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Cognitive Ergonomics and Its Role for Industry Safety Enhancements

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Introduction

Although ergonomic interventions have shown a great success to improve safety and productivity in the industry [1-4], ergonomists and safety researchers have faced a new challenge to move one step further. The industry's recent requests from ergonomists and cognitive psychologists are to find solutions for workers who have cognitive disorders and failures such as reductions in visual and hearing functions at least to some extents. A large part of occupational accidents and injuries is caused by human errors due to cognitive breakdowns. The human errors have different causes, but cognitive abilities and limitations of workers play an important role [5,6].

Cognitive failures are described as cognitively-based errors arising in a simple task that persons or workers can do without any error [7]. These events differ in their natures and rates amongst workers or individuals. Cognitive failures occur in job-related and non-job-related activities. Specifically, work-related cognitive failures are cognitively-based human errors and clusters of breakdowns that appear in working environments [7]. For this reason, it needs to examine relationships between occupational cognitive failures and safety consequences.

The associations between general cognitive failures and workplace accidents have been extensively assessed by researchers. For example, Arthur et al. showed a positive correlation between cognitive failures and occupational safety and concluded that workplace accidents were caused by inattention, distraction, and mental errors [8]. The similar outcome was obtained in a study of the traffic domain [9]. Other studies also conducted to find the connotation between cognitive failures and minor injuries and found a positive correlation between cognitive failures and fall injuries [10,11].

A study from Wadsworth et al. found a significant correlation between cognitive failures and minor injuries and accidents, and reported that the relationship amongst accidents, minor injuries, and cognitive failures shared common relations and all three outcomes were related to each other [12]. In a different study, Wallace and Chen stated a positive correlation between cognitive failures and accidents and a negative correlation with safety behaviors [13]. A recent study assessing the relationship between cognitive failure types and safety consequences found that cognitive failures such as memory failure and inattention could predict performance and behavior of workers [14].

Findings from the literature, it becomes clear that information on cognitive failures is an important source to investigate accidents and injuries at workplace environments. That is, observation of high prevalence of cognitive failures in the industry may provide reliable knowledge to predict safety performance. However, research is still limited to precisely foresee what ergonomics and ergonomists can do for preventing industry accidents and injuries due to cognitive failures and disorders. Therefore, the challenges for cognitive ergonomics and ergonomists are to develop theoretical knowledge and methodologies for facilitating to further reduce and prevent accidents, injuries, and illness caused by cognitive interruptions.

Cognitive Ergonomics and Industry Safety Enhancements

Cognitive ergonomics

According to the International Ergonomics Association, cognitive ergonomics is concerned with mental processes such as perception, memory, reasoning, and motor response, as they affect interactions amongst humans and other elements of a system [15]. It is the discipline and practices for making human-system interaction compatible with human cognitive abilities and limitations, particularly at work [16]. It aims to ensure appropriate communications amongst human needs, works, products, environments, capabilities, and limitations [15,16].

The relevant research topics in cognitive ergonomics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress, and training as these may relate to human-system design [15,16]. Hence, cognitive ergonomics mainly studies cognition in work and operational settings in order to optimize human well-being and system performance. It is a subset of the larger disciplinary fields of ergonomics and human factors.

In the human-system interaction, cognitive ergonomics employ the knowledge emerging from cognitive sciences on mental processes such as perception, attention, memory, decision-making, and learning [16]. The methods of these research areas are applied to gain a better understanding of the factors that affect cognitive function.

The practical purpose of cognitive ergonomics is to elucidate the nature of human abilities and limitations in information processing. This means that the specific goal is to improve work conditions and human performance, as well as safety and health, and to avoid human errors and unnecessary load and stress. These aspects need to be comprehensively studied in the context of work and other systems. In recent years, there has also been a trend to exploit the methods of neuroscience in the field of cognitive ergonomics [16].

Cognitive processes

Cognition covers processing and handling information in the human mind and brain. Cognition processes involve in encoding, maintaining, rehearsing, recalling, and transforming information [16]. Human cognition can be alienated into several functions that stimulate optimal human performance [17]. It is imperative to understand cognitive functions that are pertinent to a specific work or task and to safeguard that the working environment is suitable for these job conditions. The basic cognitive follows the following processes [16]:

1) Sensation and perception:

Signifies perception of stimuli gathered through the senses such as sight, hearing, taste, smell, and/or touch. For example, in the medical care environment, health care workers need to be able to recognize the symbols on the monitor. In the construction industry, workers should hear the warning signals and read the safety hazard symbols.

2) Attention:

A stage where the processing is focused on certain aspects of perceived information or processing may be divided into two or several aspects. For example, in a control room, workers should notice if there has been a significant change in the situation. In a nursery, nurses and/or nursery caregivers may need to concentrate their supervisions on several children at the one time.

3) A short term memory:

Information storage is available for up to 30 seconds. It suggests to the processes with which information is actively rehearsed and manipulated in the mind. For example, a telephone operator has to practice the name of the desired person until she/he has connected the call. A laboratory assistant needs to keep a track of the order of locations when working with several samples.

4) Long-term memory:

This is a permanent store for different kinds of information such as semantic memory, episodic memory, autobiographical memory, and procedural knowledge. Semantic memory concerns the storage of knowledge in the world, symbols, and concepts. Episodic memory covers information on events and episodes, whereas events in an individual´s personal life are referred to as autobiographical memories. Procedural knowledge concerns 'knowing how' and 'skills'. For example, all work requires specific knowledge of the field and specific skills such as how to use a machine in a safe way, or how to organize a meeting.

Cognitive ergonomics for work safety improvements

Cognitive ergonomics aims to design work conditions and environments that enhance cognitive functioning and human performance at work, and as a consequence, improve productivity, safety, and health at work. With cognitive ergonomics in the industry, main purposes are largely focused on improving work functioning and reducing human errors.

Safety and product quality improvements are the key concerns because workplaces with mechanization can result in increased operator decision making and monitoring requirements, which can increase the likelihood of human errors and accidents. Therefore, practicing cognitive ergonomics can provide the following benefits to improving safety and productivity and reducing accidents and injuries at workplaces [18]:

1) User-centred design of a software interface.

2) The design of a sign to convey the message so that people will understand and act in an intended manner.

3) The design of safer tools and machinery so that operators will not make catastrophic errors.

4) The design of information technology systems that support cognitive tasks.

5) Work redesign to manage cognitive workload and increase human reliability.

Conclusion

Cognitive functions are critical to safe and effective operations in the industries and workplaces. Although large variations are found amongst individuals, they are mainly caused by cognitive disorders and failures. However, even though their immense importance, cognitive issues have not been systematically highlighted in workplace ergonomic programs. Activities that involve this branch of the field have mainly focused on complex equipment such as nuclear power plants and aircraft manufacturing industries [19]. There are profound safety issues involved in the poor cognitive designs of equipment such as lack of standardized controls and unclear directions [20].

Making things understandable and user-friendly designs would significantly facilitate to avoid mistakes, increase reaction times, and lessen learning curves [20]. In this sense, cognitive ergonomics is an emerging branch of ergonomics and is a subset of the larger field of human factors and ergonomic disciplines. However, cognitive ergonomics is still an unexploited area for improving the design of machine controls, sets of instructions, and so forth. Therefore, it can be expected that cognitive ergonomics would provide significant contributions to improving work performance, lean operations, productivities, and eventually creating safer and healthier work environments in the industry.

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