Cognitive Ergonomics is a Matter of Cognitive Factors

Virpi Kalakoski

Finnish Institute of Occupational Health, Topeliuksenkatu 41 b, PO Box 40,
FI-00251 Helsinki, Finland,
virpi.kalakoski@ttl.fi

Abstract. We discuss two main possible reasons for the surprisingly modest visibility of the concept of cognitive ergonomics in both the research and application literature, and suggest remedies. First, when using this concept, we should be more explicit about the human cognitive limitations and abilities and their role in human–system interaction. Second, the field of cognitive ergonomics should also place more emphasis on the cognitive aspects of the socio-technical context part of human factors. Although the focus of ergonomics, and human factors, is on human–system interaction, it is essential to understand that one piece of this puzzle is a constant and the other is constantly changing. Human cognitive functions and information-processing principles and their underlying brain structures have remained approximately the same for at least 30 000 years. In contrast, the current era of digitalization, automation, robotization, and big data has brought, and will continue to bring, changes that also affect the cognitive demands of the socio-technical context.

Keywords: Cognitive ergonomics, Cognitive psychology, Applied cognitive psychology

1 Introduction

Despite 40 years of cognitive ergonomics, surprisingly few articles use this concept. When searching for ‘cognitive ergonomics’ or just ‘ergonomics’ in the Human Factors, the Ergonomics, and the Applied Ergonomics journals, only 9 out of 79, 69 out of 776, and 89 out of 1313 documents concern specifically cognitive ergonomics rather than any ergonomics, respectively. In the whole Web of Science, ‘cognitive ergonomics’ is present as a topic in 582 documents, which is relatively seldom if compared to ‘ergonomics’ that can be found as a topic in 8747 documents. However, it is evident that both practices and research do deal with cognitive ergonomics, but under different concepts and constructions, such as ‘human factors’, ‘human-centred design’, and ‘cognitive engineering’. When these are used together in a search (excluding ‘ergonomics’), there are 8475 topic matches in the Web of Science. In sum, whereas all documents

referring to ergonomics and related fields total more than 17 000, the concept of 'cognitive ergonomics' is visible in the leading journals of our field in less than 170 documents. What is this concept and why is it relatively unpopular?

Ergonomics (or human factors) practices aim to ensure 'appropriate interaction between work, product and environment, and human needs, capabilities and limitations', as defined by the Human Factors and Ergonomics Society [1]. The International Ergonomics Association further describes three domains of specialization within the discipline, one of which is cognitive ergonomics, which is concerned with 'mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system' [2]. Both definitions name the human and system parts of human factors and stress their successful interaction.

We suggest that, in the future, the field of cognitive ergonomics should place more emphasis on the cognitive aspects of both the human and the socio-technical context parts of human factors in order to increase our contribution to productive and healthy human-system interaction. Cognitive ergonomics is a matter of cognitive factors. While the significance of cognitive factors increases with the development of digitalization, robotization, and artificial intelligence, also the field of cognitive ergonomics should expand its contribution and impact.

1.1 Human cognition is still the same

Although the definition of cognitive ergonomics provides a comprehensive list of human cognitive functions, there is a need to describe human cognitive abilities and limitations in more detail. What aspects and principles of cognitive functioning are relevant when we study the interaction of human cognition with the socio-technical context? Such knowledge already exists in the human factors field, but these theories and examples are often associated with specific types of tasks and context, and very often with high-demand safety-critical tasks and environments. For example, the very useful concept of situational awareness [3] combines several cognitive functions that are relevant in demanding dynamic tasks such as air traffic control [4]. However, this concept refers to a specific combination of cognitive functions and particular task demands and is not directly applicable to other contexts. There is therefore a need to expand both the application of knowledge on human cognitive functions and the scope of the socio-technical context.

The field of experimental and applied cognitive psychology offers a huge amount of information on the limitations and capacities of the human cognitive system and the factors that affect cognitive performance. For example, our capacity to rehearse and process information in our short-term working memory is limited to 3–4 items [5-6]. We better recall the first and last items from serially presented information [7], there are various cognitive tendencies that bias our decisions [8], and developing expert-level knowledge and skills requires 10 000 hours of deliberate practice [9]. These and other findings define the cognitive factors and information-processing principles that have remained approximately the same for at least 30 000 years, as long as the underlying brain structures have been the same [10]. They are shared by all humans and constrain

their behaviour and performance, even when we are not aware of them. Cognitive ergonomics should expand the utilization of the large, deep scope of theories and findings regarding experimental and applied cognitive psychology and bring the current understanding of the human information processor to the core of cognitive ergonomics research and practice.

1.2 Changing socio-technical context creates new demands

It is not only the human part of human factors that requires a detailed description of cognition; we should also clearly describe the cognitive aspects related to the changing socio-technical context. In the definitions of (cognitive) ergonomics, the system parts interacting with the human parts are tasks, jobs, products, systems, organizations, and environments. It is essential to describe the cognitive demands of these systems and contexts, which cognition functions are required when we interact with a specific socio-technical context, and whether some conditions are cognitively straining and likely to impair our cognitive performance.

Information and communication technology and artificial intelligence continue to develop, which has provoked changes in all contexts and will continue to do so. In work life, these changes can lead to job intensification and increase the cognitive demands in work. For instance, a growing number of knowledge work tasks require working with abstract knowledge and acquiring, creating and applying knowledge, as well as continuous on-the-job learning [11-12]. Moreover, new technologies, work designs and environments such as open-plan offices have made cognitive load prevalent in current work and life: disruptions such as speech and office noise, interruptions, and information overload manifested as multitasking or through new interaction technologies can have harmful consequences and hinder task performance [13-17]. It is important that cognitive ergonomics constantly updates its view on the changes in the socio-technical context, related cognitive demands, and the relevance they have for human cognitive performance and well-being [18].

2 Conclusions

We argue that the societal contribution of cognitive ergonomics will increase in the future if we define both the cognitive human and the cognitive socio-technical context in more detail and constantly update the relevance of new research findings from the perspective of human–context interaction. In research, we need to apply the detailed findings of cognitive psychology and demonstrate how cognitive limitations manifest in conventional everyday tasks. Cognitive ergonomics can play a theory-building role in providing applied cognitive psychology models that can handle complex everyday tasks in which no single cognitive function is dominant, and in which different functions work in concert [19].

As regards designing the socio-technical context, recognizing the changes in the cognitive demands in the context allows the identification on the one hand, of the possibilities they can provide in enhancing human cognitive performance, well-being, and

productivity; and on the other hand, the risks to cognitive performance and well-being if the new demands exceed human cognitive abilities and capacities and lead to cognitive failure or impair (occupational) safety and health [20-21]. Cognitive ergonomics can offer a detailed description of the cognitive aspects of the context and enhance the study of the antecedents and moderating factors in the socio-technical context that predict human behaviour and interaction [22].

We also need new methods that quickly provide us with a general overview of the cognitive demands and cognitively demanding conditions in the new contexts and within any task. Changes in socio-technical contexts now pertain to all fields – not only the high-demand and safety-critical tasks that have previously been the focus of human factors studies. Some excellent examples update our view of specific socio-technical contexts, such as models that describe the complexity of interruptions in health care and their consequences [23]. However, whereas many of the job and task analysis methods currently in use are valuable in research, they are often too time-consuming and expensive to be realistic options for design purposes or in conventional workplaces with limited resources. Therefore, we have developed a new cognitive ergonomics method at the Finnish Institute of Occupational Health. This method quickly provides both a general overview of the prevalence of different types of cognitive demands at work, and a more detailed picture of the cognitive demands of the specific tasks and the work environment.

In sum, cognitive ergonomics is a field that can anticipate how the changing cognitive context around us will affect the cognitive human; our performance and related productivity, as well as well-being on individual, organizational, and institutional levels. We suggest that the concept of cognitive ergonomics should be more clearly defined as the part of human factors that focuses on the cognitive aspects of both the human and the socio-technical parties, whose interaction is at the core of cognitive ergonomics. The more we understand both parts of the equation, the more successfully we can anticipate their interaction, which is also changing in line with the context changes. For design, cognitive ergonomics should provide the means to model and predict how the new products and applications to be developed would either support or hinder human performance in this context. To the fields of work design and job crafting [24-25], cognitive ergonomics can bring the cognitive edge that is essential for designing reformed work life.

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