Human factors in a contemporary organization

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Abstract

The presented paper concerns publications presented as part of XXXI International Seminar of Ergonomics. It presents basic information on ergonomics terminology. In addition, the development directions of the ergonomics research area in historical terms were shown. This is because, among other things organizing background for over 40 years *International Ergonomics Seminars* series in *Poland*. The second part of the text contains short descriptions of the research area presented in individual publications, highlighting their specificity and connections with the leading topic of human factors.

Keywords Ergonomics · Published research · Ergonomics conference

1 Introduction

On the occasion of the *XXXI International Seminar of Ergonomics*—held in Poznan, Poland (May 23–25, 2018) (<http://www.iset.poznan.pl/>), the *Central European Journal of Operations Research (CEJOR)* invited submissions of papers to a special issue. The special issue focused on theoretical, methodological and applied *Operations Research* contributions to improvements for both *organizations* and *humans* related with them.

International Ergonomics Seminars series in *Poland* aims to create an opportunity to share experiences between practitioners and theoreticians who deal with various areas of ergonomics. The *31st seminar*'s main topic was “Human Factors in a Contemporary Organization”, broadening the scope of ergonomics. Following both the aforementioned tradition and the special subject, this *CEJOR Special Issue* aimed to

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be a forum for debate and exchange on new knowledge, experiences and avenues, to address OR activities towards a better human-supported, and a more human-friendly and qualitative world of tomorrow in contemporary and emerging industries, managerial and administrative sectors, both public and private, and in daily life.

2 Ergonomics: as it began

The concept of ergonomics, such as we accept today, as a science that deals with the adaptation of all technical objects to the capabilities and limitations of man, was not known in the past. Despite this, people tried to make their work easier, making it less exhausting. In the mid-nineteenth century, Wojciech Bogumił Jastrzębowski—a Polish scientist, naturalist and inventor, professor of botanic, physics, zoology—introduced the term ergonomics (from the Greek *εργον*—‘work’ and *νομος*—‘natural law’) writing an ergonomic dissertation entitled ‘The Outline of Ergonomics, i.e. Science of Work, Based on the Truths Taken from the Natural Science’ (1857). Wojciech Bogumił Jastrzębowski was not only the creator of the term ergonomics, but among the interests in many areas it is worth mentioning that he was the creator of the draft of the first ever constitution of a united Europe as one republic without internal borders, with uniform legislation and organs of power composed of representatives of all nations entitled ‘About the everlasting peace between the nations’ (1831). However, both the peaceful coexistence of European nations and the concept of ergonomics did not become popular at that time. They were simply forgotten, so that many researchers came to similar conclusions again after many years. It wasn’t until the twentieth century that there was a significant development in ergonomics research, and the concept itself became widely known only at the end of the twentieth century. However, in the period of intensive industrialization of some fields of manufacturing (mainly textiles, mining, metallurgy, machine construction) until the beginning of the twentieth century, problems in non-adaptation of technical devices to human were common. The beginnings of ergonomic activities focused on limiting the employee’s effort (energy expenditure). It was only further steps to adapt the machines and devices to the psychomotor capabilities of the people using them. Often, this applies to the adaptation of the device interface as an element through which the user communicates with the machine.

The period of high intensification of ergonomic research was World War II due to the complexity of the design of aircraft, ships, tanks, as well as the appearance of radar stations and encryption devices. The operators of these devices operated not only under time pressure, but also in high stress and difficult environmental conditions. The achievements of this period were used in civilian applications. In the second half of the twentieth century, the development of more complex technical production structures, including automation, means that human performs auxiliary activities in the production process. Man becomes an addition to the machine. This necessitates the need for new research. Automatic machines force people to perform the same, simple tasks constantly, enforce a static position and generate noise. The operator’s work is monotonous, intellectually poor, boring, not requiring thinking. This situation lasts as long as the machine is operating normally. If a failure occurs, the situation

changes radically. The operator is usually not qualified to remove the causes of the failure and must call service personnel. Machine downtime causes large losses. This causes pressure that intensifies mental tension, and additional stress is caused by the low repetition of emergency situations and the inability to predict the moment of its occurrence.

The end of the twentieth century and the beginning of the twenty-first century is a period of very rapid development of computers and IT. Information technologies have a huge impact on people. The use of computers at many workplaces causes that this impact affects many people. The most obvious and commonly understood burdensome of working on a computer is the need for prolonged sitting and lack of movement, as well as eye strain, back pain, arms and wrists caused by excessive static load. However, this is only part of the research challenges. Much more difficult to investigate is the impact that huge amounts of information on computer users. This creates new research fields for psychologists, sociologists and people dealing with software ergonomics. Modern challenges include contact with intelligent systems, especially collaboration between human and autonomous systems.

Currently, adapting devices to human limitations also takes into account users' disabilities and limitations due to their age. In addition, ergonomic analysis applies to all human activity, also not related to work. Despite the diverse issues in various areas of ergonomic activity, ergonomics studies mainly concern working conditions, i.e., factors of the material work environment and organizational factors, as well as the ergonomics of products, i.e., the adaptation of technical objects to human capabilities. In the case of complex systems, where research concerns various disciplines, the concept of macroergonomics is introduced. The terms human engineering and human factors in technology used by researchers in the US symbolize the importance of man in ergonomic research. The main topic of the 31st International Seminar of Ergonomics "Human factors in a contemporary organization" also emphasizes the importance of man in all his actions. In addition, it should be emphasized that in over 40 years of history of this conference, the presented papers relate constantly to new areas of research related to ergonomics.

As *Human Factors* remain at the forefront of Operations Research and Management Science (OR/MS), *Energy* and *Renewability* is now an all-important study area. As, furthermore, *Human-Oriented Smart Technology* continues to rise while always becoming refined, its applications broaden and they enhance in their potential impact on leading to paradigm shifts and even revolutionize views and studies about sustainability. This potential can only be fully realized with a careful understanding of the most recent breakthroughs in the fields of *Human-Oriented Smart Technology* and *Renewable Energy* themselves and in their emerging methodologies from Mathematics, Statistics, Analytics, Probability Theory and Stochastics, Operations Research and Artificial Intelligence.

This *CEJOR* Special Issue "Human Factors in a Contemporary Organization" is a worldwide collection of organizational applications in sustainability and an overall "smiling face" towards Humankind and addressing the innovative research that explores the recent steps forward towards smart managerial inventions and needs and offeres of every Human Being. Featuring the coverage on a wide range of topics including neural fuzzy control, energy assessment and biogeography, this special issue is

ideally designed for academicians and researchers, for students, economists, managers, advocates, policy-makers, engineers, implementers of solutions, multipliers of information spread and opinion building.

At all of these points, modern *Optimization* and *Optimal Control*, *Data Mining*, *Machine Learning*, *AI* and *OR* come into play as *key technologies* of modeling, regularization and careful selection, of pre- and post-processing, of simulation and preparation, of guidance and interest, of continuous respect and concern (Akteke-Öztürk et al. 2020; Babaei et al. 2019; Kara et al. 2019; Onak et al. 2019). The population of people on earth steadily grows, putting on the agenda numerous and hard questions, so many urgent problems. For instance, there is the need to offer all the necessary food, clothes, housing, services, infrastructure, medical and many further commodities and goods of all kinds. *Optimization* and *Decision-making* has to find, choose and allocate new territories, particularly, in rural countrysides, and vast amounts of energy, while all of this should be implemented with not more than a moderate complexity by organizations and governments, within an overall atmosphere of care, empathy and freedom. In situations like these, *Human-Oriented Smart Technology*, *Data Mining*, *Analytics*, *Optimization*, and *Renewable Energy* are making a big difference and emerge as *Key Technologies* of the future (Roy et al. 2019; Lotfi et al. 2020).

3 Published research

Based on very careful reviewing processes, 13 articles were accepted for publication and became part of this exclusive collection of papers—our CEJOR Special “Human Factors in a Contemporary Organization”. The total number of pages is 246. Short descriptions of these articles are given subsequently.

In their paper “The measurement of human capital as an alternative method of job evaluation for purposes of remuneration”, Wojciech Koziol and Anna Mikos (2019) address contemporary science and business practice in the field of remuneration management, including many concepts and models of the remuneration systems and job evaluation. Still the practice of payroll systems is based on the compromise, usually between the expectations of employees and the financial capacity of the employer or as a result of interaction between the market forces, supply and demand. There can be a risk of distortions resulting in too low or too high salaries or an incorrect pay relationship in the organization, so that the welfare of the employees is reduced, or the employer’s financial balance is at risk. The authors aim at a method of human capital measurement as a conceptual basis of job evaluation for improving the remuneration system in the organization. This method allows an objective measurement. Hence, it is possible to provide a pay standard for such a job.

With their contribution “Effects of Scatter Plot Initial Solutions on Regular Grid Facility Layout Algorithms in Typical Production Models”, Jerzy Grobelny and Rafal Michalski (2019) conducted two simulation experiments to verify whether the idea of *virtual force* scatter plot algorithm, used for searching solutions of the facility layout problems, could be employed as an input to the classical CRAFT and simulated annealing (SA) algorithms. The authors’ approach uses a regular grid for specifying

possible locations of objects. Three independent variables were investigated in the first experiment: (1) size of the problem: 16, 36 and 64 objects, (2) type of links between objects: *grid*, *line*, and *loop*, and (3) shape of the possible places in which the objects can be situated: *circle*, *row* and *square*. The patterns of possible location places were adapted, too. Data were statistically analyzed. The results show a substantial decrease in goal function means in all examined experimental conditions, if the proposed starting solutions are applied to the CRAFT algorithm. The application of the approach to SA is profitable in specific tasks. Comparative numerical results demonstrate under which circumstances the new method is superior over various genetic algorithms and other hybrid approaches.

Andrzej Marek Lasota and *Krzysztof Hankiewicz* (2019) in their article “Self-reported fatigue and health complaints of refuse collectors” aim to evaluate the fatigue and subjective complaints of musculoskeletal disorders (MSDs) among refuse collectors. To evaluate fatigue a modified 30-piece questionnaire with a Borg scale was used. MSDs were measured by the Nordic Standardized Questionnaire with the Borg scale. After work, the highest rates of fatigue were reported for symptoms such as “feel thirsty”, “give a yawn”, “want to lie down”. There was a high intensity of MSDs reported for the body segments “shoulders/upper arms”, “lower back”, “upper back”, “hips/upper legs”, “head/neck”, “elbows/forearms” and “wrists/hands”. Complaints regarding limited mobility due to MSDs at work and outside of work have been observed. Refuse collectors complained more about “drowsiness and dullness” than the “projection of physical impairment” and “difficulty in concentration”. Discomfort occurred primarily in the upper segments of the body. Test results can be used in the prevention of fatigue and discomfort. It is recommended to conduct training on the correct ways of performing work and resting, and the repair or replacement of faulty containers.

In their paper “Knowledge Accelerator by Transversal Competences and Multivariate Adaptive Regression Splines”, *Magdalena Graczyk-Kucharska*1, *Ayşe Özmen*, *Maciej Szafranski*, *Gerhard-Wilhelm Weber*, *Marek Goliński* and *Małgorzata Spychała* (2019) address a set of the knowledge, skills and attitudes required for various positions and in different professions, called as transversal competences; they include entrepreneurship, teamwork, creativity and communicativeness. Employers in different countries list them more and more as the key requirements. The authors model the acceleration of the acquisition process of transversal competences, based on data from four EU: Poland, Finland, Slovakia and Slovenia. Therefore they use the method of Multivariate Additive Regression Spline (MARS), and Artificial Neural Networks (ANN), to create the best model or system. They show that herewith the acquisition of the transversal competence of entrepreneurship is influenced by: rank of the training method in the developed matrix, student numbers and the weighted average of the pace of acceleration regarding the acquisition of the remaining transversal competences, i.e., teamwork, communicativeness and creativity. The results may be used in the educational framework of planned vocational courses, and for developing skills required.

In the article “Single workgroup scheduling problem with variable processing personnel”, *Bentao Su* and *Naiming Xie* (2019) point out that human resource allocation, as a scheduling problem, has gained more and more attention from both industry and

academia. However, the commonly used scheduling methods fail to fully address the relationship between tasks and employees. The authors consider a single workgroup scheduling problem under the assumption of variable human resources. Jobs must be assigned to employees, where the number of processing personnel and the processing time are variable for one job. They model the problem as a combinatorial optimization problem and the objective targeted is to minimize the maximal finalization time which is named as makespan. This problem is transformed into a two-dimensional rectangle strip packing problem, and a hybrid optimization algorithm is proposed which combines a scheduling algorithm with a packing algorithm. Here, the new strategy and algorithm turn out to be suitable for solving very well single workgroup scheduling.

In his contribution “Ergonomics as basis for a Decision Support System in the Printing Industry”, *Manuel Mateo, Marc Tarral, Pedro M. Rodríguez and M. Asunción Galera (2019)* are concerned about the rapid manufacturing step of newspapers as producers have to ergonomically determine the maximum capacity to setup and feed the line by the workers and improve the knowledge on the input conditions of each supplement. In fact, newspapers must be printed each night in such a short time to deliver them next morning. A printing plant must perfectly design the production, in which some manual operations as the supplement insertion are critical. The authors develop a decision support system to determine the number of hired workers needed for the manual insertion (setup and feeding) for a printing plant. It involves the supplement characteristics, ergonomic issues and the production rates. The new system has lead to a 13% increase in productivity, a reduction in cost overruns and an important reduction in labor costs.

The paper “The Concept of the Trichotomy of Motivating Factors in the Workplace” by *Leszek Koziol and Michal Koziol (2020)* investigates motivation at the workplace and its methodological aspects, it classifies the factors of motivation and describes characteristics of selected factors. The author introduce a new approach to factors based on the concept of the trichotomy of motivation factors in the workplace, extending Herzberg’s two-factor theory. The concept identifies three groups of factors: (1) “motivators” which, when they occur, lead to satisfaction, (2) “hygiene factors” which, when they do not occur, lead to dissatisfaction, and (3) “demotivators” which, when they occur, lead to dissatisfaction. Hence, the new concept provides a methodological directive that suggests the extension of the research area by including an analysis of factors which reduce motivation to work.

Marcin Nowak, Rafał Mierzwiać and Marcin Butlewski (2019) in their article “Occupational Risk Assessment with Grey System Theory” propose a new method of occupational risk assessment by using Grey Decision Model (GDM), also called as Grey Occupational Risk Assessment Model (GORAM). This new method permits for combining measurable and qualitative factors in the process of occupational risk assessment through the employment of expert knowledge. This method can be applied to the multifaceted occupational risk assessment of complex and uncertain sociotechnical systems. The authors present the problems of currently used methods of occupational risk assessment in the context of the chance of solving them using the methods of the Grey System Theory (GST). Eventually, developed GORAM is used regarding the position of the mechanic in the technical department of a production company.

In their contribution “Job Analysis and Time Study in Logistic Activities: A Case Study in Packing and Loading Processes”, *İbrahim Halil Korkmaz, Erkan Alsu, Eren Özceylan and Gerhard-Wilhelm Weber (2019)* focus on enhancing the permeate flux of helical shaped membrane by Group Method of Data Handling (GMDH) algorithm. Variables such as operating pressure, pore size, and feed velocity were selected as input, while permeate flux is the output variable. An Uncertainty Analysis evaluates the acceptability of the model and it is found that values of Nash–Sutcliffe efficiency (NSE), ratio of the root mean squared error to the standard deviation, and percent bias are close to optimal, demonstrating the model acceptability. By using a Sensitivity Analysis, the effect of input parameters on the output is calibrated. It shows that pore size is the most sensitive parameter followed by feed velocity. The errors in GMDH model are compared with multi-linear regression (MLR) model, showing that GMDH predicts results with a smaller error; the predicted variable follows the actual one with good accuracy.

The contribution “Application of hidden Markov models to eye tracking data analysis of visual quality inspection operations” by *Berna Haktanirlar Ulutas, N. Fırat Özkan and Rafał Michalski (2019)* are concerned with visual inspection made in numerous fields for its possibly high inspection costs related errors such as injury, fatality, loss of expensive equipment, scrapped items, rework, or failure to procure repeat business. This paper presents an application of Hidden Markov Models (HMMs) to the analysis for sequences of fixations during visual inspection of front panels in a home appliance facility. The results support the difference between expert and novice operator. The authors demonstrate, analyze and discuss four HMMs with two and three hidden states both for novice and experienced operators.

Izabela Kudelska and Grzegorz Pawłowski (2019) in their paper “Influence of assortment allocation management in the warehouse on the human workload” address activities related to allocation of goods in the warehouse. All operations in and around the warehouse are labor-intensive and time-consuming, which in turn generates warehousing costs. Despite the ongoing automation in this area, human labor is still applicable in many warehouses. This research deals with the impact of the assortment allocation in the warehouse on the “Human Factor” (HR). A simulation is conducted with a swarm algorithm, and the results undergo a statistical analysis. Correlation of cost optimization and factors influencing the operation’s ergonomics is determined.

In their article “Hesitant interval-valued intuitionistic fuzzy-linguistic term set approach in Prisoners’ dilemma game theory using TOPSIS: A case study on Human-trafficking”, *Ankan Bhaumik, Sankar Kumar Roy and Gerhard Wilhelm Weber (2019)* point out that sometimes, when considering the totality, the outcome of a game is not zero literally, and we apply the name of a “Non-zero-sum Game”. “Prisoners’ Dilemma Game” is one of most famous examples of a non-zero-sum game. In this article, human trafficking, one of the most emerging problems of today’s society is investigated through prisoners’ dilemma game using a hesitant interval-valued intuitionistic fuzzy-linguistic term set, where linguistic interval terms are expressed by linguistic semantics first and, then, corresponding indices are used. Finally, a “Nash Equilibrium” is derived from the given setting, and the achieved result establishes a close contact with reality using the “Technique for Order of Preference by Similarity to

Ideal Solution” (TOPSIS) and “Dominance Property” of matrix game theory. Further reading (Das et al. 2019; Khalilpourazari et al. 2019).

In the paper “The concept of the qualitolology and grey system theory application in marketing information quality cognition and assessment”, *Joanna Majchrzak, Marek Goliński and Władysław Mantura (2019)* present the basics of qualitolology, grey-incidence clustering model and their application for recognition and assessment of marketing information quality. First, the authors explain the concept of qualitative (qualitological) modeling of marketing information quality. Quality, marketing information quality and the evaluated marketing information quality are presented. Along several steps, marketing information quality become specified, recognized and assessed. The authors introduce an innovative solution through integration of fundamental qualitative principles, operations and methods with the grey incidence clustering model. The developed concept facilitates the recognition of the marketing information quality in a systematic (holistic) manner, considering the states of features belonging to marketing information and their structure. The new solution methodology was applied for an industrial company.

References

- Akteke-Öztürk B, Weber G-W, Köksal G (2020) Generalized desirability functions: a structural and topological analysis of desirability functions. *Optimization* 69(1):115–130. <https://doi.org/10.1080/02331934.2019.1570192>
- Babae TE, Mahdavi I, Seyyed Esfahani MM, Weber G-W (2019) A hybrid augmented ant colony optimization for the multi-trip capacitated arc routing problem under fuzzy demands for urban solid waste management. *Waste Manag Res*. <https://doi.org/10.1177/0734242X19865782>
- Bhaumik A, Roy SK, Weber GW (2019) Hesitant interval-valued intuitionistic fuzzy-linguistic term set approach in Prisoners’ dilemma game theory using TOPSIS: a case study on human-trafficking. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00638-9>
- Das SK, Roy SK, Weber G-W (2019) Heuristic approaches for solid transportation- p -facility location problem. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00610-7>
- Graczyk-Kucharska M, Özmen A, Szafranski M, Weber G-W, Goliński M, Spychała M (2019) Knowledge accelerator by transversal competences and multivariate adaptive regression splines. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00636-x>
- Grobelny J, Michalski R (2019) Effects of scatter plot initial solutions on regular grid facility layout algorithms in typical production models. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00632-1>
- Kara G, Özmen A, Weber G-W (2019) Stability advances in robust portfolio optimization under parallel piped uncertainty. *Cent Eur J Oper Res* 27(1):241–261. <https://doi.org/10.1007/s10100-017-0508-5>
- Khalilpourazari S, Soltanzadeh S, Weber G-W, Roy SK (2019) Designing an efficient blood supply chain network in crisis: neural learning, optimization and case study. *Ann Oper Res*. <https://doi.org/10.1007/s10479-019-03437-2>
- Korkmaz İH, Alsü E, Özceylan E, Weber G-W (2019) Job analysis and time study in logistic activities: a case study in packing and loading processes. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00624-1>
- Koziol L, Koziol M (2020) The concept of the trichotomy of motivating factors in the workplace. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00658-5>
- Koziol W, Mikos A (2019) The measurement of human capital as an alternative method of job evaluation for purposes of remuneration. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00629-w>
- Kudelska I, Pawłowski G (2019) Influence of assortment allocation management in the warehouse on the human workload. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00623-2>

- Lasota AM, Hankiewicz K (2019) Self-reported fatigue and health complaints of refuse collectors. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00637-w>
- Lotfi R, Weber G-W, Sajadifar SM, Mardani N (2020) interdependent demand in the two-period newsvendor problem. *J Ind Manag Optim* 16(1):117–140. <https://doi.org/10.3934/jimo.2018143>
- Majchrzak J, Goliński M, Mantura W (2019) The concept of the qualilogy and grey system theory application in marketing information quality cognition and assessment. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00635-y>
- Mateo M, Tarral M, Rodríguez PM, Galera MA (2019) Ergonomics as basis for a decision support system in the printing industry. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00667-4>
- Nowak M, Mierzwia R, Butlewski M (2019) Occupational risk assessment with grey system theory. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00639-8>
- Onak ÖN, Serinagaoglu DY, Weber G-W (2019) Evaluation of multivariate adaptive non-parametric reduced-order model for solving the inverse electrocardiography problem: a simulation study. *Med Biol Eng Comput* 57(5):967–993
- Roy SK, Midya S, Weber G-W (2019) Multi-objective multi-item fixed-charge solid transportation problem under twofold uncertain environment solved. *Neural Comput Appl* 31(12):8593–8613. <https://doi.org/10.1007/s00521-019-04431-2>
- Su B, Xie N (2019) Single workgroup scheduling problem with variable processing personnel. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00655-8>
- Ulutas BH, Özkan NF, Michalski R (2019) Application of hidden Markov models to eye tracking data analysis of visual quality inspection operations. *Cent Eur J Oper Res*. <https://doi.org/10.1007/s10100-019-00628-x>

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