International Journal of Financial, Administrative, and Economic Sciences (IJFAES)
Vol. (3), No. (5)

IJFAES
May 2024

المجلة الدولية للعلوم المالية والإدارية والاقتصادية

الإصدار (3)، العدد (5)

Human Risk in Work Situation: Theoretical Framework

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Summary

To improve the contribution of human risk management in different work activities and thus to the general reliability of safety systems, this research proposes a theoretical framework for human risk management in work situations, through a detailed analysis design elements of human factors in the genesis of work accidents.

Keywords: Human Risk, Human Factor, Failure.

Introduction

Human risk has been for long time the center of the concerns of the responsible for the industrial systems safety, particularly in all process management situations. These errors are the source of significant production losses, and in the most severe cases, dramatic accidents.

In his professional environment, there are many and multiple tasks where the one must face situations which require rapid, reliable and adapted reactions in a very short time. Driving various machines is of course the best known example, from driving a locomotive to driving different types of cars.

In this type of context, humans must be able to maintain sufficient attention and concentration to successfully anticipate certain of their reactions. The transition from a situation which described as normal to a situation that can be considered degraded requires, to a certain extent, to manage as effectively as possible the moments of stress or tension caused by the unforeseen event. He must also, when faced to make decision, respond to visual stimulations with calm, composure, while maintaining exact and prompt motor reactions.

Furthermore, assessing risk as objectively as possible and integrating it into decision-making and ongoing management processes, in the community of risk-related work activities, constitutes a major challenge in terms of research and methodological developments.

The traditional methods of analysing accidents (quantitative approaches, tree of causes, etc.), while remaining relevant for the study of certain of their aspects, appeared to us to be insufficient for understanding the emergence of an incident in dynamic situation in a macro-system.

Traditional approaches to risk, as they are still widely practiced and particularly in Morocco for the management of human risk, are essentially deterministic. They do not make it possible to understand the overall safety of structures and do not provide direct guidance for the development of a preventive risk management policy. However, the overall methods of probabilistic risk analysis are, fundamentally, quite close to the reliability studies popular in the industry in general.

Thus, in our current theoretical and methodological reflections we must seek to explain "human risk" no longer only because of the organization, through the search for dysfunction at strategic levels, but also because of the operator who is the last link in a complex chain leading to the accident, (Baram, 1995; McDonald, 1995; Stoop, 1995)1.

[1] Quoted by C. deGarza (1999).

https://doi.org/10.59992/IJFAES.2024.v3n5p10 E-ISSN 2977-1498

As part of this work, we will seek to present a theoretical framework for the management of human risk in a work situation, through a detailed analysis of the design elements of human factors in the genesis of work accidents.

This study will be organized around the following points: in the first chapter, we will focus on the need to define the notion of human risk. Our reflection will then focus on the need to take human factors into account in the analysis of professional risks. And finally, we will also see some lessons from theoretical work on the failure of skills.

1- Human Risk Management

After having shed light on the evolution of the consideration of human factors and the conceptions of error which, during recent decades, have been at the center, it is necessary to consider the concept of risk management, always from the angle of human factors.

In this paragraph, we will first explain the notion of risk. Then we will seek to clarify, once again, the place of Man and his role in the system by emphasizing the importance of knowledge of the activity.

At first glance, the word risk denotes a rather simple concept. In everyday life, if someone says that there is a risk associated to a situation, we understand that there is uncertainty[2]about the occurrence of a certain event and that unfavorable consequences may result.

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[2] Uncertainty is a concept associated with that of risk. In this context, uncertainty is the consequence of the non-deterministic nature of the risk but also of the knowledge and perception that a person has of the probability of adverse events occurring.

Following a more precise and formal definition given by AMALBERTI (1996):

"Risk is a condition characterized by the possibility of the occurrence of an event causing an unfavorable deviation from expected or hoped for results."

There is therefore a risk if a combination of elements is combined. First, there must be the possibility of loss. The event must have a probability greater than zero and less than 1:

$0 < \text{Prob (event)} < 1$.

This event is neither impossible nor certain, and its probability is not necessarily measurable. It should also be remembered that this undesirable event is described as "an unfavorable deviation" from what is expected or desired.

Thus, to better understand the place of Man and his role in the system, it is important to recall the well-known opposition of ergonomists, which is the expression of one of them, François DANIELLOU. A first way of thinking about risks is to see man as a victim of a "flow of dangers" and to try to describe and explain the risk factors: we then try to categorize the risks (physical, chemical, electrical, etc.) to reduce the frequency, or to interpose "screens". Risk management requires expertise to detect risks and implement technical and/or prescriptive action to avoid them. We consider man as an "actor in the interactions which contribute to the organization of work". The vision prioritizes understanding of the actual work and knowledge of the activity, taking into account the complexity of the factors that determine how the activity is carried out, as well as the health/safety consequences.

Considering man as an actor will modify the point of view to adopt to manage risks, in particular by highlighting the role of knowledge of activities (in different forms: operating methods, strategies, etc.).

https://doi.org/10.59992/IJFAES.2024.v3n5p10 E-ISSN 2977-1498

Indeed, malfunctions and especially accidents cannot be caused by prior technical factors alone, and their understanding requires knowledge of human activity in the system. Understanding and managing risks depends on knowledge of the activity.

In this context, risk can still be perceived in two distinct ways (AMALBERTI, 1996):

- from an external point of view, it can be evaluated by the consequences of the occurrence of a given failure;
- from an internal point of view, that is to say from the point of view specific to the human operator, it can be evaluated in subjective terms of quality control of the work situation and adequacy between knowledge- do and work requirements.

Objective or "external" risk is the classic notion of accident risk developed by users of probabilistic risk analysis models. It objectively expresses the objective risk of observable, observable or predictable failure. The probabilistic outcome of the product is usually the probability of failure x severity of consequences... It would be necessary to add the probability of recovery. It is objective and measurable, but its measurement does not correspond to the way the operator functions.

"Internal" risk corresponds to the subjective risk specific to each person, which can be broken down into:

- The risk of not having the skills necessary to achieve the desired objective can be assessed before the action and can be anticipated.
- The risk of inability to manage resources during execution, loss of control of the action. It is difficult to predict this risk at the time of execution; it is only manageable at the time of action.

From a professional risk prevention point of view, external risk prevention strategies make it possible to avoid breakdowns or limit their effects. We define tolerance

https://doi.org/10.59992/IJFAES.2024.v3n5p10 E-ISSN 2977-1498

thresholds for minimal risks; unacceptable risks are controlled, prevented or protected in their effects. This is true for the risk of accidents and for health...

The operator's internal risk management methods regulate a tolerable level of risk, with a view to satisfactory performance. The operator can no longer accept the risk if it escapes control, that is to say if he considers, by anticipation or observation, that he is no longer able to cancel the risk by an action. It is then no longer a question of the objective frequency, but of the salience of the incidents in the operator's memory which then becomes a determining factor of the prevention strategy.

Alongside the taken human factors in the prevention of occupational risks, risk management consists, itself, of the assessment and the anticipation risks, and to put in place a system of monitoring and systematic collection of data to detect risks from a preventive perspective.

2- Human Factors Design[3] in the Genesis of Work Accidents

Monteau and Pham (1987) emphasize that the risks generated by new modes of production were poorly controlled at the end of the 19th century in the midst of industrial machinery. The direct causes of many accidents are easily attributed to unreliable technical processes, unprotected machines and poorly mastered techniques.

Technical causes are predominant, the causal and temporal link with the accident being most often clear. The search for cause and effect was reinforced by mainstream and deterministic scientists of the time. According to Taylorian analyses, the scientific organization of work announces a man/machine dichotomy which establishes a classification of accidents into two categories of factors: technical factors and human factors.

[3] "It is a field of concern which concerns all elements relating to people as well as the interactions they have with each other and with the systems in which they are integrated" (Pierre Vignes, 2005).

In fact, it quickly turns out that certain accidents can only be attributed to technical causes. Also, at the same time that the human sciences are interested in man at work as an object of study, a whole current of research on the genesis of accidents, which is above all the work of doctors and psychologists, seeks to highlight the role of physiological and psychological factors in this genesis.

It is possible to simplify the notion of "predisposition to accidents" into two main concepts and to present it in two stages in an entire stream of research (from 1900 to 1950) (Michel NEBOIT, 1999)

The first step was to statistically demonstrate that a small number of individuals suffered the majority of accidents. Groups of multiple casualties are actually highlighted in certain works.

The role of individual variables, such as age, sex, fatigability, intelligence, personality or even attitude towards risk, "risk taking" was then researched (this is the second step and the second notion) It is possible to affirm that if these factors can play a role, they cannot be considered, themselves, as dominant factors.

It is obvious that these apparently multi-accident groups are constantly renewing themselves, according to certain analyses. Certain situational factors can therefore be the cause of accidents. It would no longer be a question of individual or personal factors, but of factors linked to the family, professional or social context. This observation has directed research towards the identification of psychosocial factors of insecurity at work.

But an exclusively human conception of the causality of accidents not only reduces reality, but above all has, most often, only allowed victims to be blamed rather than to renew risk management. However, it has enabled the introduction, for prevention, of training, information and even assignment measures, which are now part of the management tools for safety and health at work.

The single conception of the accident has been modified in relation to general risk management, which has led to the appearance of multi-causal conceptions of the accident. After the 1950s, it was established that the accident was an event that did not result from the interaction between the operator and all other elements of the work situation.

For some (Heinrich, 1950; cited by Michel NEBOIT, 1999), it is a logic of heredity in the environment, of personal incapacity for dangerous acts, for injuries.

For others (Raymond, 1952; Michel NEBOIT, 1999), it is necessary to reconcile the technical factor and the human factor to avoid an accident, most often involved in the negligence of the victim. However, this conception completely excludes other elements of the professional situation.

It is precisely for these aspects that other authors, and especially those who are part of the research of the English school of psychoanalysis of the “Tavistoc clinic”, or the work of the sociologist Moreno, believe that the group work, as a psychosocial entity, is a parameter of the situation.

Security is linked to the cohesion of the group, or to its "sociometric balance", while risks are inversely associated with the absence of group cohesion or the absence of a recognized leader (Jenkins, 1948; Michel NEBOIT, 1999).

The importance of this development of multicausal conceptions of the genesis of the accident lies in the establishment of hypotheses but also of concepts and methods which determined the subsequent development of research.

These determining factors are in fact summarized in an overview of the accident which highlights (Michel NEBOIT, 1999):

- The multiplication of factors.
- the dynamic interactions of factors and not just mechanical causal determinism.

https://doi.org/10.59992/IJFAES.2024.v3n5p10 E-ISSN 2977-1498

- It is important to analyse the usual work to understand the (punctual) accident.

The multi-causal conception of the accident served as the basis for a new conception, a systemic conception of the accident.

In 1960, the company was considered as a socio-technical system finalized and organized into interdependent elements following the work of the Tavistoc Institute and the CECA, in particular that of FAVERGE. The accident is considered as a sign of system dysfunction and no longer as an isolated or circumscribed phenomenon. The investigation no longer focuses solely on the accident, but focuses on the operation of the entire system.

The ergonomics of systems, recommended by FAVERGE, against “traditional” ergonomics (that is to say of the workstation) and based on a theory of system reliability. FAVERGE establishes the first elements of a systemic analysis of work and accident as a consequence of incident recovery.

The last current to mention is the reliability current which has developed since the 1980s under the dual effect of technological developments and the evolution of the way in which the human sciences have treated the problem of accidents. This technological evolution is marked by automation and computerization, but also by the domination of control, surveillance and maintenance functions. On the other hand, the complexity of systems increases either by the number of interactions, or by the degree of dependence of one element on the other.

At the same time, and paradoxically, security systems themselves are also the weaknesses of complex systems. This succession of defensive barriers makes these systems not only fragile, but also increasingly difficult to understand, and therefore difficult to control, for those who are called upon to manage, operate and maintain them. Indeed, in “normal” times, the system can be automated. But certain malfunctions, if they require human intervention, and especially if they are rare, will find an operator who has lost his know-how, an operator who must, in addition, make a decision in uncertainty and in the deadline: all the conditions are then met to favor the appearance of a "human error".

It is this change which gave birth to a stream of research called "reliability" and more precisely centered on "human reliability". Man is one component among others of the production system which is conceived as a set of interacting elements. In summary, just as we try to measure the reliability of technical elements, we will try to measure the reliability of the human operator, in the hope of improving the overall reliability of the system.

The parallel development of conceptions of human functioning in work systems has fostered much work on human reliability and human error.

3- Theories Explaining Human Error

It is interesting to quickly recall the stages in the evolution of what we could call the explanatory theories of error.

The first current in the use of ergonomics which emerges from the communications theory of Shannon and Weaver (1949) applied to humans is an information processing system. Humans' limited some informations processing capacity makes it possible to explain errors due to a lack of resources.

If there is an error, according to its authors, it is because:

- Ambient noise (i.e. data not linked to the action in progress) disturbs the image of the signal.
- The transmission channel was affected by the influx of information and some information could not be processed.
- Competitive information blocked the processing of the main information.

This trend is at the origin, on the one hand, of the emergence of the concept of mental load and, on the other hand, of the practices for evaluating this load. It is possible to consider these methods as the first tools for error analysis and evaluation, particularly at a time when the tasks of monitoring complex dynamic systems are increasing.

Conceptions that explain the error by a decrease in alertness, stress, an impairment of functional abilities or an imbalance between the demand of the task and the resource to perform it are included in this conception.

Furthermore, a second major step has been put in place by problem-solving work (NEWELL and SIMON, 1972), in a concept where the reasoning steps leading to the resolution of a problem can be formalized in the form of an optimal algorithm. It is therefore wrong to seek a solution in a faulty reasoning phase. This approach has the advantage of being interested in human functioning in its form of reasoning and not only in its passive reactive form. This work has had a considerable impact on certain contemporary designs. Their limitation is that this design does not take into account the significant importance of the information processed. But above all, it does not sufficiently take into consideration the fact that, in cases of solving everyday problems:

– either we know the solution, which then implies automatisms and not reasoning,

– or the solution is not known, and it is then heuristics which are at play and not programmed sequential reasoning.

A third type of representation, also put forward by psychologists, is to see in the data that we store in memory, not as a correspondence to reality, but as a “mental representation”, an “internalized object”, a model. Action will be guided by this mental representation in memory, or schema. Michel NEBOIT (1999) affirms that the error is interpreted as a gap or rather a distortion between the mental representation and the reality that it has perceived.

What should be noted in this conception is the apparent paradox which is, for the mental representation in question, both the source of rapid responses, of adapted solutions, sometimes automated and at the same time and for the same reasons, the source of dysfunction. It therefore already appears that the error is no longer, stricto sensu, a defect, a dysfunction since its appearance is the sign of an adjustment process.

In the 1980s, Jens Rasmussen (1986), drawing inspiration from psychologists, schematized the information and decision functions taking into account the more or less automated nature of reasoning. It consists of 3 floors:

- The most automated is represented by sensorimotor skills.
- Based on knowledge, it is the most cognitively controlled.
- Passing through an intermediate level “governed by the rules”.

The interest of this schematization is not only to highlight the different phases and levels of operation, but also to provide a framework for analysis, classification and explanation of errors according to the level of processing at which they appeared. We can think that this cognitive architecture also contains the “representation” dimensions mentioned above. It can also be considered as a recapitulation of the various conceptions presented above. It has mainly been and remains used to analyze driving errors in complex systems.

The most comfortable mode of operation in which the human operator is most comfortable is an anticipatory mode. The human operator constantly checks, more or less explicitly, assumptions and controls expectations to avoid any surprises.

This activity of monitoring the expected results, or even monitoring the activity itself, works on several levels:

- Automatic action controls.

- This includes controlling representation in the event of problem resolution.

– Even checks which allow, if the error occurs, to recover it.

In this model, the conditions of the error appearance must be studied at the level of cognitive control mechanisms: little control is cheaper, faster, but leads to acting in uncertainty (risk-taking); on the contrary, too much control is expensive and above all delays action. This conception has, among other things, the merit of emphasizing that cognitive mechanisms are powerful adaptation mechanisms, but that these same processes, functional and well adjusted, can also be the cause of dysfunction and error. The error is therefore not the consequence of a faulty mechanism, but it is the sign of a limit of adaptation to the environment which expresses, thereby, the functioning obtained. The error is therefore a component, in this case, of the adjustment processes.

Conclusion

Zero risk does not exist, this principle is blatantly obvious in everyday life, whether it is crossing the street, taking your car, etc. Major accidents like that of the Chernobyl power plant (1986), are there to remind you that the risk also concerns industrial and technological installations. The specificity of this type of risk lies first of all in the collective or even social scale of the consequences but, also, in the perception of the risk often considered as imposed on the individual.

Indeed, the scale of risks is logarithmic: a risk can be reduced, without ever being cancelled. So, for example, a minimal risk, because the probability of the event in question is very low, can have consequences that would be incalculable.

In this type of context, the establishment of a human risk assessment system proves to be of paramount importance, on the one hand, to detect and predict operators at risk, and on the other hand, to guarantee better reliability of the industrial system in general.

In this regard, this research allowed us to carry out a theoretical framing of human risk management in a real work situation, and this througha detailed analysis of the design elements of human factors in the genesis of workplace accidents.

Finally, this research constitutes a modest contribution and a basis of study for all researchers on the problem of analyzing human risk in a work situation by seeking to minimize risks of a human nature, while specifying the need to take human factors into account in the prevention of occupational risks.

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