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Original Article

Analysis Testing of Sociocultural Factors Influence on Human Reliability within Sociotechnical Systems: The Algerian Oil Companies

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ABSTRACT

Background: The influence of sociocultural factors on human reliability within an open sociotechnical systems is highlighted. The design of such systems is enhanced by experience feedback.
Methods: The study was focused on a survey related to the observation of working cases, and by processing of incident/accident statistics and semistructured interviews in the qualitative part. In order to consolidate the study approach, we considered a schedule for the purpose of standard statistical measurements. We tried to be unbiased by supporting an exhaustive list of all worker categories including age, sex, educational level, prescribed task, accountability level, etc. The survey was reinforced by a schedule distributed to 300 workers belonging to two oil companies. This schedule comprises 30 items related to six main factors that influence human reliability.
Results: Qualitative observations and schedule data processing had shown that the sociocultural factors can negatively and positively influence operator behaviors.
Conclusion: The explored sociocultural factors influence the human reliability both in qualitative and quantitative manners. The proposed model shows how reliability can be enhanced by some measures such as experience feedback based on, for example, safety improvements, training, and information. With that is added the continuous systems improvements to improve sociocultural reality and to reduce negative behaviors.

1. Introduction

Humans have always occupied a significant place in the design, exploitation and maintenance of industrial systems. With technological advances, systems have become more sophisticated and complex. This complexification requires some abilities (cognitive, sensorimotor, and intellectual) and knowledge that sometimes exceed the limits of human operators. For example, the human operator could be failing on more than one criterion (saturation, loss of vigilance, tiredness, error, etc.).To that is added the constraints inherent in operator unsuitability to the technology of these systems that are conceived within sociocultural setting with no relationship to the local context. Such human failings are often the origin of incidents that evolve into catastrophes and sometimes have dramatic consequences not only for the operators and the installations but also to nearby populations and even to the environment. To prevent risks related to human error, several approaches to human reliability have been developed.

Since the 1950s, safety studies of industrial systems started to take an interest in human error with the purpose of establishing a quantifiable assessment allowing the calculation of the reliability of the human operator as a simple component of the system. Thus the first quantified estimates of human reliability were developed by Sandia National Laboratories, New Mexico, Albuquerque, USA in 1952 [1], with the purpose of quantifying the human error probabilities to build up evaluations, *ex ante*, of human reliability and using these data to calculate the overall system reliability.

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In the 1960s, the French Academy of Sciences accepted human reliability as a discipline belonging to the engineering sciences. Since then, studies have tried to build databases containing human error rates. Within this context, the human error rates method of prediction, technique for human error prediction was created in 1964 [2], followed by several similar methods such as technica empirica stima errori operatori (TESEO) [3], success likelihood method index (SLIM) [4], human error assessment and reduction technique (HEART) [5], and human cognitive reliability (HCR) [6]. These constituted the first generation [7] of methods based on human error, by considering the human as a simple component of the system characterized by failures that one can evaluate by probabilistic approaches. The second generation of these methods—cognitive reliability and error analysis method (CREAM) [8], a technique for human event analysis (ATHEANA) [9], and méthode d'evaluation de la réalisation des missions opérateur pour la sûreté (MERMOS) [10]—were developed from the 1990s and were focused on cognitive processes to try to predict and explain human failures. These methods tried to take into account some contextual factors within the framework of a systemic approach. The third generation—functional resonance analysis method [11], barrier and operational risk analysis [12], and other similar methods that developed from the end of the 1990s—were concerned with the organizational environment of work and its role in the genesis of human error.

The technicist approach—based on the improvement of a system's overall reliability by the increase in the reliability of each one of their components—considers the human a simple element of the system, hoping to evaluate the human's reliability as one evaluates the reliability of any system component. This approach appears to be outdated. This is in spite of their positive and undeniable contributions in the assessment of human reliability in terms of error prediction and quantification, especially their contribution to the improvement of maintainability and availability of systems. The technicist approaches had reduced the accident effects and the accident frequencies.

Nevertheless these tools had shown some limitations, because they adopt reductive and mechanist views [13]. Their application is heavy and complex, because they are based on arbitrary task division in elementary operations without taking into account the interactions between the tasks [14] and the probabilistic assessment is based on expert views and database extracts which differ in context to one another.

Thus these tools were centered on assessment rather than on reduction of human error risks because they are unaware of the human operation-specific characteristics and did not focus on the human operator negative aspects, hiding the operator's positive role especially in the recovery of incidental situations [15].

Many studies have highlighted the positive role of the human as a reliability agent [1], such as the ability to innovate and to invent new solutions according to situations, the expectation and recovery of failures, the adaptation to various unusual situations, the fast selection of relevant information, and the ability to synthesize and reason. Therefore, any reliability approach must bypass the comprehension of the human, in its thinking, its representations, its interactions with its environment, and its reactions when faced with constraints.

The comprehension of human conduct requires taking into consideration several factors such as personality, affectivity, cognitive function registers, cognitive styles, culture, training, and social environment.

The approach should tackle the issue of human reliability within a widened framework, by considering the studied system as being an open sociotechnical system on the external environment (social organization, economic, cultural, etc.) because this approach will not have to be limited to negative aspects (errors, maladjustment) but will have to be focused on operator strengths (recovery, correction, expectation).

In this article, we will try to emphasize the relevance of the influence of sociocultural factors on the operator reliability of the human—machine system within an open environment because the interactions of the elements composing the system cannot be considered within a closed system. We have limited these factors to six main ones in order to consolidate our in-site survey. This choice is justified by the theories of social psychology, the sociology of organizations, and by the works of the French Foundation for Industrial Security Culture. The selected factors are: standards and social values; group culture; commitment, mobilization, and culture of safety; socioeconomic environment; resistance to change; and the influence of the use of new information and communication technologies (NICT).

2. Materials and methods

For the site survey, we chose two major Algerian oil companies with large workforces. They were Sonatrach/DP Hassi Messaoud, Algeria, and ENTP (National Company for Oil Wells) Hassi Messaoud, Algeria. In accordance with the objective of the research, we initially adopted a qualitative approach centered on work cases. These observations let us foresee deviations in operator behavior when executing prescribed tasks. We also considered the statistical analysis of incidents/accidents which occurred following human errors and semistructured interviews with some of the managers that are accountable on managing systems showing all significant risks.

In order to consolidate the study approach, we made a schedule, through which we tried to be unbiased by supporting all workers categories according to their age, sex, education level, prescribed task, accountability level, etc. This schedule is made up of 30 items, each item comprises two parts: one closed question (yes or no) about the adoption of such behavior towards a given situation; if the response is positive then the operator is called to choose the sociocultural factors having motivated his behavior.

The sample took into consideration 300 workers distributed as shown in Table 1.

The average age of the executive managers was 38 years, that of the supervisors was 44 years, and that of the skilled workers was 46 years. The executive managers were from specialized institutes or from universities, supervisors were from certain specialized institutes and skilled workers came from training centers or institutes.

While choosing standard measurements to calculate the percentage of the behaviors adopted by the operators (positive and negative) and the part of the sociocultural factors which justified the adoption of such behaviors, it became quantitatively foreseeable to estimate the behaviors that are revealing in the assessment of human reliability and that are likely to be influenced by the sociocultural factors characterizing the local context.

Table 1
Schedule consistency and distribution

Companies	Studied workers			Sex		Nature of tasks		
	W1	W2	W3	M	F	T1	T2	T3
Sonatrach	50	50	50	138	12	62	58	30
ENTP	50	50	50	144	06	55	56	39
Total	100	100	100	282	18	117	114	69

T1, supervising and monitoring; T2, operation; T3, maintenance; W1, executive managers; W2, supervisors; W3, skilled workers.