]), but remains well in place. Without judging the legitimacy of this division, it could be thought that it is of no interest to ergonomists whose role, for the past 50 years, has been to use, in human sciences, that which might appear useful in various disciplines, even if it means perverting them due to a concern for utility. Although ergonomists now have to exercise their epistemologically risky efforts on branches of sociology and anthropology, this is unimportant as regards our perspective of utility in as much as our work is done in a clearly defined theoretical context using adequate and precise methodologies. Theoretical aid may now come from French-speaking anthropologists who are interested in work (Althabe and Selim 1990). In the first part, consideration will be given to the methodology of EWA in its relations with the contributions from ethnological methods, then an investigation will be made of the extent to which the theoretical work of cognitive psychology and anthropology relative to situated cognition may be useful for ergonomics, in particular for ergonomic work analysis. Finally, an examination will be made of what EWA and situated cognition can contribute to anthropotechnology, i.e. better technology transfers and the adaptation of technology to the countries and populations that acquire it. As such, what is proposed is the acknowledgement that ergonomics has an anthropological dimension, both in terms of its methodology and its fields of application.

2. Ergonomic work analysis and the methodological contributions from ethnology

2.1. *Diversity of practices in ergonomics*

Most often the ergonomist is called in when there is an opening anomaly; errors, quality

problems, incidents, accidents, continuous process control difficulties, staff fatigue, anxiety, laboriousness, etc. In many cases, the causes of these operating defects are fairly easy to detect. The answer is found through the use of literature or simple and fast experimentation that does not always respect all the rules of experimentation publishable in a scientific journal (quick and dirty). More often, a survey has to be carried out in the field so that operators or users can be heard. Literature contains exploratory studies, participative observations and systematic surveys that may have a statistical value. These come closer to sociological studies or research into subjectivity, which are presently gaining some ground. These investigations have the merit of situating the problem, measuring its importance and appreciating the scale of the transformations that the company is prepared to allow. In this way, the question is posed in a technical, economic and social context and one can appreciate the diversity of viewpoints developed by the various persons concerned; operators, supervisors, designers, customers, shopkeepers, etc. Thus, certain ergonomists feel that they are able to reformulate the question asked. Finding the solution to the problem as formulated by the demander is very rare. However, the dangers of reformulation are known, which are quite simply liable to draw the request towards a particular scientific field, dear to the ergonomist concerned, while leaving aside the major aspects that are beyond him. This movement may also please the demander, at least in an initial phase as long as the intersubjectivity relation is successful.

After this reformulation, a solution can be proposed through experimentation and material or computer modelling. However, there is a certain risk of the real problem not being treated if a precise observation of the activity is not compared with the representation of the persons questioned. In particular, the unconscious dimensions of cognition may be missed by the analysis.

That is why a large number of ergonomists tend to make increasing use of EWA, which provides an exhaustive description of the activities of certain operators or users in phases of implementation of the technical system that are considered to be critical. The full value of this detailed study of behaviour is revealed when it is compared with the representation that the operator or the user has of his own activities during the same period (self-confrontation). In general, in order to approach cognitive activities, the use of several methods appears to be vital in highlighting beneficial contradictions.

There are numerous variations in ergonomic work analysis according to each author, but also in terms of the situations studied. A description of EWA that is shared by a lot of French-speaking ergonomists is given; they are the ones who appear to make the most use of it.

2.2. *Methodology of ergonomic work analysis*

Many texts describe the current methodology of ergonomic work analysis (Guérin *et al.* 1991, De Keyser 1991). 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. For example, through experience, the ergonomist who works for a company knows the validity of the request and the way is could be reformulated. Often, he has a simulator (automobile, nuclear industries, etc.). On the contrary, the consultant ergonomist, who is often a general practitioner, has to make a close examination of the question asked and often has to

reformulate it in order to deal with the real questions that are often hidden by a trivial formulation of the request. He also has to know the limits of the action that he might take, by taking into account the specific technical, economic and social realities specific to the company that asked for his services; sometimes, he has to find out what these realities can teach about the system or the specific workstation that he is studying. However, frequently, the analysis of activities can be reduced and concerned with only a few critical points in the case of usual ergonomic problems for which vast ergonomic know-how is more or less available according to the experience of the consultant. It is then a 'short diagnosis' (Boutterin *et al.* 1994).

The formulation of the recommendations may be a rather simple, short-term phase. It could also be the subject of a complex process in collaboration with designers and future users, especially if the system is to differ considerably from the original one. The need for iterative simulation often appears (Pinsky 1990, 1992). Sometimes a specific methodology has to be used in order to define the probable future activities of a production system that is being prepared (Daniellou and Garrigou 1992).

2.3. *Analysis of activities*

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, 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 correcting 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 follow-up of such procedures takes a long time. Analysis, in particular, is tedious. Therefore, they cannot be multiplied and, most often, one has to abandon the idea of using them in a statistical way. As such, the choice of the persons to be studied and the work periods to be considered are highly critical. Yet, the type of request is an essential guide: analysis of activities is done in the perspective of detecting the causes of one or more anomalies and the changes that must be made in the critical situation. This polarization of research through the need to solve the problem posed constitutes an essential feature of EWA that distinguishes it from the ethnological survey to which EWA may appear very close. For example, in ethnological literature, discussions are found which are very useful for ergonomists when it comes to choosing the subjects observed and the critical periods (Werner 1969, Gardner 1976, Boster 1985). The way in which the members of a group work is shared in the double sense of the sharing of task and the pooling of part of the know-how (Resnick *et al.* 1991). It is obvious that the results obtained on the basis of a detailed analysis of the activities of a small number of persons over very short periods (Six and Vaxevanoglou 1993) may be used for the

subsequent construction of a systematic observation of a more limited number of critical phenomena on a larger population for longer periods of time. This use of a second phase, which leads to the production of data with a statistical value, may be reassuring from the methodological viewpoint, but this takes nothing away from the value of the first phase of detection of the complex relations that may exist between the technical system and the persons who work with it.

2.4. *Recording tools*

The effort of exhaustiveness in the observation of behaviour obviously has technical limits. Recording with a videotape recorder can be useful when the paper-pencil or recorder notation (Kerguelen 1991) does not enable events to be followed rapidly. Suchman (1987) also recommended it, but she appears to give it particular qualities of objectivity. This opinion is debatable, since any experienced photographer knows that the choice of centring and details highlighted in a scene constitute an option that is just as clear as the elements that an observer notes by hand. The real advantage of videotape recording lies in the subsequent possibility of self-confrontation with the operator or reinterpretation by ergonomists. Recording speech on a tape recorder is vital as long as the speech is to be analysed in detail. Here again, interesting debates have taken place between ethnologists in regard to the role of the data collection method and the value of the research results. The verbal expression of populations of Trobriand (Malinowski 1922, 1965, Lee 1940, Hutchins 1979) is a good example of this methodological discussion.

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.

2.5. *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 thus closely linked to

previous activities and to culture (Ohlsson 1985). Considerable work has also shown the mechanisms of recognition of speech, voice, faces or silhouettes. Evans (1989) took up this question in order to understand the nature of bias, which often leads to the wrong representation of situations. He started with the conceptions of Henle (1962) who considered that subjects (operators, users) add, delete and alter the proposed premises. In other words, the subject does not reason in terms of the proposed subject, 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 the human cognitive capacity. Alongside self-confrontation and the Ochanine method, Vermersch (1990) proposed other methods of approaching the cognitive unconscious.

2.6. *Body aspects of work*

The considerable development of cognitive psychology and its use in EWA may have the effect of underestimating the importance of the body aspects of work. An important initial point concerns body techniques. Gatewood (1985) called the article he produced from his participative observation of salmon fishing 'Action speaks louder than words', since in order to throw the net properly from the bridge of a boat rocked by the waves, you have to know all sorts of body techniques for which there are no words; the words themselves do not correspond to anything specific for those who have not learned the trade. The reflection of this ethnologist is a reaction in regard to the conceptions of Sapir (1958) and Whorf (1956) according to which language is the sole inlet for cultural or professional know-how. In fact, there is a neurophysiological explanation for this fact. Control of the balance and the situation of the body in space is located at the level of the cerebellum and has no conscious expression. As shown by Burton *et al.* (1984) in regard to learning to ski, there is ergonomics in relating to body techniques of balance and the space reference.

In a more general way, certain behaviour at work cannot be understood without taking into account the functional state of the operator (lack of sleep, fatigue, pathology) and his suffering at work (musculo-skeletal pains, for example) or his fears (accidents, burns, blinding, etc.).

2.7. *Work and interpersonal communications*

The methodology described previously may be considered as relatively objective when relations with the machine dominate. Work is increasingly an activity in which inter-human communication prevails and even constitutes the entire activity. Under these circumstances, there is always a risk of the discourse being considered as a simple behaviour without referring to intersubjectivity and, in a more radical way, at the limits of ergonomics. Could this speciality include situations where possible improvements do not concern the technical system? More often, in the context of EWA, technical communications at work can be interpreted when they belong to a vast group of different types of behaviour. However, the dialogue between the user and the employee at the counter or on the telephone, the interview between the nurse or doctor and the patient, and the discussion between the salesman and his customer are work activities, yet they

do not come under EWA since one cannot ignore the contextualization of the language that is both given by the situation and created by the dialogue itself (Gumperz 1992). As such, the dialogue lets the speakers form 'frames' that enable the theatre of life to be staged at any moment in time (Goffman 1976). It is very obvious that this corresponds to the dimensions of the activity that are of greatest interest but whose sociolinguistic and ethnolinguistic theoretical references must be respected, otherwise serious errors of interpretation will be made. However, even in work analysis that does not include a study of the discourse, the question of meaning is inevitable. Work activities submitted to the most Taylorian of organization methods include aspects that come under the significance of work: why do skilled workers increase their already heavy workload if not to make the work easier for other operators located downstream, thus respecting their work ethic?

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

3.1. *Contributions from cognitive anthropology*

One of the bases of modern ethnology was expressed by Boas (1911) 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.

In this initial period (1955–65), models of cognitive operation had to be deduced from observations of behaviour and material objects. These conceptual models had to be constructed like controllable hypotheses evaluated on the basis of their power of prediction and their formal elegance. Subsequently, 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 for cognitive reorganization and creativity in behaviour and understanding (Dougherty 1985: 8).

One can see to what extent cognitive anthropology is close to the principles that are the basis of 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 an hypothesis of operators' rationality and may lead to computerized formalization as done by cognitive engineering and, more particularly, situated cognitive simulation (Woods and Roth 1988, Pavard *et al.* 1990, Benchekroun 1994). The operator no longer appears as the more or less faulty performer of the prescribed work, but as the permanent creator of his own activity which depends on what the operator understands about his own real work situation (the real work).

3.2. *The limits of cognitive anthropology in analysis of activities*

Under these circumstances, one might be tempted to attribute the theoretical context of cognitive anthropology to EWA. It is interesting to read about the attempt that Suchman (1987) made along these lines. The very title of her book on man-machine communications is significant: *Plans and Situated Actions*. The plans are the instructions, the task and the work prescribed and the situated actions are the real work.

As such, the interest of Suchman's way of thinking, like that of many of her psychologist and anthropologist colleagues, is all the greater when the ultimate forms of theory and methodology are not tackled. She chose a very significant example of this: the ease with which naïve users can operate a new photocopier. This type of question is relevant in ergonomics but does not constitute the heart of the difficulties encountered when studying an experienced operator who has to contribute to quality and productivity under the difficult circumstances of the state of the technical system, the quality of raw materials and supplies and, in particular, time constraints. On the other hand, the critical aspect of the action in time is underlined by Gatewood (1985), one of the few anthropologists to experience tough production conditions through his observations of sea fishing. He quoted Fischer (1980) who noted that one of the classic problems of most cognitive approaches is that their constructions do not explain how thought is transformed into action. Furthermore, Gatewood (1985) recalled that knowledge, thought and know-how take time in the same way as more observable actions like blinking or grasping an object.

Another remark that could be made in regard to Suchman's research into photocopiers is that the author's stance in favour of the ethnomethodology of Garfinkel (1967) led her to provoke and study the dialogue between users in difficulty rather than to make an extensive exploration of the behaviour of an operator and to confront the operator with this behaviour. It is true that doing a crucial part of research in the experimental situation of the laboratory would lead to the significance of EWA being lost. It is curious to see such a severe criticism of experimental psychology ending in the laboratory. Sometimes it is difficult to accept the theoretical positions of the best cognitive anthropologists (Lave 1988).

Owing to this, our positions 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 positions of authors favourable to the 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.

3.3. *Adaptation to the diversity and reduction of information*

As Simon (1992) wrote:

> The human mind is an adaptive system. It chooses behaviours in the light of its

> goals, and as appropriate to the particular context in which it is working. Moreover, it can store new knowledge and skills that will help it attain its goals more effectively tomorrow than yesterday: It can learn. As a consequence of the mind's capacities for adaptation and learning, human behaviour is highly flexible and variable, altered by both circumstances and experience. Nor are the alternatives from which the actor might choose usually known in advance. Human beings spend much of their time inventing or discovering actions that fit the circumstances.

To this author, this text is a remarkable demonstration of the need for EWA in order to find out about behaviour and, through this, the critical circumstances and level of experience of operators. The results of EWA enable the circumstances (ergonomic action) and the knowledge (training action) to be modified. From the same viewpoint, Evans involuntarily defended ergonomic action when he underlined that 'the concrete conditions of the task affect the sensitiveness of subjects (operators) to error and bias'. Thus the conception of environments (the work situation) is an anti-bias approach. This means encouraging the best selection of data in the phase that precedes reasoning, since the limited cognitive capacities of the human brain force the subject (the operator) to make a massive reduction of the existing information. However, there is a formidable concrete difficulty. It was seen previously that the image constituted by the operator is deformed in order to comply with the functional state of the system. If this functional state changes, the operator does not have a usable functional representation. Therefore, professional experience is both a resource and a danger if the operator does not have the capacity to build other simple, efficient representations for other states of the system. Montmollin (1986) evoked 'cognitive misery' in this respect.

The situation is all the more serious since operators often produce a poor representation of the limits and characteristics of their knowledge (in this respect, De Keyser speaks of 'mosaic' knowledge). Their metacognition is often limited. They have difficulty representing the relative character of their knowledge which, at the same time, constitutes their social power. Challenging the relative character of this knowledge may lead to formidable conflicts with, first engineers responsible for design or execution, since the logic of use differs from the logic of design, and, second, because the logic of use situated in specific time limits necessarily corresponds to a massive and directed reduction in the collection of data, while the designer does not suffer these constraints.

3.4. *Problem building*

Scribner (1984) also insists on the fact that problem building is the first stage of dealing with concrete questions since, unlike school questions and experimental systems, there are no necessary and sufficient 'data', but multiple indications, some of which are necessary but perhaps not sufficient.

Ergonomic work analysis constitutes an efficient methodology for grasping problem building (Wisner 1994). It corresponds to the heuristic character of this phase and gives an understanding of the bases that an individual uses to solve the problem posed. EWA may also highlight the pragmatic obstacles in the path of this elaboration.

It may be advisable to insist on the fact that if a more extensive analysis of the causes that render EWA necessary are made, two main categories of the sources of variation are found. First of all, the technical system does not operate in a stable way owing to breakdowns, maladjustment and variations that are specific to the very nature of the

industrial phenomenon of transformation. In addition, fluctuations in the quality of raw materials have to be taken into account. Second, operators differ from each other owing to their level of training and experience. Furthermore, in team-work, members of the team often change owing to the increasing use of temporary staff. This instability in the composition of work teams means that the skills of each member are uncertain for the other members of the team and have an influence on the quality of the knowledge shared.

3.5. *The 'naturalization' of cultural situations*

From a more subtle viewpoint, designers of technical systems form an image that is sometimes far removed from the characteristics of the staff who will use the technical system. For example, this image neglects the substantial reduction, at present, of latent knowledge derived from the rural past and the fact that workers have a higher level of education. These staff changes reflect the transformations of society.

There is nothing fortuitous about this negligence. It corresponds to what Sahlins (1976) considered as the 'naturalization' of Western (industrial?) society in order to avoid consideration of socio-cultural characterisitcs. This naturalization necessarily encounters insuperable difficulties when technology is transferred to a very different society, that of an industrially developing country (IDC). In this case, from the viewpoint of the exporters, the technical system has to be 'adapted' owing to foreign 'capacities' and 'mentalities': *Ethnic Variables in Human Factors Engineering* (Chapanis 1975) have to be considered. What is really needed is a wider approach: anthropotechnology (Wisner 1976, 1984).

4. Anthropotechnology

4.1. *The role of situated cognition and ergonomic work analysis*

4.1.1. *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 Ivory Coast, India, Indonesia, Japan, the Phillipines, the Central African Republik, 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. These components are clearly reflected in the multiple expression used in the popular press (Third World, Developing Countries, Countries of the South, Peripheral Countries, etc.). However, 40 years after the start of the widespread distribution of industrial technologies throughout the world, it has to be admitted that the evolution of many nations has differed considerably, despite the fact that, at the outset, they had comparable

socio-economic levels. Among the countries that we prefer to call Industrially Developing Countries (IDC), some have become Newly Industrialized Countries (NIC) and are challenging the established industrialized countries. Other countries will soon be classed as NICs. On the other hand, some have all sorts of difficulties: their GNP (Gross National Product) is not rising as fast as their population. Owing to this, the populations in question see their personal and indirect income dropping constantly.

Many authors endeavour to explain or even predict these evolutions, which are so different, in order to advise the buyer countries or the exporting industrialists. Unfortunately, most of these studies exclusively respect a single discipline (most often economics) or even an ideology. They have little interest in giving advice about real improvements in work and the use of technology.

4.1.2. *Anthropotechnological methodology*: The orientation of anthropotechnology is similar to that of ergonomics. It is aimed at solving particular problems using general methods, reducing the health 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 to be 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. Finally, installation of the new technical system by mixed teams of managers and operators from the two countries should be followed up by an ergonomist who practices the necessary EWA. It is obvious that such a method is cumbersome, but it provides lessons and creates knowledge that could be used in a wider sense. In any event, it is preferable to precipitated test runs and long production rate build-ups that are littered with incidents and disputes.

Justification of the use of EWA in a technology transfer is still more convincing than that of its general 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 sub-tropical 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 action. 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 the 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 expensive 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.

4.1.3. *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. Surveys carried out properly might have highlighted such determining factors in these complex situations. The reason why ergonomic work analysis turns out to be determining is that, in a industrially developing country, situated cognition is even more remote from planning, as Suchman said, and the real work is 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 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.

4.1.4. *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 programme 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 unsuitable 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 organization.

In industrially developing countries, the difficulty is further increased by the fact that it is a foreign society that provides the technology and the local society that imposes its social organization. Under these circumstances, it can be seen why work organization becomes the major field of conflict (Wisner 1992), that work is only possible through the management of these difficulties and through individual and socially-shared cognition. The latter constitutes an item that is located between the numerous constraints mentioned and the real activities, excluding blind determinism whose predomination is seen for certain.

The role of the anthropotechnologist and the ergonomist is then to remove a certain number of constraints that give operators and their managers a better chance of constituting their work, being efficient in terms of production and protecting their health and life at the workplace. In anthropotechnology, as in ergonomics, the approach to these work activities through EWA prohibits a simplistic interpretation of the opening defects of imported technical systems and enables spaces to be created at various levels in order to solve the difficulties noted.

5. Conclusions

Ergonomic work analysis, the specific description of the real activity, shows that the operator and the user are not always reliable performers of the work prescribed but, more often, have to take into account a lot of variables owing to the work itself, its environment and the personal state of the actors(s). In many cases, the work is the subject of a construction or a reconstruction in terms of the situation where the activity takes place. The aim of ergonomics is then to modify this situation in a favourable way. When the technical system is transferred from one country to another, the sources of variations are multiplied and have an even greater impact on the work. Thanks to the anthropotechnological approach, it is possible to track down the economic, social and anthropological causes of the difficulties observed and to avert them. Here again, a

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detailed analysis of situated activities leads to the identification of the obstacles to be removed or transformed.

References

ABRAHAO, J. I. 1986, Organisation du travail, représentation et régulation du système de production. Etude anthropotechnologique de deux distilleries situées dans deux tissus industriels différents du Brésil. Thèse de Doctorat en Ergonomie, Laboratoire d'Ergonomie du CNAM, Paris.

ALTHABE, G. and SELIM, L. 1990, L'entreprise dans le cadre de l'investigation ethnologique et de sa méthodologie, *Journal des Anthropologues*, **43–44**, 17–22.

BARTLETT, F. C. 1932, *Remembering: A Study in Experimental and Social Psychology* (Cambridge University Press, Cambridge).

BARTLETT, F. C. 1958, *Thinking: An Experimental and Social Study* (Basic, New York).

BENCHEKROUN, T. H. 1994, Modélisation et simulation des processus intentionnels d'interlocution. Application à la conception d'un système d'aide à la communication multi-agents. Thèse de Doctorat en Ergonomie, Laboratoire d'Ergonomie du CNAM, Paris.

BOAS, F. 1911, *Handbook of American Indian Languages* (Bureau of American Ethnology, Washington).

BOSTER, J. S. 1985, "Requiem for the omniscient informant". There is life in the old girl yet, in J. W. D. Dougherty, *Directions in Cognitive Anthropology* (University of Illinois Press, Chicago), 177–197.

BOUTTERIN, C., DELTOR, S. and GUERIN, F. 1994, *Evaluation du diagnostic court* (ANACT, Lyon).

BURTON, W. R., BROWN, J. S., and FISCHER, G. 1984, Skiing as a model of instruction, in B. Rogoff and J. Lave, *Everyday Cognition, its Development in Social Context* (Harvard University Press, Cambridge, MA), 139–150.

CASSON, R. W. 1981, *Language, Culture and Cognition: Anthropological Perspectives* (Macmillan, New York).

CHAPANIS, A. 1975, *Ethnic Variables in Human Factors Engineering* (Johns Hopkins University Press, Baltimore).

COLE, M. and SCRIBNER, G. 1974, *Culture and Thought: A Psychological Introduction* (Wiley, New York).

DANIELLOU, F. and GARRIGOU, A. 1992, Human factors in design: sociotechnics or ergonomics? in M. Helander, *Design for Manufacturability and Process Planning* (Taylor & Francis, London).

DE KEYSER, V. 1991, Work analysis in French Language ergonomics: origin and current research trends, *Ergonomics*, **34**, 653–669.

DOUGHERTY, J. W. D. 1985, *Directions in Cognitive Anthropology* (University of Illinois Press, Chicago).

DURKHEIM, L. 1986, *Les règles de la méthode sociologique* (PUF, Paris).

EVANS, J. ST. B. T. 1989, *Bias in Human Reasoning, Causes and Consequences* (Lawrence Erlbaum, Hillsdale).

FISCHER, K. W. 1980, A theory of cognitive development. The control and construction of hierarchies of skills, *Psychological Review*, **87**, 447–531.

GARDNER, P. M., 1976, Birds, words and a requiem for the omniscient informant, *American Ethnologist*, **3**, 446–468.

GARFINKEL, H., 1967, *Studies in Ethnomethodology* (Prentice Hall, Englewood Cliffs).

GATEWOOD, J. B. 1985, Actions speak louder than words, in J. W. D. Dougherty, *Directions in Cognitive Anthropology* (University of Illinois Press, Chicago).

GOFFMAN, E. 1976, *Frame Analysis* (Harper, New York).

GOODENOUGH, W. H. 1957, *Cultural Anthropology and Linguistics*, George Town University Monograph Series on Languages and Linguistics, vol. 9 (George Town University Press), 167–173.

GUERIN, F., LAVILLE, A., DANIELLOU, F., DURAFFOURG, J. and KERGUELEN, A. 1991, *Comprendre le travail pour le transformer: la pratique de l'ergonomie* (ANACT, Paris).

GUMPERZ, J. J. 1992, Contextualisation revisited, in P. Auer and A. Di Luzio, *The Contextualisation of Language* (John Benjamins, Amsterdam).

HENLE, M. 1962, On the relation between logic and thinking, *Psychological Review*, **69**, 366–378.

HUTCHINS, E. 1979, Reasoning in Trobriand's discourse, *Quarterly Newsletter of the Laboratory of Comparative Human Cognition* **1–2**, 13–17, Reproduced in R. W. Casson (1981), *Language, Culture and Cognition* (Macmillan, New York), 481–489.

KERGUELEN, A. 1991, Pre- and post-observational categorisation of observables: application to the KRONOS software aid for activity analysis, in Y. Queinnec and F. Daniellou, *Designing for Everyone*, vol. 1 (Taylor & Francis, London), 504–506.

KOHLER, W. 1927, *The Mentality of Apes* (Harcourt Brace, New York).

LANGA, M. B. 1994, Adaptation ou création de l'organisation du travail lors d'un transfert de tchnologie. Analyse de l'activité de l'encadrement et conception de l'organisation. Thèse de Doctorat en Ergonomie, Laboratoire d'Ergonomie du CNAM, Paris.

LANGA, M. B. and WISNER, A. 1994, *Organisational Design Contribution of the Anthropotechnological Approach. Human Factors in Organizational Design and Management*, IV (Elsevier, Amsterdam).

LAVE, J. 1988, *Cognition in Practice* (Cambridge University Press, Cambridge).

LEE, D. O. 1940, A primative system of values, *Philosophy of Sciences*, **7**, 3.

MADI, M. 1994, Personal communication.

MAGAUD, J. and SUGITA, K. 1993, Le retour des réseaux, une comparaison franco-japonaise, *Annales des Mines*, No. 6, 60–68.

MALINOWSKI, B. K. 1922, *Argonauts of the Western Pacific* (Routledge, London).

MALINOWSKI, B. K. 1965, *Coral Gardens and their Magic*, Vol. 2, *The Language of Magic and Gardening* (American Books, New York).

MEISTER, D. 1989, *Conceptual Aspects of Human Factors* (Johns Hopkins University Press, Baltimore).

MONTMOLLIN, M. DE 1986, *L'intelligence de la tâche* (Peter Lang, Berne).

NEISSER, V. 1976, General academic and artificial intellignece, in L. B. Resnick, *The Nature of Intelligence* (Lawrence Erlbaum, Hillsdale), 135–144.

OCHANINE, D. and ZALTMAN, A. 1973, *Operativité de l'image d'un contrôle de processus in Regulation de l'activité* (Editions de Moscou, Moscou).

OHLSSON, S. 1985, Retrieval processes in restructuring, *Scandinavian Journal of Psychology*, **26**, 366–368.

OMBREDANE, A. and FAVERGE, J. M. 1955, *L'analyse du travail* (Presses Universitaires de France, Paris).

PACAUD, S. 1949, Recherches sur le travail de téléphonistes. Etude psychologique d'un métier, *Le Travail Humain.*, **12**, 46–65.

PAVARD, B., BENCHEKROUN, H. and SALEMBIER, P. 1990, La régulation collective des communications: analyse et modélisation in C.R. du Colloque, 'Les apports de l'ergonomie et de l'information avancée à la conception des systèmes interactifs,' Biarritz, 19–22 September 1990.

PINSKY, L. 1990, User activity centered design, in L. Berlinguet and D. Berthelette, *Work with Display Units* (Elsevier, Amsterdam), 445–453.

PINSKY, L. 1992, *Concevoir pour l'action et la communication* (essais d'ergonomie cognitive) (Peter Lang, Neufchatel).

RESNICK, L. B. 1976, *The Nature of Intelligence* (Lawrence Erlbaum, Hillsdale).

RESNICK, L. B., LEVINE, J. M. and TEASLEY, S. D. 1991, *Socially Shared Cognition* (American Psychological Association, Washington).

ROGOFF, B. and LAVE, J. 1984, *Everyday Cognition, its Development in Social Context* (Harvard University Press, Cambridge).

SAHBI, N. 1984, Anthropometric measurements and work analysis in modern technology in the Tunisian phosphate mines, in H. Shahnawaz and M. Babri, *Ergonomics in Developing Countries* (CEDL Lulea University Press, Sweden).

SAHLINS, M. 1976, *Culture and Practical Reason* (University of Chicago Press).

SAPIR, E. 1958, *Selected Writings by Edward Sapir*, edited by O. G. Mandelbaum (University of California Press, Berkeley).

SCRIBNER, S. 1984, Studying working intelligence, in B. Rogoff and J. Lave, *Everyday Cognition, its Development in Social Context* (Harvard University Press, Cambridge, MA), 9–40.

SIMON, H. A. 1992, What is an 'explanation' of behaviour? *Psychological Science*, **3**, 150–161.

SINAIKO, H. W. 1975, Verbal factors in human engineering, some cultural and psychological data, in A. Chapanis, *Ethnic Variables in Human Factors Engineering* (Johns Hopkins University Press, Baltimore).

SIX, F. and VAXEVANOGLOU, X. 1993, *Les aspects collectifs du travail* (Octares, Toulouse).

STERNBERG, R. G. and WAGNER, R. K. 1986, *Practical intelligence. Nature and Origins of Competence in Everyday World* (Cambridge University Press, Cambridge).

SUCHMAN, L. A. 1987, *Plans and Situated Actions. The Problem of Human-Machine Communication* (Cambridge University Press, Cambridge).

THEUREAU, J. 1992, *Le cours d'action: analyse semi-logique* (Peter Lang, Neufchatel).

VERMERSCH, P. 1990, Questionner l'action; l'entretien d'explicitation, *Psychologie Française*, **35**, 227–235.

VYGOTSKY, L. S. 1934 [1962], *Thought and Language* (MIT Press, Cambridge, MA).

WERNER, O. 1969, The basic assumptions of ethnoscience, *Semiotica*, **1**, 329–338.

WERTSCH, J. W., MINICK, N. and ARNS, F. J. 1984, The creation of context in joint problem solving, in B. Rogoff and J. Lave, *Everyday Cognition, its Development in Social Context* (Harvard University Press, Cambridge, MA).

WHORF, B. L. 1956, *Language, Thought and Reality: Selected Writings of Benjamin Lee Whorf*, (MIT Press, Cambridge, MA).

WISNER, A. 1972, Diagnosis in ergonomics or the choice of operating models in field research, *Ergonomics*, **15**, 601–620.

WISNER, A. 1976, Ergonomics in the engineering of a factory for exportation. VIth IEA Congress, Maryland on Ergonomics, Mental Load, Anthropotechnology. Laboratoire d'Ergonomie du CNAM, Paris.

WISNER A. 1984, Ergonomics or anthropotechnology, a limited or wider approach to working conditions in technology transfer, in H. Shanavaz, *Ergonomics in Developing Countries* (CEDL, Lulea University Press, Sweden).

WISNER, A. 1992, De la ergonomia de la antropotecnologica. La organisacion de la empresa y del trabajo en las transferencias de tecnologia, *Sociologia del Trabajo*, **17**, 3–73.

WISNER, A. 1995, Understanding problem building: ergonomic work analysis, *Ergonomics*, **38**, 596–606.

WOODS, D. D. and ROTH, E. M. 1988, Cognitive systems engineering, in M. Helander (ed.), *Handbook of Human-Computer Interaction* (Elsevier, Amsterdam).

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SITUATED COGNITION AND ACTION: IMPLICATIONS FOR ERGONOMIC WORK ANALYSIS AND ANTHROPOTECHNOLOGY

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INTRODUCTION: SHORT HISTORY OF THE STUDY OF WORK ACTIVITIES

One of the reasons for the present difficulties of ergonomics stems from the modesty of theoretical and epistemological studies of our discipline, with the exception of some notable examples (Meister, 1989). Many of us maintained a rather positivistic conception of the science which led them to claim their attachment to experimentation and a priori modelling. However, in order to succeed in their professional practice, they are concerned with what happens in reality and try to understand the reasons for the behaviour of operators in real situations. As such, they provoke an epistemological slide that is both substantial and partly hidden. However, for more than 40 years, French-speaking ergonomists (Pacaud, 1949), Ombredane and Faverge (1955) made a clearer choice by creating Ergonomic Work Analysis (E.W.A.). But there are few theoretical texts of this origin which give an account of this practical method. Only the efficiency of E.W.A. appears to justify its existence, thus ruling out the possibility of dialogue with specialists in neighbouring disciplines.. It's true that, at the time of creation of E.W.A., the dominant paradigms were those of behaviourism and laboratory experimentation, the results of which were supposed to be applicable in real situations. Certain ergonomists felt uneasy about the contradictions between what they saw in the field and the experimental results obtained (Wisner, 1972). But in the literature, they found no conceptual aid, only the same concern (Bartlett, 1932, 1958).

However, anthropologists and psychologists, most of them working in the USA, felt uneasy in the theoretical contexts of the period, in particular that of cultural anthropology: they created cognitive anthropology. Cognitive anthropology, which was first of all directed towards the relation between cognition and languages (Sapir (1958) and Worf (1956)) sought a grammar generative of thought, inspired by Chomsky, the theoretical study of which played an essential role at the time. Gradually, thanks to a group of psychologist and anthropologist authors, a collection of works led to the creation of a new field: thought and

action in situation, situated cognition, which was very close to what E.W.A. was analyzing (see, for example, Resnick (1976), Casson (1981), Rogoff and Lave, 1984, Dougherty, 1985). It might appear interesting to see to what extent theoretical studies of situated cognition, which appeared 30 years after E.W.A., are able to shed light on the epistemological problems raised by the latter. Very few ergonomists, even French-speaking ones, with the notable exception of Theureau (1992) and Pinsky (1990, 1992) established the link between E.W.A. and the American school of situated cognition. This paper will attempt to examine the possible relation. But this attempt involves risks for those who cling to the division of human sciences proposed a hundred years ago by Durkheim (1895, [1986]), leaving the study of thought mechanisms to psychologists and the study of thought content to sociologists (and anthropologists). This arbitrary division raised protests for some considerable time (Malinowski (1922) and Vygotsky (1934, [1962], for example), but remains well in place. Without judging the legitimacy of this division, it could be thought that it is of no interest to ergonomists whose role, for the past 50 years, has been to use, in human sciences, that which might appear useful in various disciplines, even if it means perverting them due to a concern for utility. Although ergonomists now have to exercise their epistemologically risky efforts on branches of sociology and anthropology, this is unimportant as regards our perspective of utility in as much as our work is done in a clearly defined theoretical context using adequate and precise methodologies. Theoretical aid may now come from French-speaking anthropologists who are interested in work (Althabe and Selim, 1990). In the first part, we shall consider the methodology of E.W.A. in its relations with the contributions from ethnological methods, then we shall see to what extent the theoretical work of cognitive psychology and anthropology relative to situated cognition may be useful for ergonomics, in particular for Ergonomic Work Analysis. Finally we shall examine what E.W.A. and situated cognition can contribute to anthropotechnology, i.e. better technology transfers and the adaptation of technology to the countries and populations which acquire it. As such, what is proposed is the acknowledgement that ergonomics has an anthropological dimension, both in terms of its methodology and its fields of application.

ERGONOMIC WORK ANALYSIS AND THE METHODOLOGICAL CONTRIBUTIONS FROM ETHNOLOGY

Diversity of practices in Ergonomics

Most often the ergonomist is called in when there is an operating anomaly: errors, quality problems, incidents, accidents, continuous process control difficulties, staff fatigue, anxiety, laboriousness, etc. In many cases, the causes of these operating defects are fairly easy to detect. The answer is found through the use of literature or simple and fast experimentation which does not always respect all the rules of experimentation publishable in a scientific magazine (quick and dirty). More often, a survey has to be carried out in the field so that operators or users can be heard. Literature contians exploratory studies, participative observations and systematic surveys which may have a statistical value. As such, we come closer to sociological studies or research into subjectivity which are presently gaining some ground. These investigations have the merit of situating the problem, measuring its importance and appreciating the scale of the transformations which the company is prepared to allow. In this way, the question is posed in a technical, economic and social context and one can appreciate the diversity of viewpoints developed by the various persons concerned: operators, supervisors, designers, customers, shopkeepers, etc. Thus, certain ergonomists feel they are able to reformulate the question asked. Finding the solution to the problem as formulated by the demander is very rare. However, we know the dangers of reformulation, which is quite simply liable to draw the request towards a particular scientific field, dear to the ergonomist concerned, while leaving aside the major aspects that are beyond him. This movement may also please the demander, at least in an initial phase as long as the intersubjectivity relation is successful.

After this reformulation, a solution can be proposed through experimentation and material or computer modelling. But there is a certain risk of the real problem not being treated if a precise observation of the activity is not compared with the representation of the persons questioned. In particular, the unconscious dimensions of cognition may be missed by the analysis.

That is why a large number of ergonomists tend to make increasing use of Ergonomic Work Analysis (E.W.A.) which provides an exhaustive description of the activities of certain operators or users in phases of implementation of the technical system which are considered as critical. The full value of this detailed study of behaviour is revealed when it is compared with the representation which the operator or the user has of his own activities during the same period (self-confrontation). In general, if we wish to approach cognitive activities, the use of several methods appears vital in order to highlight beneficial contradictions.

There are numerous variations in Ergonomic Work Analysis according to the authors, but also in terms of the situations studied. Here we shall give a description of E.W.A. which is shared by a lot of French-speaking ergonomists. They are the ones who appear to make the most use of it.

Methodology of ergonomic work analysis

Many texts describe the current methodology of ergonomic work analysis (see, for example, Guérin and coll., 1991; De Keyser, 1991). 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. For example, through experience, the ergonomist who works for a company knows the validity of the request and the way it could be reformulated. Often, he has a simulator (automobile, nuclear industries, etc.). On the contrary, the consultant ergonomist, who is often a general practitioner, has to make a close examination of the question asked and often has to reformulate it in order to deal with the real questions which are often hidden by a trivial formulation of the request. He also has to know the limits of the action he might take, by taking into account the specific technical, economic and social realities specific to the company which asked for his services; sometimes, he has to find out what these realities can teach about the system or the specific workstation he is studying. But frequently, the analysis of activities can be relatively reduced and only concern a few critical points in the case of usual ergonomic problems for which vast ergonomic know-how is more or less available according to the experience of the consultant. It is then a "short diagnosis" (Boutterin and coll., 1994).

The formulation of the recommendations may be a rather simple, short-term phase. But it could also be the subject of a complex process in collaboration with designers and future users, especially if the future system is to differ considerably from the one concerned by the work analysis. The need for iterative simulation often appears (Pinsky, 1990, 1992). Sometimes a specific methodology has to be used in order to define the probable future activities of a production system that is being prepared (Daniellou and Garrigou, 1992).

Analysis of activities

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, 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 on 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 due 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 correcting 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 follow-up of such procedures takes a long time. Analysis, in particular, is tedious. Therefore, they cannot be multiplied and, most often, one has to abandon the idea of using them in a statistical way. As such, the choice of the persons to be studied and the work periods to be considered are highly critical. Yet, the type of request is an essential guide: analysis of activities is done in the perspective of detecting the causes of one or more anomalies and the changes which must be made in the critical situation. This polarization of research through the need to solve the problem posed constitutes an essential feature of E.W.A. which distinguishes it from the ethnological survey to which E.W.A. may appear very close. For example, in ethnological literature, we find discussions which are very useful for ergonomists when it comes to choosing the subjects observed and the critical periods (Werner, 1969; Gardner, 1976; Boster, 1985). The way in which the members of a group work is shared in the double sense of the sharing of tasks and the pooling of part of the know-how (Resnick and coll., 1991). It is obvious that the results obtained on the basis of a detailed analysis of the activities of a small number of persons over very short periods (Six and Vaxevanoglou, 1993) may be used for the subsequent construction of a systematic observation of a more limited number of critical phenomena on a larger population for longer periods of time. This use of a second phase which leads to the production of data with a statistical value may be reassuring from the methodological viewpoint, but this takes

nothing away from the value of the first phase of detection of the complex relations which may exist between the technical system and the persons who work with it.

Recording tools

The effort of exhaustiveness in the observation of behaviour obviously has technical limits. Recording with a videotape recorder can be useful when the paper-pencil or recorder notation (Kerguelen, 1991) does not enable events to be followed rapidly. Suchman (1967) also recommended it, but she appears to give it particular qualities of objectivity. This opinion is debatable, since any experienced photographer knows that the choice of centring and details highlighted in a scene constitute an option that is just as clear as the elements which an observer notes by hand. The real advantage of videotape recording lies in the subsequent possibility of self-confrontation with the operator or reinterpretation by ergonomists.

Recording speech on a tape recorder is vital as long as the speech is to be analyzed in detail. Here again, interesting debates have taken place between ethnologists in regard to the role of the data collection method in regard to the value of the research results. The verbal expression of populations of Trobriand (Malinowski (1922, 1965); Lee (1940); Hutchins (1979) is a good example of this methodological discussion.

The behaviour observed, even when grouped in "histories", does not always give an understanding of the cognitive activities which 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 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 which 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-confrontation is probably that it highlights elements of the cognitive unconscious. This plays an essential part in heuristic activities which enable problem-building. Thanks to Kohler (1927), since the start of the century we know that man is far from grasping the integrality of observable facts. He uses unconscious processes to select certain elements which 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 thus closely linked to previous activities and to culture (Ohlsson, 1985). Considerable work has also shown the mechanisms of recognition of speech, voice, faces or silhouettes. Evans (1989) took up this question in order to understand the nature of bias which often leads to the wrong representation of situations. He started with the conceptions of Henle (1962) who considered that subjects (operators, users) add, delete and alter the proposed premises. In other words, the subject does not reason in terms of the proposed subject, but in terms of a personal representation of it. An elegant demonstration of this reality was given by Ochanine (Ochanine and Zaltzman, 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 the human cognitive capacity. Alongside self-confrontation and the Ochanine method, Vermersch (1990) proposed other methods of approaching the cognitive unconscious.

Body aspects of work

The considerable development of cognitive psychology and its use in E.W.A. may have the effect of underestimating the importance of the body aspects of work. An important initial point concerns body techniques. Gatewood (1985) called the article he produced from his participative observation of salmon fishing "Action speaks louder than words", since in order to throw the net properly from the bridge of a boat rocked by the waves, you have to

know all sorts of body techniques for which there are no words; the words themselves do not correspond to anything specific for those who have not learned the trade. The reflection of this ethnologist is a reaction in regard to the conceptions of Sapir and Worf according to which language is the sole inlet for cultural or professional know-how. In fact, there is a neurophysiological explanation for this fact. Control of the balance and the situation of the body in space is located at the level of the cerebellum and has no conscious expression. As shown by Burton and coll. (1984) in regard to learning to ski, there is ergonomics in relation with these body techniques of balance and the space reference.

In a more general way, certain behaviour at work cannot be understood without taking into account the functional state of the operator (lack of sleep, fatigue, pathology) and his suffering at work (musculo-skeletal pains, for example) or his fears (accident, burns, blinding, etc.).

Work and interpersonal communications

The methodology described previously may be considered as relatively objective when relations with the machine dominate,. But work is increasingly an activity in which inter-human communication prevails and even constitutes the entire activity. Under these circumstances, there is always a risk of the discourse being considered as simple behaviour without asking the question of intersubjectivity and, in a more radical way, that of the limits of ergonomics. Could this speciality include situations where possible improvements do not concern the technical system? More often, in the context of E.W.A., technical communications at work can be interpreted when they belong to a more vast group of different types of behaviour. But the dialogue between the user and the employee at the counter or on the phone, the interview between the nurse or doctor and the patient and the discussion between the salesman and his customer are work activities, yet they do not come under E.W.A. since one cannot ignore the contextualization of the language which is both given by the situation and created by the dialogue itself (Gumperz, 1992). As such, the dialogue lets the speakers form "frames" which enable the theatre of life to be staged at any moment in time (Goffman, 1976). It is very obvious that this corresponds to the dimensions of the activity which are of greatest interest but whose sociolinguistic and ethnolinguistic theoretical references must be respected, otherwise serious errors of interpretation will be made. However, even in work analysis which does not include a study of the discourse, the question of meaning is inevitable. Work activities submitted to the most Taylorian of organization methods include aspects which come under the significance of work: why do

skilled workers increase their already heavy workload if not to make the work easier for other operators located downstream, thus respecting their work ethic?

ANALOGIES AND DIFFERENCES BETWEEN THE STUDY OF SITUATED ACTION AND ERGONOMIC WORK ANALYSIS

Contributions from cognitive anthropology

One of the bases of modern ethnology was expressed by Boas (1911) who thought that each culture should be understood from its own premises, while Malinovski 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 which should be taken into account in order to understand human behaviour; these mental phenomena are considered as complex and rational and able to be studied thanks to strict methods which lead to reproducible results.

In this initial period (1955-1965), models of cognitive operation had to be deduced from observations of behaviour and material objects. These conceptual models had to be constructed like controllable hypotheses evaluated on the basis of their power of prediction and their formal elegance. Subsequently, 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 for cognitive reorganization and creativity in behaviour and understanding." (Dougherty, 1985, p. 8).

One can see to what extent cognitive anthropology is close to the principles which are the basis of ergonomic work analysis. We have to understand the operator's cognition (and not give him ours or that of the designer). This can only be done through long, detailed field studies. The models are based on a hypothesis of operators' rationality and may lead to computerized formalization as done by cognitive engineering and, more particularly, situated cognitive simulation (Woods and Roth, 1988; Pavard and coll., 1990; Benchekroun, 1994).

The operator no longer appears as the more or less faulty performer of the prescribed work, but as the permanent creator of his own activity which depends on what the operator understands about his own real work situation (the real work).

The limits of cognitive anthropology in analysis of activities

Under these circumstances, one might be tempted to attribute the theoretical context of cognitive anthropology to E.W.A. It is interesting to read about the attempt which Suchman (1987) made along these lines. The very title of his book on Man-Machine communications is significant: "Plans and situated actions". The plans are the instructions, the task and the work prescribed and the situated actions are the real work.

As such, the interest of Suchman's way of thinking, like that of many of her psychologist and anthropologist colleagues, is all the greater when the ultimate forms of theory and methodology are not tackled. She chose a very significant example of this: the ease with which naive users can operate a new photocopier. This type of question is relevant in ergonomics but does not constitute the heart of the difficulties encountered when studying an experienced operator who has to contribute to quality and productivity under the difficult circumstances of the state of the technical system, the quality of raw materials and supplies and, in particular, time constraints. On the other hand, the critical aspect of the action in time is underlined by Gatewood, one of the few anthropologists to experience tough production conditions through his observations of sea fishing. He quoted Fisher (1980) who noted that one of the classic problems of most cognitive approaches is that "their constructions do not explain how thought is transformed into action." Furthermore, Gatewood recalled that knowledge, thought and know-how take time in the same way as more observable actions like blinking or grasping an object.

Another remark which could be made in regard to Suchman's research into photocopiers is that the author's stance in favour of Garfinkel's Ethnomethodology (1967) led her to provoke and study the dialogue between users in difficulty rather than to make an extensive exploration of the behaviour of an operator and to confront the operator with this behaviour. It is true that doing a crucial part of research in the experimental situation of the laboratory would lead to the significance of E.W.A. being lost. It is curious to see such a severe criticism of experimental psychology ending in the laboratory. Sometimes it is

difficult to accept the theoretical positions of the best cognitive anthropologists (Lave, 1988).

Due to this, 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, 1984; Scribner (1984); Sternberg and Wagner (1986), etc.

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 E.W.A. 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 positions of authors favourable to the situated action. But it also has a more ergonomic aim, that of identifying pragmatic obstacles, the elements of the situation which hinder an easier constitution and resolution of the problem.

Adaptation to the diversity and reduction of information

As Simon (1992) wrote: "The human mind is an adaptive system. It chooses behaviours in the light of its goals, and as appropriate to the particular context in which it is working. Moreover, it can store new knowledge and skills that will help it attain its goals more effectively tomorrow than yesterday: It can learn. As a consequence of the mind's capacities for adaptation and leaning, human behaviour is highly flexible and variable, altered by both circumstances and experience. Nor are the alternatives from which the actor might choose usually known in advance. Human beings spend much of their time inventing or discovering actions that fit the circumstances." In our view, this text is a remarkable demonstration of the need for E.W.A. in order to find out about behaviour and, through this, the critical circumstances and level of experience of operators. The results of E.W.A. enable the circumstances (ergonomic action) and the knowledge (training action) to be modified.

From the same viewpoint, Evans involuntarily defended ergonomic action when he underlined that "the concrete conditions of the task affect the sensitiveness of subjects (operators) to errors and bias." Thus the conception of environments (the work situation) is

an anti-bias approach. This means encouraging the best selection of data in the phase which precedes reasoning, since the limited cognitive capacities of the human brain force the subject (the operator) to make a massive reduction of the existing information. However, there is a formidable concrete difficulty. We saw previously that the image constituted by the operator is deformed in order to comply with the functional state of the system. If this functional state changes, the operator does not have a usable functional representation. Therefore, professional experience is both a resource and a danger if the operator does not have the capacity to build other simple, efficient representations for other states of the system. Montmollin (1986) evoked "cognitive misery" in this respect.

The situation is all the more serious since operators often produce a poor representation of the limits and characteristics of their knowledge (in this respect, De Keyser (1990) spoke of "mosaic" knowledge). Their metacognition is often limited. They have difficulty representing the relative character of their knowledge which, at the same time, constitutes their social power. Challenging the relative character of this knowledge may lead to formidable conflicts with, firstly, engineers responsible for design or execution, since the logic of use differs from the logic of design, and, secondly, because the logic of use situated in specific time limits necessarily corresponds to a massive and directed reduction in the collection of data, while the designer does not suffer these constraints.

Problem building

Scribner (1986) as well insists on the fact that problem building is the first stage of dealing with concrete questions since, unlike school questions and experimental systems, there are no necessary and sufficient "data", but multiple indications, some of which are necessary but perhaps not sufficient.

Ergonomic Work Analysis constitutes an efficient methodology for grasping problem building (Wisner, 1994). It corresponds to the heuristic character of this phase and gives an understanding of the bases which an individual uses to solve the problem posed. E.W.A. may also highlight the pragmatic obstacles in the path of this elaboration.

It may be advisable to insist on the fact that if we make a more extensive analysis of the causes which render E.W.A. necessary, we find two main categories of the sources of variation.

First of all, the technical system does not operate in a stable way due to breakdowns, maladjustment and variations which are specific to the very nature of the industrial phenomenon of transformation. In addition, we have to take fluctuations of the quality of raw materials into account.

Secondly, operators differ from each other due to their level of training and experience. Furthermore, in team-work, members of the team often change due to the increasing use of temporary staff. This instability in the composition of work teams means that the skills of each member are uncertain for the other members of the team and have an influence on the quality of the knowledge shared.

The "naturalization" of cultural situations

From a more subtle viewpoint, designers of technical systems form an image which is sometimes far removed from the characteristics of the staff who will use the technical system. For example, this image neglects the substantial reduction, at present, of latent knowledge derived from the rural past and the fact that workers have a higher education level. These staff changes reflect the transformations of society.

There is nothing fortuitous about this negligence. It corresponds to what Sahlins (1976) considered as the "naturalization" of Western (industrial?) society in order to avoid consideration of socio-cultural characteristics.

This naturalization necessarily encounters insuperable difficulties when technology is transferred to a very different society, that of an industrially developing country (IDC). In this case, from the viewpoint of the exporters, the technical system has to be "adapted" due to foreign "capacities" and "mentalities". Consider the "Ethnic Variables in Human Factors Engineering" (Chapanis, 1975). As we see it, what is needed is a wider approach: "Anthropotechnology" (Wisner, 1976-1984).

ANTHROPOTECHNOLOGY

THE ROLE OF SITUATED COGNITION AND ERGONOMIC WORK ANALYSIS

Technical, economic and social constraints and anthropological treatments

The ergonomics of technology transfers was called Anthropotechnology in order to underline the fact that knowledge which 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 Ivory Coast, India, Indonesia, Japan, the Philippines, the Central African Republic, 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 which acquire foreign technologies and attempt to implement them with various degrees of success. Due 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. 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. These components are clearly reflected in the multiple expression used in the popular press (Third World, Developing Countries, Countries of the South, Peripheral Countries, etc.). However, forty years after the start of the widespread distribution of industrial technologies throughout the world, it has to be admitted that the evolution of many nations has differed considerably, despite the fact that, at the outset, they had comparable socio-economic levels. Among the countries which we prefer to call Industrially Developing Countries (IDC), some have become Newly Industrialized Countries (NIC) and are challenging the established industrialized countries. Other countries will soon be classed as NICs. But, on the other hand, some have all sorts of difficulties: their GNP (Gross National Product) is not rising as fast as their population. Due to this, the populations in question see their personal and indirect income dropping constantly.

Many authors endeavour to explain or even predict these evolutions, which are so different, in order to advise the buyer countries or the exporting industrialists. Unfortunately, most of these studies exclusively respect a single discipline (most often economics) or even an ideology. They have little interest in giving advice about real improvements in work and the use of technology.

Anthropotechnological methodology

The orientation of anthropotechnology is similar to that of ergonomics. It is aimed at solving particular problems using general methods, reducing the health 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 practiced 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 E.W.A. of the critical points of the technical system in the seller countries, thus avoiding a situation where the system is necessarily considered to be 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 which has similar characteristics. Finally, installation of the new technical system by mixed teams of managers and operators from the two countries should be followed up by an ergonomist who practices the necessary E.W.A. It is obvious that such a method is cumbersome, but it provides lessons and creates knowledge which could be used in a wider sense. In any event, it is preferable to precipitated test runs and long production rate build-ups which are littered with incidents and disputes.

Justification of the use of E.W.A. in a technology transfer is still more convincing than that of its general use in Ergonomics. The factors which influence work are too numerous for a forecast to be made, from the outside, of those which 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, we go further in the search for the origin of the difficulties encountered and we construct a tree of causes which is not limited to the technical and organizational aspects that are closest to the workstation. For example, we could discover that the air conditioning system of a continuous process control centre is not working in a sub-tropical 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 due 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 action. But 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 which owns the mixing plant. In another situation (Abrahao, 1986), among the 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 expensive hydraulic props out of order was 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.

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 and the Russian school, attach great importance to society in the construction of cognition (Wertsch and coll., 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 (see also 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 E.W.A. 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.

Surveys carried out properly might have highlighted such determining factors in these complex situations. The reason why Ergonomic Work Analysis turns out to be determining is that, in a industrially developing country, situated cognition is even more remote from planning, as Suchman said, and the real work is 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. Due to this, operators have to construct their tasks under special circumstances which 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 they can understand and without the help of supervisory staff able to express themselves in the sense of their problems. Social distances which are increased by substantial wage differences and sometimes class and political differences may create conflict situations in the company which further complicate the comprehension of and the solution to technical difficulties. It can be seen that the concept of cognition in situation then takes on a great significance and that E.W.A. is the least that can be done to approach reality.

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

Considering the operator as the repeated creator of his task, a position which might appear audacious at first glance, thus becomes a necessity since he cannot execute a programme 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 to progressively turn from a farm labourer into an efficient worker in a work team according to modalities of the type evoked by Garfinkel (1962) 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 which Vygotsky saw between the person and society which, firstly, provides him with technologies and, secondly, acts through its social organization.

In industrially developing countries, the difficulty is further increased by the fact that it is a foreign society which provides the technology and the local society which imposes its social organization. Under these circumstances, it can be seen why work organization becomes the major field of conflict (Wisner, 1992), that work is only possible through the management of these difficulties and through individual and socially-shared cognition. The latter constitutes an essential instance which is located between the numerous constraints mentioned and the real activities, excluding blind determinism whose predomination is seen by certain.

The role of the anthropotechnologist and the ergonomist is then to remove a certain number of constraints which give operators and their managers a better chance of constituting their work, being efficient in terms of production and protecting their health and life at the workplace.

In Anthropotechnology, as in Ergonomics, the approach to these work activities through E.W.A. prohibits a simplistic interpretation of the operating defects of imported technical systems and enables spaces to be created at various levels in order to solve the difficulties noted.

CONCLUSIONS

Ergonomic work analysis, the specific description of the real activity, shows that the operator and the user are not always reliable performers of the work prescribed but, more often, have to take into account a lot of variables due to the work itself, its environment and the personal state of the actor(s). In many cases, the work is the subject of a construction or a reconstruction in terms of the situation where the activity takes place. The aim of ergonomics is then to modify this situation in a favourable way. When the technical system is transferred from one country to another, the sources of variations are multiplied and have an even greater impact on the work. Thanks to the anthropotechnological approach, it is possible to track down the economic, social and anthropological causes of the difficulties observed and to avert them. Here again, a detailed analysis of situated activities leads to the identification of the obstacles to be removed or transformed.

ABRAHAO J.I (1986) Organisation du travail, représentation et régulation du système de production. Etude anthropotechnologique de deux distilleries situées dans deux tissus

industriels différents du Brésil. Thèse de Doctorat en Ergonomie. Laboratoire d'Ergonomie du CNAM pub Paris.

ALTHABE G., SELIM L. (1990). L'entreprise dans le cadre de l'investigation ethnologique et de sa méthodologie. JOURNAL DES ANTHROPOLOGUES 43-44, p. 17-22.

BARTLETT F.C. (1932) Remembering: a study in experimental and social psychology. Cambridge University Press, Cambridge (G.B.)

BARTLETT F.C. (1958) Thinking: an experimental and social study. Basic Books, New York.

BENCHEKROUN T.H. (1994) Modélisation et simulation des processus intentionnels d'interlocution. Application à la conception d'un système d'aide à la communication multi-agents. Thèse de Doctorat en Ergonomie, Laboratoire d'Ergonomie du CNAM pub PARIS

BOAS F. (1911) Introduction in Boas F. Handbook of American Indian languages. Bureau of American Ethnology, Washington (D.C.)

BOSTER (1985) "Requiem for the omniscient informant". There is life in the old girl yet, in Dougherty J.W.D., op. cit. 177-197

BOUTTERIN C., DELTOR S., GUERIN F. (1994) Evaluation du diagnostic court. ANACT pub. Lyon

BURTON W.R., BROWN J.S., FISCHER G. (1984) Skiing as a model of instruction, in Rogoff B., Lave J., op. cit. 139-150.

CASSON R.W. (1981). Language, culture and cognition: anthropological perspectives, MacMillan, New York.

CHAPANIS A. (1975). Ethnic variables in human factors engineering, John Hopkins University Press pub Baltimore

COLE M. and SCRIBNER G. (1974) Culture and thought: a psychological introduction. Wiley pub. New York

DANIELLOU F., GARRIGOU A. (1992) Human factors in design: sociotechnics or ergonomics? in Helander M. Design for manufacturability and process planning, Taylor and Francis, London.

DE KEYSER V. (1990) Why field studies? in Karwoswki W. Human factors in design for manufacturability and process-planning proceedings.

DE KEYSER V. (1991) Work analysis in French language ergonomics: origin and current research trends. ERGONOMICS 34 6 653-669.

DOUGHERTY J.W.D. (1985) Directions in cognitive anthropology. University of Illinois Press Chicago

DURKHEIM L. (1986) Les règles de la méthode sociologique, PUF Paris

EVANS J. St. B.T. (1989) Bias in human reasoning, causes and consequences, Lawrence Erlbaum, Hillsdale

FISCHER K.W. (1980) A theory of cognitive development. The control and construction of hierarchies of skills, Psychological Review 87 447-531.

GARDNER P.M. (1976) Birds, words and a requiem for the omniscient informant, American Ethnologist 3 446-468.

GARFINKEL (1967) Studies in Ethnomethodology, Prentice Hall pub Englewood Cliffs, New York

GATEWOOD J.B. (1985) Actions speak louder than words, in Dougherty J.W.B. op. cit. 199-219

GOFFMAN E. (1976) Frame analysis, Harper New York

GOODENOUGH W.H. (1957) Cultural anthropology and linguistics, George Town University Monograph series on languages and linguistics 9 167-173 George Town University Press pub.

GUERIN F., LAVILLE A., DANIELLOU F., DURAFFOURG J., KERGUELEN A. (1991). Comprendre le travail pour le transformer: la pratique de l'ergonomie, ANACT Paris

GUMPERZ J.J. (1992) Contextualisation revisited in Auer P., Di Luzio A. The contextualisation of language, John Benjamins Publishing Company, Amsterdam.

HENLE M. (1962) On the relation between logic and thinking, Psychological Review 69 366-378.

HUTCHINS E. (1979) Reasoning in Trobriand's discourse, Quarterly Newsletter of the laboratory of comparative human cognition 1-2, 13-17 reproduced in Casson R.W. (1981). Language, culture and cognition, MacMillan pub New York p. 481-489.

KERGUELEN A. (1991) Pre and post-observational categorisation of observables: application to the KRONOS software aid for activity analysis in Queinnec Y., Daniellou F. Designing for everyone, Vol. 1, p. 504-506 Taylor and Francis pub. London

KOHLER W. (1927) The mentality of apes. Harcourt Brace pub. New York

LANGA M.B. (1994) Adaptation ou création de l'organisation du travail lors d'un transfert de technologie. Analyse de l'activité de l'encadrement et conception de l'organisation. Thèse de Doctorat en Ergonomie. Laboratoire d'Ergonomie CNAM Paris pub.

LANGA M.B., WISNER A. (1994) Organisational design contribution of the anthropotechnological approach. Human factors in Organizational Design and Management IV Elsevier pub. Amsterdam

LAVE J. (1988) Cognition in practice, Cambridge University Press, Cambridge (G.B.)

LEE D.O. (1940) A primitive system of values, Philosophy of Sciences 7 3

MADI M. (1994) Personal communication

MAGAUD J., SUGITA K. (1993) Le retour des réseaux, une comparaison franco-japonaise, Annales des Mines (Juin 1993) 60-68

MALINOWSKI B.K. (1922) Argonauts of the Western Pacific, Routledge pub. London.

MALINOWSKI B.K. (1965) Coral gardens and their magic. The language of magic and gardening Vol. 2, American Book pub New York

MEISTER D. (1989) Conceptual aspects of human factors, John Hopkins University Press pub Baltimore

MONTMOLLIN M. de (1986) L'intelligence de la tâche, Peter Lang pub. Berne

NEISSER V. (1976) General academic and artificial intelligence in Resnick L.B. The nature of intelligence, Lawrence Erlbaum, Hillsdale (N.J.) 135-144.

OCHANINE D., ZALTMAN A. (1973) Operativité de l'image d'un contrôle de processus in Regulation de l'activité, Editions de Moscou pub. Moscou

OHLSSON S. (1985) Retrieval processes in restructuring, Scandinavian Journal of Psychology 26 366-368.

OMBREDANE A., FAVERGE J.M. (1955) L'analyse du travail, Presses Universitaires de France, Paris

PACAUD S. (1949) Recherches sur le travail des téléphonistes. Etude psychologique d'un métier, Le Travail Humain 12 46-65.

PAVARD B., BENCHEKROUN H., SALEMBIER P. (1990). La régulation collective des communications: analyse et modélisation in C.R. du Colloque "Les apports de l'ergonomie et de l'information avancée à la conception des systèmes interactifs," Biarritz 19-22 septembre 1990

PINSKY L. (1990) User activity centered design in Berlinguet L., Berthelette D. Work with display units, Elsevier Amsterdam 445-453.

PINSKY L. (1992) Concevoir pour l'action et la communication (essais d'ergonomie cognitive), Peter Lang, Neufchatel

RESNICK L.B. (1976) The nature of intelligence, Lawrence Erlbaum Hillsdale (N.J.)

RESNICK L.B., LEVINE J.M., TEASLEY S.D. (1991) Socially shared cognition, American Psychological Association, Washington

ROGOFF B, LAVE J. (1984) Everyday cognition, its development in social context, Harvard University Press, Cambridge (Mass).

SAHBI N. (1984) Anthropometric measurements and work analysis in modern technology in the Tunisian phosphate mines in Shahnawaz H., Babri M.. Ergonomics in developing countries C.E.D.L. Lulea University Press pub Sweden

SAHLINS M. (1976) Culture and practical reason, University of Chicago Press pub.

SAPIR E. (1958) Selected writings by Edward Sapir (Mandelbaum O.G. ed) University of California press pub. Berkeley Cal.

SCRIBNER S. (1984) Studying working intelligence in Rogoff B., Lave J. Everyday cognition, its development in social context. Harvard University Press pub. Cambridge (Mass), p. 9-40.

SELIM M., SUGITA K. (1990) L'entreprise dans le cadre de l'investigation ethnologique et de sa méthodologie. Journal des Anthropologues 43-44 p. 9-16.

SIMON H.A. (1992) What is an "explanation" of behaviour? Psychological Science 3 150-161.

SINAIKO H.W. (1975) Verbal factors in Human Engineering, some cultural and psychological data in Chapanis A. op. cit. 159-177.

SIX F., VAXEVANOGLOU X. (1993) Les aspects collectifs du travail, Octares pub., Toulouse.

STERNBERG R.J., WAGNER R.K. (1986) Practical intelligence. Nature and origins of competence in everyday world, Cambridge University Press pub. Cambridge U.K.

SUCHMAN L.A. (1987) Plans and situated actions. The problem of human-machine communication, Cambridge University Press (U.K.)

THEUREAU J. (1992) Le cours d'action: analyse semi-logique, Peter Lang Neufchatel

VERMERSCH P. (1990) Questionner l'action: l'entretien d'explicitation, Psychologie Française 35 227-235

VYGOTSKY L.S. (1934 [1962]) Thought and language, M.I.T. press Cambridge Mass.

WERNER O. (1969) The basic assumptions of Ethnoscience Semiotica 1 329-338.

WERTSCH J.W., MINICK N., ARNS F.J. (1984) The creation of context in joint problem solving in Rogoff B., Lave J. Everyday cognition, its development in social context, Harvard University Press pub Cambridge (Mass).

WHORF B.L. (1956) Language, thought and reality: selected writings of Benjamin Lee Whorf M.I.T. pub Cambridge Mass.

WISNER A. (1972) Diagnosis in Ergonomics or the choice of operating models in field research, Ergonomics 15 601-620.

WISNER A. (1976) Ergonomics in the engineering of a factory for exportation, VIth I.E.A. Congress Maryland. Ergonomics, mental load, anthropotechnology. Laboratoire d'Ergonomie du CNAM pub. Paris.

WISNER A. (1984) Ergonomics or anthropotechnology, a limited or wider approach to working conditions in technology transfer in Shanavaz H. Ergonomics in developing countries C.E.D.C. pub. Lulea University Press, Lulea, Sweden

WISNER A. (1992) De la ergonomia la la antropotecnologica. La organisacion de la empresa y del trabajo en las transferencias de tecnologia Sociologia del Trabajo 17 3-73

WISNER A. (1994) Understanding problem building: ergonomic work analysis, Ergonomics (to be published)

WOODS D.D., ROTH E.M. (1988) Cognitive systems engineering in Helander M. (ed) Handbook of Human-Computer Interaction, Elsevier pub.

SITUATED COGNITION AND ACTION: IMPLICATIONS FOR ERGONOMIC WORK ANALYSIS AND ANTHROPOTECHNOLOGY

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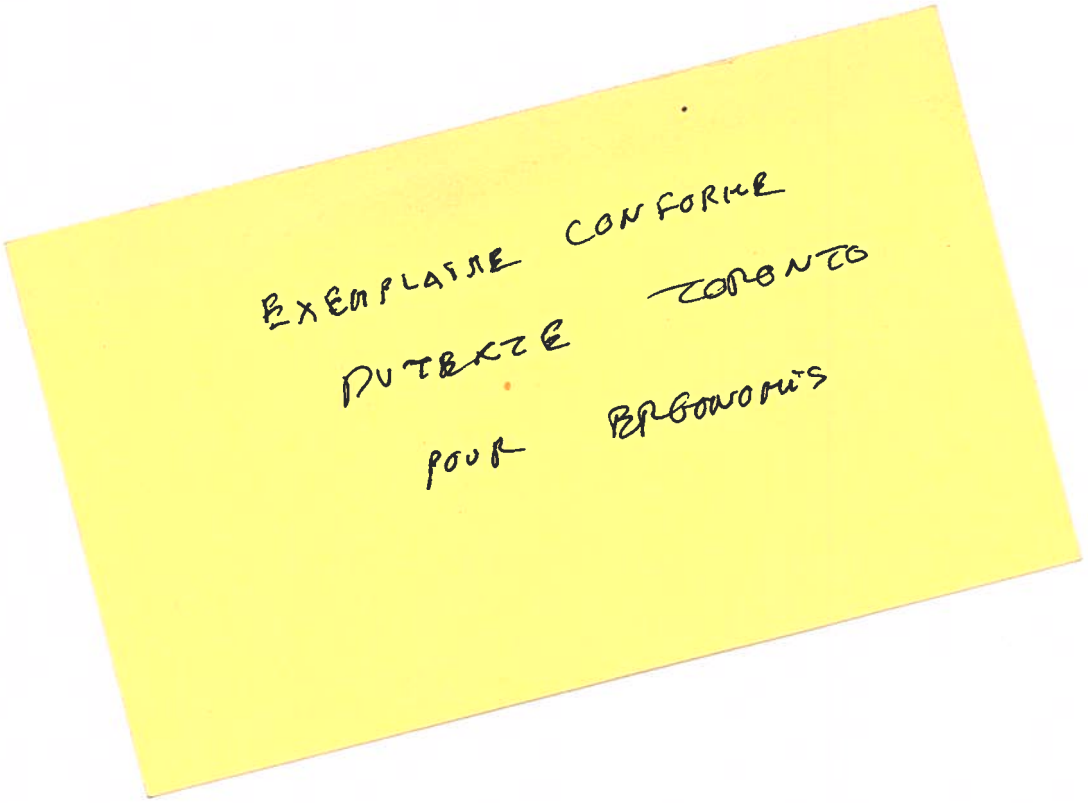

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ABSTRACT

After a short history of the study of work activities, we describe the methodology of Ergonomic Work Analysis (E.W.A.) and underline the diversity of practices. The methodology of analysis of activities involves exhaustive checks of the behaviour of operators in critical situations and confronts the operator with his own behaviour in order to obtain pertinent explanations and evoke the cognitive unconscious.

Ethnological work may constitute a contribution as regards the choice of the operator(s) whose behaviour is the most significant for the problem posed. In the same way, ethnologists using recording tools that are similar to those of ergonomists offer interesting frameworks for discussion of the qualities of these tools and the posture and balance aspects of behaviour. Moreover, interpersonal communications lead to beneficial exchanges with the ethnographic experience. Although the American school of situated cognition (cognitive and psychological anthropology) is very useful to know for activity analysts, it should not be confused with E.W.A. which, by definition, is directed towards an objective: knowing and transforming obstacles of all types which hinder and prevent satisfactory activities. First of all, E.W.A. has to show, from the viewpoint of operators, how they build problems in order to be able to solve them. Ergonomists and ethnologists note how difficult this problem building may be in view of the variability of the technical system and of the state of operators' knowledge.

The technology transfer situations studied by anthropotechnology need E.W.A. even more in view of the frequent degradation of technical systems and the heterogeneous character of the two cultures present in the mind of the operator: his own culture and that which has inspired the imported technology. From this viewpoint, here and there the operator may be considered not as a performer but as the iterative creator of his task.

INTRODUCTION: SHORT HISTORY OF THE STUDY OF WORK ACTIVITIES

One of the reasons for the present difficulties of ergonomics stems from the modesty of theoretical and epistemological studies of our discipline, with the exception of some notable examples (Meister, 1989). Many of us maintained a rather positivistic conception of the science which led them to claim their attachment to experimentation and a priori modelling. However, in order to succeed in their professional practice, they are concerned with what happens in reality and try to understand the reasons for the behaviour of operators in real situations. As such, they provoke an epistemological slide that is both substantial and partly hidden. However, for more than 40 years, French-speaking ergonomists (Pacaud, 1949), Ombredane and Faverge (1955) made a clearer choice by creating Ergonomic Work Analysis (E.W.A.). But there are few theoretical texts of this origin which give an account of this practical method. Only the efficiency of E.W.A. appears to justify its existence, thus ruling out the possibility of dialogue with specialists in neighbouring disciplines.. It's true that, at the time of creation of E.W.A., the dominant paradigms were those of behaviourism and laboratory experimentation, the results of which were supposed to be applicable in real situations. Certain ergonomists felt uneasy about the contradictions between what they saw in the field and the experimental results obtained (Wisner, 1972). But in the literature, they found no conceptual aid, only the same concern (Bartlett, 1932, 1958).

However, anthropologists and psychologists, most of them working in the USA, felt uneasy in the theoretical contexts of the period, in particular that of cultural anthropology: they created cognitive anthropology. Cognitive anthropology, which was first of all directed towards the relation between cognition and language (Sapir (1958) and Worf (1956)) sought generative grammar of thought, inspired by Chomsky, the theoretical study of which played an essential role at the time. Gradually, thanks to a group of psychologist and anthropologist authors, a collection of works led to the creation of a new field: thought and action in situation, situated cognition, which was very close to what E.W.A. was analyzing (see, for example, Resnick

(1976), Casson (1981), Rogoff and Lave, 1984, Dougherty, 1985). It might appear interesting to see to what extent theoretical studies of situated cognition, which appeared 30 years after E.W.A., are able to shed light on the epistemological problems raised by the latter. Very few ergonomists, even French-speaking ones, with the notable exception of Theureau (1992) and Pinsky (1990, 1992) established the link between E.W.A. and the American school of situated cognition. This paper will attempt to examine the possible relation. But this attempt involves risks for those who cling to the division of human sciences proposed a hundred years ago by Durkheim (1895, [1986]), leaving the study of thought mechanisms to psychologists and the study of thought content to sociologists (and anthropologists). This arbitrary division raised protests for some considerable time (Malinowski (1922) and Vygotsky (1934, [1962], for example), but remains well in place. Without judging the legitimacy of this division, it could be thought that it is of no interest to ergonomists whose role, for the past 50 years, has been to use, in human sciences, that which might appear useful in various disciplines, even if it means perverting them due to a concern for utility. Although ergonomists now have to exercise their epistemologically risky efforts on branches of sociology and anthropology, this is unimportant as regards our perspective of utility in as much as our work is done in a clearly defined theoretical context using adequate and precise methodologies. Theoretical aid may now come from French-speaking anthropologists who are interested in work (Althabe and Selim, 1990). In the first part, we shall consider the methodology of E.W.A. in its relations with the contributions from ethnological methods, then we shall see to what extent the theoretical work of cognitive psychology and anthropology relative to situated cognition may be useful for ergonomics, in particular for Ergonomic Work Analysis. Finally we shall examine what E.W.A. and situated cognition can contribute to anthropotechnology, i.e. better technology transfers and the adaptation of technology to the countries and populations which acquire it. As such, what is proposed is the acknowledgement that ergonomics has an anthropological dimension, both in terms of its methodology and its fields of application.

ERGONOMIC WORK ANALYSIS AND THE METHODOLOGICAL CONTRIBUTIONS FROM ETHNOLOGY

Diversity of practices in Ergonomics

Most often the ergonomist is called in when there is an operating anomaly: errors, quality problems, incidents, accidents, continuous process control difficulties, staff fatigue, anxiety, laboriousness, etc. In many cases, the causes of these operating defects are fairly easy to detect. The answer is found through the use of literature or simple and fast experimentation which does not always respect all the rules of experimentation publishable in a scientific magazine (quick and dirty). More often, a survey has to be carried out in the field so that operators or users can be heard. Literature contains exploratory studies, participative observations and systematic surveys which may have a statistical value. As such, we come closer to sociological studies or research into subjectivity which are presently gaining some ground. These investigations have the merit of situating the problem, measuring its importance and appreciating the scale of the transformations which the company is prepared to allow. In this way, the question is posed in a technical, economic and social context and one can appreciate the diversity of viewpoints developed by the various persons concerned: operators, supervisors, designers, customers, shopkeepers, etc. Thus, certain ergonomists feel they are able to reformulate the question asked. Finding the solution to the problem as formulated by the demander is very rare. However, we know the dangers of reformulation, which is quite simply liable to draw the request towards a particular scientific field, dear to the ergonomist concerned, while leaving aside the major aspects that are beyond him. This movement may also please the demander, at least in an initial phase as long as the intersubjectivity relation is successful.

After this reformulation, a solution can be proposed through experimentation and material or computer modelling. But there is a certain risk of the real problem not being treated if a

precise observation of the activity is not compared with the representation of the persons questioned. In particular, the unconscious dimensions of cognition may be missed by the analysis.

That is why a large number of ergonomists tend to make increasing use of Ergonomic Work Analysis (E.W.A.) which provides an exhaustive description of the activities of certain operators or users in phases of implementation of the technical system which are considered as critical. The full value of this detailed study of behaviour is revealed when it is compared with the representation which the operator or the user has of his own activities during the same period (self-confrontation). In general, if we wish to approach cognitive activities, the use of several methods appears vital in order to highlight beneficial contradictions.
There are numerous variations in Ergonomic Work Analysis according to the authors, but also in terms of the situations studied. Here we shall give a description of E.W.A. which is shared by a lot of French-speaking ergonomists. They are the ones who appear to make the most use of it.

Methodology of ergonomic work analysis

Many texts describe the current methodology of ergonomic work analysis (see, for example, Guérin and coll., 1991; De Keyser, 1991). 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. For example, through experience, the ergonomist who works for a company knows the validity of the request and the way it could be reformulated. Often, he has a simulator (automobile, nuclear industries, etc.). On the contrary, the consultant ergonomist, who is often a general practitioner, has to make a close examination of the question asked and often has to reformulate it in order to deal with the real questions which are

often hidden by a trivial formulation of the request. He also has to know the limits of the action he might take, by taking into account the specific technical, economic and social realities specific to the company which asked for his services; sometimes, he has to find out what these realities can teach about the system or the specific workstation he is studying. But frequently, the analysis of activities can be relatively reduced and only concern a few critical points in the case of usual ergonomic problems for which vast ergonomic know-how is more or less available according to the experience of the consultant. It is then a "short diagnosis" (Boutterin and coll., 1994).

The formulation of the recommendations may be a rather simple, short-term phase. But it could also be the subject of a complex process in collaboration with designers and future users, especially if the future system is to differ considerably from the one concerned by the work analysis. The need for iterative simulation often appears (Pinsky, 1990, 1992). Sometimes a specific methodology has to be used in order to define the probable future activities of a production system that is being prepared (Daniellou and Garrigou, 1992).

Analysis of activities

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, 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 on 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 due 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 correcting 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 follow-up of such procedures takes a long time. Analysis, in particular, is tedious. Therefore, they cannot be multiplied and, most often, one has to abandon the idea of using them in a statistical way. As such, the choice of the persons to be studied and the work periods to be considered are highly critical. Yet, the type of request is an essential guide: analysis of activities is done in the perspective of detecting the causes of one or more anomalies and the changes which must be made in the critical situation. This polarization of research through the need to solve the problem posed constitutes an essential feature of E.W.A. which distinguishes it from the ethnological survey to which E.W.A. may appear very close. For example, in ethnological literature, we find discussions which are very useful for ergonomists when it comes to choosing the subjects observed and the critical periods (Werner, 1969; Gardner, 1976; Boster, 1985). The way in which the members of a group work is shared in the double sense of the sharing of tasks and the pooling of part of the know-how (Resnick and coll.,-1991). It is obvious that the results obtained on the basis of a detailed analysis of the activities of a small number of persons over very short periods (Six and Vaxevanoglou, 1993) may be used for the subsequent construction of a systematic observation of a more limited number of critical phenomena on a larger population for longer periods of time. This use of a second phase which leads to the production of data with a statistical value may be reassuring from the methodological viewpoint, but this takes nothing away from the value of the first phase of detection of the complex relations which may exist between the technical system and the persons who work with it.

Recording tools

The effort of exhaustiveness in the observation of behaviour obviously has technical limits. Recording with a videotape recorder can be useful when the paper-pencil or recorder notation (Kerguelen, 1991) does not enable events to be followed rapidly. Suchman (1967) also recommended it, but she appears to give it particular qualities of objectivity. This opinion is debatable, since any experienced photographer knows that the choice of centring and details highlighted in a scene constitute an option that is just as clear as the elements which an observer notes by hand. The real advantage of videotape recording lies in the subsequent possibility of self-confrontation with the operator or reinterpretation by ergonomists. Recording speech on a tape recorder is vital as long as the speech is to be analyzed in detail. Here again, interesting debates have taken place between ethnologists in regard to the role of the data collection method in regard to the value of the research results. The verbal expression of populations of Trobriand (Malinowski (1922, 1965); Lee (1940); Hutchins (1979) is a good example of this methodological discussion.

The behaviour observed, even when grouped in "histories", does not always give an understanding of the cognitive activities which 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 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 which 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-confrontation is probably that it highlights elements of the cognitive unconscious. This plays an essential part in heuristic activities which enable problem-building. Thanks to Kohler (1927), since the start of the century we know that man is far from grasping the integrality of observable facts. He uses unconscious processes to select certain elements which 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 thus closely linked to previous activities and to culture (Ohlsson, 1985). Considerable work has also shown the mechanisms of recognition of speech, voice, faces or silhouettes. Evans (1989) took up this question in order to understand the nature of bias which often leads to the wrong representation of situations. He started with the conceptions of Henle (1962) who considered that subjects (operators, users) add, delete and alter the proposed premises. In other words, the subject does not reason in terms of the proposed subject, but in terms of a personal representation of it. An elegant demonstration of this reality was given by Ochanine (Ochanine and Zaltzman, 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 the human

cognitive capacity. Alongside self-confrontation and the Ochanine method, Vermersch (1990) proposed other methods of approaching the cognitive unconscious.

Body aspects of work

The considerable development of cognitive psychology and its use in E.W.A. may have the effect of underestimating the importance of the body aspects of work. An important initial point concerns body techniques. Gatewood (1985) called the article he produced from his participative observation of salmon fishing "Action speaks louder than words", since in order to throw the net properly from the bridge of a boat rocked by the waves, you have to know all sorts of body techniques for which there are no words; the words themselves do not correspond to anything specific for those who have not learned the trade. The reflection of this ethnologist is a reaction in regard to the conceptions of Sapir and Worf according to which language is the sole inlet for cultural or professional know-how. In fact, there is a neurophysiological explanation for this fact. Control of the balance and the situation of the body in space is located at the level of the cerebellum and has no conscious expression. As shown by Burton and coll. (1984) in regard to learning to ski, there is ergonomics in relation with these body techniques of balance and the space reference.
In a more general way, certain behaviour at work cannot be understood without taking into account the functional state of the operator (lack of sleep, fatigue, pathology) and his suffering at work (musculo-skeletal pains, for example) or his fears (accident, burns, blinding, etc.).

Work and interpersonal communications

The methodology described previously may be considered as relatively objective when relations with the machine dominate,. But work is increasingly an activity in which inter-human communication prevails and even constitutes the entire activity. Under these circumstances, there is always a risk of the discourse being considered as simple behaviour

without asking the question of intersubjectivity and, in a more radical way, that of the limits of ergonomics. Could this speciality include situations where possible improvements do not concern the technical system? More often, in the context of E.W.A., technical communications at work can be interpreted when they belong to a more vast group of different types of behaviour. But the dialogue between the user and the employee at the counter or on the phone, the interview between the nurse or doctor and the patient and the discussion between the salesman and his customer are work activities, yet they do not come under E.W.A. since one cannot ignore the contextualization of the language which is both given by the situation and created by the dialogue itself (Gumperz, 1992). As such, the dialogue lets the speakers form "frames" which enable the theatre of life to be staged at any moment in time (Goffman, 1976). It is very obvious that this corresponds to the dimensions of the activity which are of greatest interest but whose sociolinguistic and ethnolinguistic theoretical references must be respected, otherwise serious errors of interpretation will be made. However, even in work analysis which does not include a study of the discourse, the question of meaning is inevitable. Work activities submitted to the most Taylorian of organization methods include aspects which come under the significance of work: why do skilled workers increase their already heavy workload if not to make the work easier for other operators located downstream, thus respecting their work ethic?

ANALOGIES AND DIFFERENCES BETWEEN THE STUDY OF SITUATED ACTION AND ERGONOMIC WORK ANALYSIS

Contributions from cognitive anthropology

One of the bases of modern ethnology was expressed by Boas (1911) who thought that each culture should be understood from its own premises, while Malinovski 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 which should be taken into account in order to

understand human behaviour; these mental phenomena are considered as complex and rational and able to be studied thanks to strict methods which lead to reproducible results.
In this initial period (1955-1965), models of cognitive operation had to be deduced from observations of behaviour and material objects. These conceptual models had to be constructed like controllable hypotheses evaluated on the basis of their power of prediction and their formal elegance. Subsequently, 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 for cognitive reorganization and creativity in behaviour and understanding." (Dougherty, 1985, p. 8).

One can see to what extent cognitive anthropology is close to the principles which are the basis of ergonomic work analysis. We have to understand the operator's cognition (and not give him ours or that of the designer). This can only be done through long, detailed field studies. The models are based on a hypothesis of operators' rationality and may lead to computerized formalization as done by cognitive engineering and, more particularly, situated cognitive simulation (Woods and Roth, 1988; Pavard and coll., 1990; Benchekroun, 1994).
The operator no longer appears as the more or less faulty performer of the prescribed work, but as the permanent creator of his own activity which depends on what the operator understands about his own real work situation (the real work).

<u>The limits of cognitive anthropology in analysis of activities</u>

Under these circumstances, one might be tempted to attribute the theoretical context of cognitive anthropology to E.W.A. It is interesting to read about the attempt which Suchman

(1987) made along these lines. The very title of his book on Man-Machine communications is significant: "Plans and situated actions". The plans are the instructions, the task and the work prescribed and the situated actions are the real work.

As such, the interest of Suchman's way of thinking, like that of many of her psychologist and anthropologist colleagues, is all the greater when the ultimate forms of theory and methodology are not tackled. She chose a very significant example of this: the ease with which naive users can operate a new photocopier. This type of question is relevant in ergonomics but does not constitute the heart of the difficulties encountered when studying an experienced operator who has to contribute to quality and productivity under the difficult circumstances of the state of the technical system, the quality of raw materials and supplies and, in particular, time constraints. On the other hand, the critical aspect of the action in time is underlined by Gatewood, one of the few anthropologists to experience tough production conditions through his observations of sea fishing. He quoted Fisher (1980) who noted that one of the classic problems of most cognitive approaches is that "their constructions do not explain how thought is transformed into action." Furthermore, Gatewood recalled that knowledge, thought and know-how take time in the same way as more observable actions like blinking or grasping an object.

Another remark which could be made in regard to Suchman's research into photocopiers is that the author's stance in favour of Garfinkel's Ethnomethodology (1967) led her to provoke and study the dialogue between users in difficulty rather than to make an extensive exploration of the behaviour of an operator and to confront the operator with this behaviour. It is true that doing a crucial part of research in the experimental situation of the laboratory would lead to the significance of E.W.A. being lost. It is curious to see such a severe criticism of experimental psychology ending in the laboratory. Sometimes it is difficult to accept the theoretical positions of the best cognitive anthropologists (Lave, 1988).

Due to this, 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, 1984; Scribner (1984); Sternberg and Wagner (1986), etc.

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 E.W.A. 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 positions of authors favourable to the situated action. But it also has a more ergonomic aim, that of identifying pragmatic obstacles, the elements of the situation which hinder an easier constitution and resolution of the problem.

Adaptation to the diversity and reduction of information

As Simon (1992) wrote: "The human mind is an adaptive system. It chooses behaviours in the light of its goals, and as appropriate to the particular context in which it is working. Moreover, it can store new knowledge and skills that will help it attain its goals more effectively tomorrow than yesterday: It can learn. As a consequence of the mind's capacities for adaptation and leaning, human behaviour is highly flexible and variable, altered by both circumstances and experience. Nor are the alternatives from which the actor might choose usually known in advance. Human beings spend much of their time inventing or discovering actions that fit the circumstances." In our view, this text is a remarkable demonstration of the need for E.W.A. in order to find out about behaviour and, through this, the critical circumstances and level of experience of operators. The results of E.W.A. enable the circumstances (ergonomic action) and the knowledge (training action) to be modified.

From the same viewpoint, Evans involuntarily defended ergonomic action when he underlined that "the concrete conditions of the task affect the sensitiveness of subjects (operators) to errors and bias." Thus the conception of environments (the work situation) is an anti-bias approach. This means encouraging the best selection of data in the phase which precedes

reasoning, since the limited cognitive capacities of the human brain force the subject (the operator) to make a massive reduction of the existing information. However, there is a formidable concrete difficulty. We saw previously that the image constituted by the operator is deformed in order to comply with the functional state of the system. If this functional state changes, the operator does not have a usable functional representation. Therefore, professional experience is both a resource and a danger if the operator does not have the capacity to build other simple, efficient representations for other states of the system. Montmollin (1986) evoked "cognitive misery" in this respect.

The situation is all the more serious since operators often produce a poor representation of the limits and characteristics of their knowledge (in this respect, De Keyser (1990) spoke of "mosaic" knowledge). Their metacognition is often limited. They have difficulty representing the relative character of their knowledge which, at the same time, constitutes their social power. Challenging the relative character of this knowledge may lead to formidable conflicts with, firstly, engineers responsible for design or execution, since the logic of use differs from the logic of design, and, secondly, because the logic of use situated in specific time limits necessarily corresponds to a massive and directed reduction in the collection of data, while the designer does not suffer these constraints.

Problem building

Scribner (1986) as well insists on the fact that problem building is the first stage of dealing with concrete questions since, unlike school questions and experimental systems, there are no necessary and sufficient "data", but multiple indications, some of which are necessary but perhaps not sufficient.

Ergonomic Work Analysis constitutes an efficient methodology for grasping problem building (Wisner, 1994). It corresponds to the heuristic character of this phase and gives an understanding of the bases which an individual uses to solve the problem posed. E.W.A. may also highlight the pragmatic obstacles in the path of this elaboration.

It may be advisable to insist on the fact that if we make a more extensive analysis of the causes which render E.W.A. necessary, we find two main categories of the sources of variation.
First of all, the technical system does not operate in a stable way due to breakdowns, maladjustment and variations which are specific to the very nature of the industrial phenomenon of transformation. In addition, we have to take fluctuations of the quality of raw materials into account.
Secondly, operators differ from each other due to their level of training and experience. Furthermore, in team-work, members of the team often change due to the increasing use of temporary staff. This instability in the composition of work teams means that the skills of each member are uncertain for the other members of the team and have an influence on the quality of the knowledge shared.

The "naturalization" of cultural situations

From a more subtle viewpoint, designers of technical systems form an image which is sometimes far removed from the characteristics of the staff who will use the technical system. For example, this image neglects the substantial reduction, at present, of latent knowledge derived from the rural past and the fact that workers have a higher education level. These staff changes reflect the transformations of society.
There is nothing fortuitous about this negligence. It corresponds to what Sahlins (1976) considered as the "naturalization" of Western (industrial?) society in order to avoid consideration of socio-cultural characteristics.
This naturalization necessarily encounters insuperable difficulties when technology is transferred to a very different society, that of an industrially developing country (IDC). In this case, from the viewpoint of the exporters, the technical system has to be "adapted" due to foreign "capacities" and "mentalities". Consider the "Ethnic Variables in Human Factors Engineering" (Chapanis, 1975). As we see it, what is needed is a wider approach: "Anthropotechnology" (Wisner, 1976-1984).

ANTHROPOTECHNOLOGY

THE ROLE OF SITUATED COGNITION AND ERGONOMIC WORK ANALYSIS

Technical, economic and social constraints and anthropological treatments

The ergonomics of technology transfers was called Anthropotechnology in order to underline the fact that knowledge which 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 Ivory Coast, India, Indonesia, Japan, the Philippines, the Central African Republic, 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 which acquire foreign technologies and attempt to implement them with various degrees of success. Due 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. 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. These components are clearly reflected in the multiple expression used in the popular press (Third World, Developing Countries, Countries of the South, Peripheral Countries, etc.). However, forty years after the start of the widespread distribution of industrial technologies throughout the world, it has to be admitted that the evolution of many nations has differed considerably, despite the fact that, at the outset, they had comparable socio-economic levels. Among the countries which we prefer to call

Industrially Developing Countries (IDC), some have become Newly Industrialized Countries (NIC) and are challenging the established industrialized countries. Other countries will soon be classed as NICs. But, on the other hand, some have all sorts of difficulties: their GNP (Gross National Product) is not rising as fast as their population. Due to this, the populations in question see their personal and indirect income dropping constantly.

Many authors endeavour to explain or even predict these evolutions, which are so different, in order to advise the buyer countries or the exporting industrialists. Unfortunately, most of these studies exclusively respect a single discipline (most often economics) or even an ideology. They have little interest in giving advice about real improvements in work and the use of technology.

Anthropotechnological methodology

The orientation of anthropotechnology is similar to that of ergonomics. It is aimed at solving particular problems using general methods, reducing the health 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 practiced 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 E.W.A. of the critical points of the technical system in the seller countries, thus avoiding a situation where the system is necessarily considered to be 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 which has similar characteristics. Finally, installation of the new technical system by mixed

teams of managers and operators from the two countries should be followed up by an ergonomist who practices the necessary E.W.A. It is obvious that such a method is cumbersome, but it provides lessons and creates knowledge which could be used in a wider sense. In any event, it is preferable to precipitated test runs and long production rate build-ups which are littered with incidents and disputes.

Justification of the use of E.W.A. in a technology transfer is still more convincing than that of its general use in Ergonomics. The factors which influence work are too numerous for a forecast to be made, from the outside, of those which 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, we go further in the search for the origin of the difficulties encountered and we construct a tree of causes which is not limited to the technical and organizational aspects that are closest to the workstation. For example, we could discover that the air conditioning system of a continuous process control centre is not working in a sub-tropical 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 due 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 action. But 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 which owns the mixing plant. In another situation (Abrahao, 1986), among the 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 expensive hydraulic props out of order was 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.

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 and the Russian school, attach great importance to society in the construction of cognition (Wertsch and coll., 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 (see also 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 E.W.A. 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.
Surveys carried out properly might have highlighted such determining factors in these complex situations. The reason why Ergonomic Work Analysis turns out to be determining is that, in a industrially developing country, situated cognition is even more remote from planning, as Suchman said, and the real work is 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. Due to this, operators have to construct their tasks under special

circumstances which 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 they can understand and without the help of supervisory staff able to express themselves in the sense of their problems. Social distances which are increased by substantial wage differences and sometimes class and political differences may create conflict situations in the company which further complicate the comprehension of and the solution to technical difficulties. It can be seen that the concept of cognition in situation then takes on a great significance and that E.W.A. is the least that can be done to approach reality.

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

Considering the operator as the repeated creator of his task, a position which might appear audacious at first glance, thus becomes a necessity since he cannot execute a programme 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 to progressively turn from a farm labourer into an efficient worker in a work team according to modalities of the type evoked by Garfinkel (1962) 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 which Vygotsky saw between the person and society which, firstly, provides him with technologies and, secondly, acts through its social organization.

In industrially developing countries, the difficulty is further increased by the fact that it is a foreign society which provides the technology and the local society which imposes its social organization. Under these circumstances, it can be seen why work organization becomes the major field of conflict (Wisner, 1992), that work is only possible through the management of these difficulties and through individual and socially-shared cognition. The latter constitutes an essential instance which is located between the numerous constraints mentioned and the real activities, excluding blind determinism whose predomination is seen by certain.

The role of the anthropotechnologist and the ergonomist is then to remove a certain number of constraints which give operators and their managers a better chance of constituting their work, being efficient in terms of production and protecting their health and life at the workplace.

In Anthropotechnology, as in Ergonomics, the approach to these work activities through E.W.A. prohibits a simplistic interpretation of the operating defects of imported technical systems and enables spaces to be created at various levels in order to solve the difficulties noted.

CONCLUSIONS

Ergonomic work analysis, the specific description of the real activity, shows that the operator and the user are not always reliable performers of the work prescribed but, more often, have to take into account a lot of variables due to the work itself, its environment and the personal state of the actor(s). In many cases, the work is the subject of a construction or a reconstruction in terms of the situation where the activity takes place. The aim of ergonomics is then to modify this situation in a favourable way. When the technical system is transferred from one country to another, the sources of variations are multiplied and have an even greater impact on the work. Thanks to the anthropotechnological approach, it is possible to track

down the economic, social and anthropological causes of the difficulties observed and to avert them. Here again, a detailed analysis of situated activities leads to the identification of the obstacles to be removed or transformed.

ABRAHAO J.I (1986) Organisation du travail, représentation et régulation du système de production. Etude anthropotechnologique de deux distilleries situées dans deux tissus industriels différents du Brésil. Thèse de Doctorat en Ergonomie. Laboratoire d'Ergonomie du CNAM pub Paris.

ALTHABE G., SELIM L. (1990). L'entreprise dans le cadre de l'investigation ethnologique et de sa méthodologie. JOURNAL DES ANTHROPOLOGUES 43-44, p. 17-22.

BARTLETT F.C. (1932) Remembering: a study in experimental and social psychology. Cambridge University Press, Cambridge (G.B.)

BARTLETT F.C. (1958) Thinking: an experimental and social study. Basic Books, New York.

BENCHEKROUN T.H. (1994) Modélisation et simulation des processus intentionnels d'interlocution. Application à la conception d'un système d'aide à la communication multi-agents. Thèse de Doctorat en Ergonomie, Laboratoire d'Ergonomie du CNAM pub PARIS

BOAS F. (1911) Introduction in Boas F. Handbook of American Indian languages. Bureau of American Ethnology, Washington (D.C.)

BOSTER (1985) "Requiem for the omniscient informant". There is life in the old girl yet, in Dougherty J.W.D., op. cit. 177-197

BOUTTERIN C., DELTOR S., GUERIN F. (1994) Evaluation du diagnostic court. ANACT pub. Lyon

BURTON W.R., BROWN J.S., FISCHER G. (1984) Skiing as a model of instruction, in Rogoff B., Lave J., op. cit. 139-150.

CASSON R.W. (1981). Language, culture and cognition: anthropological perspectives, MacMillan, New York.

CHAPANIS A. (1975). Ethnic variables in human factors engineering, John Hopkins University Press pub Baltimore

COLE M. and SCRIBNER G. (1974) Culture and thought: a psychological introduction. Wiley pub. New York

DANIELLOU F., GARRIGOU A. (1992) Human factors in design: sociotechnics or ergonomics? in Helander M. Design for manufacturability and process planning, Taylor and Francis, London.

DE KEYSER V. (1990) Why field studies? in Karwoswki W. Human factors in design for manufacturability and process-planning proceedings.

DE KEYSER V. (1991) Work analysis in French language ergonomics: origin and current research trends. ERGONOMICS 34 6 653-669.

DOUGHERTY J.W.D. (1985) Directions in cognitive anthropology. University of Illinois Press Chicago

DURKHEIM L. (1986) Les règles de la méthode sociologique, PUF Paris

EVANS J. St. B.T. (1989) Bias in human reasoning, causes and consequences, Lawrence Erlbaum, Hillsdale

FISCHER K.W. (1980) A theory of cognitive development. The control and construction of hierarchies of skills, Psychological Review 87 447-531.

GARDNER P.M. (1976) Birds, words and a requiem for the omniscient informant, American Ethnologist 3 446-468.

GARFINKEL (1967) Studies in Ethnomethodology, Prentice Hall pub Englewood Cliffs, New York

GATEWOOD J.B. (1985) Actions speak louder than words, in Dougherty J.W.B. op. cit. 199-219

GOFFMAN E. (1976) Frame analysis, Harper New York

GOODENOUGH W.H. (1957) Cultural anthropology and linguistics, George Town University Monograph series on languages and linguistics 9 167-173 George Town University Press pub.

GUERIN F., LAVILLE A., DANIELLOU F., DURAFFOURG J., KERGUELEN A. (1991). Comprendre le travail pour le transformer: la pratique de l'ergonomie, ANACT Paris

GUMPERZ J.J. (1992) Contextualisation revisited in Auer P., Di Luzio A. The contextualisation of language, John Benjamins Publishing Company, Amsterdam.

HENLE M. (1962) On the relation between logic and thinking, Psychological Review 69 366-378.

HUTCHINS E. (1979) Reasoning in Trobriand's discourse, Quarterly Newsletter of the laboratory of comparative human cognition 1-2, 13-17 reproduced in Casson R.W. (1981). Language, culture and cognition, MacMillan pub New York p. 481-489.

KERGUELEN A. (1991) Pre and post-observational categorisation of observables: application to the KRONOS software aid for activity analysis in Queinnec Y., Daniellou F. Designing for everyone, Vol. 1, p. 504-506 Taylor and Francis pub. London

KOHLER W. (1927) The mentality of apes. Harcourt Brace pub. New York

LANGA M.B. (1994) Adaptation ou création de l'organisation du travail lors d'un transfert de technologie. Analyse de l'activité de l'encadrement et conception de l'organisation. Thèse de Doctorat en Ergonomie. Laboratoire d'Ergonomie CNAM Paris pub.

LANGA M.B., WISNER A. (1994) Organisational design contribution of the anthropotechnological approach. Human factors in Organizational Design and Management IV Elsevier pub. Amsterdam

LAVE J. (1988) Cognition in practice, Cambridge University Press, Cambridge (G.B.)

LEE D.O. (1940) A primitive system of values, Philosophy of Sciences 7 3

MADI M. (1994) Personal communication

MAGAUD J., SUGITA K. (1993) Le retour des réseaux, une comparaison franco-japonaise, Annales des Mines (Juin 1993) 60-68

MALINOWSKI B.K. (1922) Argonauts of the Western Pacific, Routledge pub. London.

MALINOWSKI B.K. (1965) Coral gardens and their magic. The language of magic and gardening Vol. 2, American Book pub New York

MEISTER D. (1989) Conceptual aspects of human factors, John Hopkins University Press pub Baltimore

MONTMOLLIN M. de (1986) L'intelligence de la tâche, Peter Lang pub. Berne

NEISSER V. (1976) General academic and artificial intelligence in Resnick L.B. The nature of intelligence, Lawrence Erlbaum, Hillsdale (N.J.) 135-144.

OCHANINE D., ZALTMAN A. (1973) Operativité de l'image d'un contrôle de processus in Regulation de l'activité, Editions de Moscou pub. Moscou

OHLSSON S. (1985) Retrieval processes in restructuring, Scandinavian Journal of Psychology 26 366-368.

OMBREDANE A., FAVERGE J.M. (1955) L'analyse du travail, Presses Universitaires de France, Paris

PACAUD S. (1949) Recherches sur le travail des téléphonistes. Etude psychologique d'un métier, Le Travail Humain 12 46-65.

PAVARD B., BENCHEKROUN H., SALEMBIER P. (1990). La régulation collective des communications: analyse et modélisation in C.R. du Colloque "Les apports de l'ergonomie et de l'information avancée à la conception des systèmes interactifs," Biarritz 19-22 septembre 1990

PINSKY L. (1990) User activity centered design in Berlinguet L., Berthelette D. Work with display units, Elsevier Amsterdam 445-453.

PINSKY L. (1992) Concevoir pour l'action et la communication (essais d'ergonomie cognitive), Peter Lang, Neufchatel

RESNICK L.B. (1976) The nature of intelligence, Lawrence Erlbaum Hillsdale (N.J.)

RESNICK L.B., LEVINE J.M., TEASLEY S.D. (1991) Socially shared cognition, American Psychological Association, Washington

ROGOFF B, LAVE J. (1984) Everyday cognition, its development in social context, Harvard University Press, Cambridge (Mass).

SAHBI N. (1984) Anthropometric measurements and work analysis in modern technology in the Tunisian phosphate mines in Shahnawaz H., Babri M.. Ergonomics in developing countries C.E.D.L. Lulea University Press pub Sweden

SAHLINS M. (1976) Culture and practical reason, University of Chicago Press pub.

SAPIR E. (1958) Selected writings by Edward Sapir (Mandelbaum O.G. ed) University of California press pub. Berkeley Cal.

SCRIBNER S. (1984) Studying working intelligence in Rogoff B., Lave J. Everyday cognition, its development in social context. Harvard University Press pub. Cambridge (Mass), p. 9-40.

SELIM M., SUGITA K. (1990) L'entreprise dans le cadre de l'investigation ethnologique et de sa méthodologie. Journal des Anthropologues 43-44 p. 9-16.

SIMON H.A. (1992) What is an "explanation" of behaviour? Psychological Science 3 150-161.

SINAIKO H.W. (1975) Verbal factors in Human Engineering, some cultural and psychological data in Chapanis A. op. cit. 159-177.

SIX F., VAXEVANOGLOU X. (1993) Les aspects collectifs du travail, Octares pub., Toulouse.

STERNBERG R.J., WAGNER R.K. (1986) Practical intelligence. Nature and origins of competence in everyday world, Cambridge University Press pub. Cambridge U.K.

SUCHMAN L.A. (1987) Plans and situated actions. The problem of human-machine communication, Cambridge University Press (U.K.)

THEUREAU J. (1992) Le cours d'action: analyse semi-logique, Peter Lang Neufchatel

VERMERSCH P. (1990) Questionner l'action: l'entretien d'explicitation, Psychologie Française 35 227-235

VYGOTSKY L.S. (1934 [1962]) Thought and language, M.I.T. press Cambridge Mass.

WERNER O. (1969) The basic assumptions of Ethnoscience Semiotica 1 329-338.

WERTSCH J.W., MINICK N., ARNS F.J. (1984) The creation of context in joint problem solving in Rogoff B., Lave J. Everyday cognition, its development in social context, Harvard University Press pub Cambridge (Mass).

WHORF B.L. (1956) Language, thought and reality: selected writings of Benjamin Lee Whorf M.I.T. pub Cambridge Mass.

WISNER A. (1972) Diagnosis in Ergonomics or the choice of operating models in field research, Ergonomics 15 601-620.

WISNER A. (1976) Ergonomics in the engineering of a factory for exportation, VIth I.E.A. Congress Maryland. Ergonomics, mental load, anthropotechnology. Laboratoire d'Ergonomie du CNAM pub. Paris.

WISNER A. (1984) Ergonomics or anthropotechnology, a limited or wider approach to working conditions in technology transfer in Shanavaz H. Ergonomics in developing countries C.E.D.C. pub. Lulea University Press, Lulea, Sweden

WISNER A. (1992) De la ergonomia la la antropotecnologica. La organisacion de la empresa y del trabajo en las transferencias de tecnologia Sociologia del Trabajo 17 3-73

WISNER A. (1994) Understanding problem building: ergonomic work analysis, Ergonomics (to be published)

WOODS D.D., ROTH E.M. (1988) Cognitive systems engineering in Helander M. (ed) Handbook of Human-Computer Interaction, Elsevier pub.