Cognitive Ergonomics in the intralogistics sector

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Abstract. As a result of growing globalization and flexibility of labour markets, the logistics sector is increasingly gaining importance. One essential process and a central function in the field of logistics is order picking. The efficiency of order picking systems depends to a large extent on employee's performance. With regard to rising digitization, dynamization and networking of working environment new forms of organization, information and communication technologies arise. According to the research field »Cognitive Ergonomics« psychological and physical work demands of order pickers and, furthermore, cognitive demands when handling different order picking methods are analysed. The aim is to optimise work systems and technical assistance systems for better and long-lasting health, work ability and job performance of employees. Based on identified psychological and physical workloads, a stress and strain model will be developed and validated for a continuous workload monitoring at order picking workplaces.

1 Introduction

In recent years economic environment in the logistics system has markedly changed [1]. As a result of growing globalization and flexibility of labour markets in Europe the logistics sector is increasingly gaining importance. Due to the modern requirements of logistics, particularly the section of intralogistics is moving more and more into the focus of attention. Nowadays more flexibility of logistics systems and workers within these systems is required, to meet customer needs [1]. Regarding rising digitization, dynamization and networking of working environment new forms of organization, information and communication technologies, and an increasing degree of automation in the field of intralogistics can be recognized [2]. The integration of employees into complex and continuously changing work environments is especially challenging for companies.

Despite an increasing mechanisation and automation in the field of intralogistics, employees are still confronted with physical demands. Nowadays, economic goods are still transported, sorted, stored, picked or distributed [3]. This means that warehouse workers often pull, push, lift and carry heavy loads at their workplaces [4]. Furthermore, working while standing and performing repetitive or manual activities are most common [4]. Besides, employees in the intralogistics sector often have to deal with work-environment conditions such as wearing protective clothing, unfavourable climatic conditions or noise [4]. Intralogistics activities are also characterized by psychosocial job demands like monotony, very rapid work, great deadline and performance pressure, prescribed work performance or multitasking [4]. Furthermore, the usage of technical assistance systems for individual information processing and related exchange of information within human-technology interaction will lead to altered psychological and particularly cognitive demands. It is supposed that new load patterns and different accumulations of stress and strain will arise.

2 Research project »Cognitive Ergonomics«

According to the national joint research project »Centre of Excellence for Logistics and IT« the unit Intralogistics and IT Planning of the Fraunhofer Institute for Material Flow and Logistics (IML) explores the research topic of »Cognitive Ergonomics«, together with the department of Ergonomics of the Leibniz Research Centre for Working Environment and Human Factors at TU Dortmund (IfADo). In this context, the pursued goal is

to expand the existing research and development centre for logistics and IT in Dortmund in cooperation with external partners from business and science. The working area of Cognitive Ergonomics belongs to one of different ergonomic approaches within human-machine interface (Fig. 1).

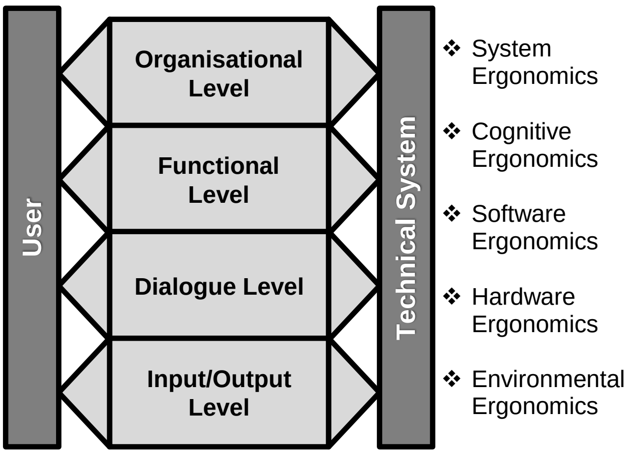

Figure 1. Levels of human-machine interface and the relevant subsections of ergonomics [5].

Short-term research objectives of the research field »Cognitive Ergonomics« include the analysis of various psychological and physical work demands of employees in the commissioning area. A comprehensive risk assessment of commissioning workplaces and the empirical investigation of the interaction between risks and smart devices are aimed. Furthermore, cognitive demands when handling different order picking methods, for instance pick-by-voice, pick-by-light, pick-by-vision, are examined in field and laboratory studies. Regarding human-machine interaction a special focus lies on the analysis of cognitive processes, for instance information processing, memory, attention, and cognitive load in complex and changing work-related situations. Recommendations for deploying and designing smart technologies in compliance with cognitive and ergonomic aspects will be given. In the long term, based on identified psychological and physical workloads, a stress and strain model will be developed and validated for a continuous workload monitoring at order picking workplaces and thus, the establishment of smart working environments which allow to monitor, evaluate and optimize mental and physical workload is pursued.

3 Order picking methods in the research focus

One important process and central function in the field of logistics is order picking [1, 6, 7]. During the process of order picking a certain amount of products out of a prepared range of stored goods is collected according to customer orders. Order picking is mostly performed manually and is therefore flexible but error-prone [7, 8]. As a commissioning area by itself generates high costs and, moreover, errors in the order picking system may have an impact on the delivery quality and finally on customer satisfaction, customer loyalty and business confidence, financial losses can be expected in the long term [1, 7]. Besides, the widespread classic manual method of the paper-based picking list, various technical assistance systems for warehouse order picking have been arising in the course of digitization, such as pick-by-light, pick-by-voice or pick-by-vision. By the use of modern order picking technologies, it is expected that setup, search, pick times and accuracy can be optimized [9]. Within the project »Cognitive Ergonomics« an extensive literature research will be conducted. Research studies are collected that compare different order picking technologies regarding error rate, task time, workload or usability factors.

4 Research methods

Field studies. Various intralogistic working areas in selected companies are investigated, in particular the commissioning area. For this purpose, questionnaire-based surveys are carried out with the help of scientifically validated survey instruments. The focus lies on psychosocial job characteristics (e.g. work ability, quantitative demands, scope for decision-making, leadership quality or working atmosphere) [10, 11] and in detail on mental load while handling different order picking technologies, for example, mental, physical and temporal demands, performance, effort and frustration [12]. Furthermore, current health complaints, sleeping behaviour, attitude toward technology, personal and socio-demographic factors are recorded. In addition, already known physical job characteristics, for instance, repetitive activities and pulling, pushing, lifting, carrying and manual handling of loads, are assessed by using traditional, validated methods, such as »key indicator method« [13, 14]. Work-related environmental conditions are measured objectively, such as digital measurement of light intensity, and subjectively, for example discomfort glare. Objective performance measurements of employees provided by the company like sick leave or several performance indicators for example key figures of commissioning are also considered.

Laboratory studies. Under standardised and controlled conditions various intralogistic activities, such as order picking, packaging or palletising, are simulated in the Future Lab of the Leibniz Research Centre for Working Environment and Human Factors at TU Dortmund (IfADo) to investigate and compare several technical assistance systems. While dealing with a head mounted display, a stationary terminal or a paper-based order list, psychological demands are recorded using psychophysiological measurement methods, for example heart rate variability or electrodermal activity. Furthermore, psychometric instruments and criteria are used for assessing workload or technology experience subjectively.

5 Conclusion

Even though the technology of automated warehousing systems shows a continuous development progress, manual order picking processes executed by human pickers are still required in the future because of their high flexibility and adaptability to heterogeneous changing product portfolios and technical environments. Furthermore, due to the advancing automation and digitization of working environments there will be an enrichment of human work duties from rather physically tasks to more monitoring and controlling responsibilities. The job enlargement towards more cognitive tasks entails an increase in information processing and decision-making responsibility and thus an increase in mental workload.

Within the project »Cognitive Ergonomics« we suppose that employees in the commissioning area individually differ in cognitive load, cognitive capacity, susceptibility to stress and cognitive performance. As employees cannot be replaced by machines in the future, deployed technical assistance systems (e.g. with regard to picking support) and user interfaces should be designed human-centred and highly customisable to support staff. Furthermore, the physical and mental workload should be kept on an optimal level by means of assistance systems and smart environments.

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