Advances in Intelligent Systems and Computing

Volume 1322

The series "Advances in Intelligent Systems and Computing" contains publications on theory, applications, and design methods of Intelligent Systems and Intelligent Computing. Virtually all disciplines such as engineering, natural sciences, computer and information science, ICT, economics, business, e-commerce, environment, healthcare, life science are covered. The list of topics spans all the areas of modern intelligent systems and computing such as: computational intelligence, soft computing including neural networks, fuzzy systems, evolutionary computing and the fusion of these paradigms, social intelligence, ambient intelligence, computational neuroscience, artificial life, virtual worlds and society, cognitive science and systems, Perception and Vision, DNA and immune based systems, self-organizing and adaptive systems, e-Learning and teaching, human-centered and human-centric computing, recommender systems, intelligent control, robotics and mechatronics including human-machine teaming, knowledge-based paradigms, learning paradigms, machine ethics, intelligent data analysis, knowledge management, intelligent agents, intelligent decision making and support, intelligent network security, trust management, interactive entertainment, Web intelligence and multimedia.

The publications within "Advances in Intelligent Systems and Computing" are primarily proceedings of important conferences, symposia and congresses. They cover significant recent developments in the field, both of a foundational and applicable character. An important characteristic feature of the series is the short publication time and world-wide distribution. This permits a rapid and broad dissemination of research results.

Indexed by SCOPUS, DBLP, EI Compendex, INSPEC, WTI Frankfurt eG, zbMATH, Japanese Science and Technology Agency (JST), SCImago.

All books published in the series are submitted for consideration in Web of Science.

More information about this series at http://www.springer.com/series/11156

Dario Russo · Tareq Ahram ·
Waldemar Karwowski ·
Giuseppe Di Bucchianico ·
Redha Taiar
Editors

Intelligent Human Systems Integration 2021

Proceedings of the 4th International Conference on Intelligent Human Systems Integration (IHSI 2021): Integrating People and Intelligent Systems, February 22–24, 2021, Palermo, Italy

Springer

Editors
Dario Russo
Università degli Studi di Palermo
Palermo, Palermo, Italy

Tareq Ahram
Institute for Advanced Systems Engineering
Florida, FL, USA

Waldemar Karwowski
University of Central Florida
Orlando, FL, USA

Giuseppe Di Bucchianico
Università degli Studi di Chieti-Pescara
Pescara, Italy

Redha Taiar
Université de Reims Champagne-Ardenne
Reims, France

ISSN 2194-5357 ISSN 2194-5365 (electronic)
Advances in Intelligent Systems and Computing
ISBN 978-3-030-68016-9 ISBN 978-3-030-68017-6 (eBook)
https://doi.org/10.1007/978-3-030-68017-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This volume, entitled *Intelligent Human Systems Integration* 2021, provides a global forum for introducing and discussing novel approaches, design tools, methodologies, techniques, and solutions for integrating people with intelligent technologies, automation, and artificial cognitive systems in all areas of human endeavor in industry, economy, government, and education. Some of the notable areas of application include, but are not limited to, energy, transportation, urbanization and infrastructure development, digital manufacturing, social development, human health, sustainability, a new generation of service systems, as well as developments in safety, risk assurance, and cybersecurity in both civilian and military contexts. Indeed, rapid progress in developments in ambient intelligence, including cognitive computing, modeling, and simulation, as well as smart sensor technology, weaves together the human and artificial intelligence and will have a profound effect on the nature of their collaboration at both the individual and societal levels in the near future.

As applications of artificial intelligence and cognitive computing become more prevalent in our daily lives, they also bring new social and economic challenges and opportunities that must be addressed at all levels of contemporary society. Many of the traditional human jobs that require high levels of physical or cognitive abilities, including human motor skills, reasoning, and decision-making abilities, as well as training capacity, are now being automated. While such trends might boost economic efficiency, they can also negatively impact the user experience and bring about many unintended social consequences and ethical concerns.

The intelligent human systems integration is, to a large extent, affected by the forces shaping the nature of future computing and artificial system development. This book discusses the needs and requirements for the symbiotic collaboration between humans and artificially intelligent systems, with due consideration of the software and hardware characteristics allowing for such cooperation from the societal and human-centered design perspectives, with the focus on the design of intelligent products, systems, and services that will revolutionize future human-technology interactions. This book also presents many innovative studies of ambient artificial technology and its applications, including the human–machine

interfaces with a particular emphasis on infusing intelligence into the development of technology throughout the lifecycle development process, with due consideration of user experience and the design of interfaces for virtual, augmented, and mixed reality applications of artificial intelligence.

Reflecting on the above-outlined perspective, the papers contained in this volume are organized into eight main sections, including:

Section 1 Human-Autonomy Teaming
Section 2 Automotive Design and Transportation Engineering
Section 3 Humans and Artificial Cognitive Systems
Section 4 Intelligence, Technology and Analytics
Section 5 Computational Modeling and Simulation
Section 6 Humans and Artificial Systems Complexity
Section 7 Technology, Materials and Inclusive Human Systems
Section 8 Applications and Future Trends

We would like to extend our sincere thanks to Axel Schulte and Stefania Camplone, for leading a part of the technical program that focuses on Human-Autonomy Teaming and Inclusive Human Systems. Our appreciation also goes to the members of Scientific Program Advisory Board who have reviewed the accepted papers that are presented in this volume, including the following individuals:

D. Andujar, USA
D. Băilă, Romania
H. Blaschke, Germany
S. Camplone, Italy
J. Chen, USA
G. Coppin, France
M. Draper, USA
A. Ebert, Germany
M. Ferrara, Italy
M. Hou, Canada
M. Jipp, Germany
E. Karana, The Netherlands
A. Kluge, Germany
D. Lange, USA
F. Leali, Italy
S. Lucibello, Italy
E. Macioszek, Poland
S. Nazir, Norway
M. Neerincx, The Netherlands
R. Philipsen, Germany
J. Platts, UK
D. Popov, USA

A. Ratti, Italy
V. Rognoli, Italy
U. Schmid, Germany
A. Schulte, Germany
G. Sierpiński, Poland
N. Stanton, UK
A. Vergnano, Italy

We hope that this book, which presents the current state of the art in Intelligent Human Systems Integration, will be a valuable source of both theoretical and applied knowledge enabling the design and applications of a variety of intelligent products, services, and systems for their safe, effective, and pleasurable collaboration with people.

Dario Russo
Tareq Ahram
Waldemar Karwowski
Giuseppe Di Bucchianico
Redha Taiar

Contents

Mental Rotation Ability and Preferences in Vocational Education

Oleksandr Burov[1(✉)], Evgeniy Lavrov[2], Olga Siryk[3], Olena Hlazunova[4], Svitlana Shevchenko[5], Oleksii Tkachenko[4], Svitlana Ahadzhanova[6], Karen Ahadzhanov-Honsales[6], and Oleksandr Viunenko[6]

[1] Institute of Information Technologies and Learning Tools, Kyiv, Ukraine
burov.alexander@gmail.com
[2] Sumy State University, Sumy, Ukraine
prof_lavrov@hotmail.com
[3] Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
lavrova_olia@ukr.net
[4] National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
o-glazunova@nubip.edu.ua, oleksii.tkachenko@gmail.com
[5] Borys Grinchenko Kyiv University, Kyiv, Ukraine
s.shevchenko@kubg.edu.ua
[6] Sumy National Agrarian University, Sumy, Ukraine
{svitlana.ahadzhanova, karen.ahadzhanov-honsales, oleksandr.viunenko}@snau.edu.ua

Abstract. The paper investigates the differences in mental rotation abilities in vocational proficiency (mathematics, IT and social and humanitarian) in schoolchildren and university students, as well as a differences in the nature of the relationship in cognitive stability under impact of internal and external factors in math and humanitarian young graduated specialists.

Keywords: Mental rotation · Cognitive performance · Education · Professional selection

1 Introduction

Global changes evoked by the Fourth Industrial Revolution [1] and consequences of the pandemic COVID-19 in 2020 affect reformation of education system worldwide [2]. The unexpected forced rapid transition to distance learning has accelerated the introduction of new technologies in education including virtual and augmented ones [3]. Virtual and augmented reality is used more and more active in all areas of a human life and activity. Accordingly, education/training uses them to meet the life requirements. But, as it has been revealed in number of studies, a human activity in the synthetic environment can lead to cybersickness [4]. Especially, this negative consequence is important for young people because of their higher susceptibility to external factors [5] in changing learning environment [6].

D. Russo et al. (Eds.): IHSI 2021, AISC 1322, pp. 267–272, 2021.
https://doi.org/10.1007/978-3-030-68017-6_40

Activity in virtual reality (VR) can be accompanied by appearance of the cybersickness [7]. The most studied side effects of it are associated with the motion sickness and eye strain. Sustainability of cognitive functions in VR is less studied. According to data known, the mental rotation ability is associated with susceptibility to cybersickness, namely in relation to age [8] and sex differences [9]. Though mental rotation study can be traced back to the 1960s, including relationship between spatial and mathematical ability across development [10], there is not enough studies explaining if it deals with occupation proficiency and if it can be revealed at the stage of education with preliminary selected vocation. But this could be a useful tool to provide adequate AR/VR means and regulation in the education process to avoid or reduce cybersickness of students, including adaptive learning tools [11].

Purpose. Analysis of general and distinctive properties in the intellect structure of students of IT, math, as well as of social & humanitarian proficiency, with the priority to mental rotation ability and human mental state estimation.

2 Method

Mental rotation is a cognitive operation during which a mental image is formed and rotated into a different orientation in space. Such a process usually requires cognitive manipulation and spatial transformation of a two-dimensional (2D) or three-dimensional (3D) object and is associated with the general intellect. Ability to the mental rotation is assessed by special tests or as components of intellect structure. In the letter case, the response time and accuracy are the measures of the test performance.

The research method was provided as the development of the method used in our previous research of the psychophysiological maintenance of cognitive performance and further applications to learners as operator-researchers [5].

Study 1. 441 pupils (8-grad … 11-grad) of information technology (IT), math & humanitarian proficiency (Math), and social & humanitarian (Soc) as well as 315 students (1 … 6 years) of the same proficiencies have been tested performing on-line R. Amthauer intellect structure test. The analysis of the results was carried out only for those subjects who performed all tests with a given level of rate and reliability. Structural components of the intellect are calculated:

1. LS (logical selection) tests the feeling of language, the ability to formulate judgments.
2. GE (revealing of common features) tests abstract ability.
3. AN (revealing of similarity) tests combinatorial abilities, dynamic thinking.
4. RA (computational, mathematical) tests the ability to solve computational problems of a practical nature.
5. ZR (revealing regularities) tests logical and mathematical thinking.
6. FS (the choice of figures) tests spatial thinking in terms of geometric combinations on a plane in the formation of an integer shape of its fragments (2D mental rotation).

7. WU (task with cubes) tests spatial thinking (3D mental rotation).
8. Me (memory, attention) tests volume and concentration of attention, as well as operational memory.

The number of right results for all intellect test components was calculated.

Study 2. Further study has been carried out to investigate dynamic changes in mental state and cognitive performance of PhD students (math) and young scientists (psychology) over a month period under influence of internal (physiological indices) and external factors (solar and geomagnetic field indices).

The cognitive (logical-combinatoric) test used. The test material: a sequence of numbers (from 0 to 9) which were not repeated and placed in a random order; the task was to rearrange the numbers in ascending order in a few steps, on each one could only change 2 adjacent numbers. Time for every task performance was free (the next task appeared just after entering the answer). The time (Tl) and accuracy of the task performance were measured. Duration of the test session was 180 min, 4 sessions (the first one was training to adapt to the cognitive test and physiological indices measurement) were organized 1 time per week, only data results of the 3^{d} session were analyzed.

As indices of physiological "cost" of activity and the human state, we registered a heart rate HR and blood pressure (systolic BPs, diastolic BPd. The indices HR, ADs and ADd we registered 1 time in the beginning of every 20 min before (index "1") and in time of the test performance.

To check the influence of the external physical factors on the cognitive task performance the solar activity was studied as in the research [5]. In our preliminary pilot research, the precise connection between effectiveness of operator activity and parameters of a solar wind (SW) was revealed. With the purpose to study this phenomenon in relation to people with different occupational mental organization, we registered indices of proton component of a solar wind - speed SWsp (km/s) and density SWden (proton/sм^3) on the data from Internet site NASA, as well as parameters of the geomagnetic field - planetary index Ks, index of "equivalent amplitude" A.

Subjects: 19 young medical and psychologist researchers, 24 PhD students in math.

3 Results and Discussion

According to results of our previous research, it has been stated that mental rotation level (both 2D and 3D) as component of the general intellect developed by the 9 grad and changed in 10^{th} and 11^{th} grads insignificantly [12]. Therefore, the pupils' and students' data were analyzed without differentiation between grades and student years, accordingly. Separate analysis was made only in relation to proficiency, as well as school and university.

In the *Study 1* significant differences in mental rotation abilities in pupils have been found between corresponded groups Math, IT and Soc (Fig. 1).

As it was expected results in test for 2D (FS) mental rotation demonstrated higher level in comparison with 3D (WU). Quite interesting result is a higher level of mental rotation abilities in IT students even than in mathematicians. A reason of that situation could be explained the fact that children prefer to be IT specialists than mathematicians

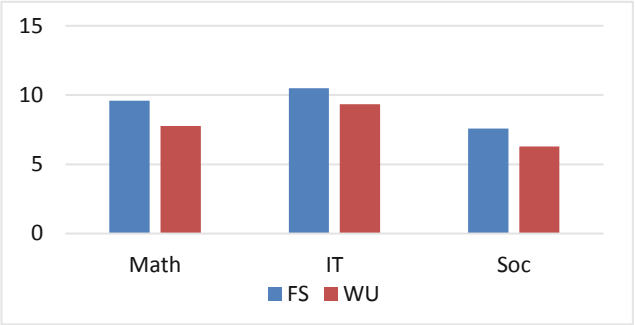

Fig. 1. Development level of mental rotation in pupils

in Ukraine. All those types of proficiency were based on the preliminary selection of schoolchildren for the vocational specialization.

Similar proportion has been revealed in university students, but difference was not so significant and not reliable in regards comparison of Math and IT students (Fig. 2).

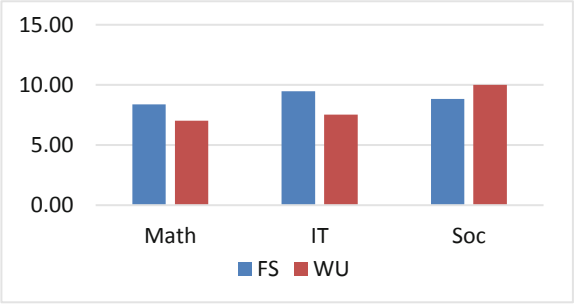

Fig. 2. Development level of mental rotation in students

But expectedly, it was revealed that development level of mental rotation demonstrated students of the social and humanitarian proficiency. This fact could be explained by the higher level of motivation to learn in national humanitarian universities which students participated in test performance more actively.

In any way, those facts should be a signal for the Generation Z preferences in chose of future occupation, at least, in our country.

Further *Study 2* has been carried out to investigate changes in mental state and cognitive performance of students (math and psychology) over a month period (physiological indices registration was carried out in parallel to the test performance).

The comparison analysis of variation of cognitive sustainability by the indicator of rate of test performance in young medical and psychologist researchers (both proficiencies relate to the mental work) demonstrated clear difference in relation of the cognitive test performance to external (solar wind parameters, i.e. solar radiation) and internal (state of the cardiovascular system) factors (Fig. 3). Correlation between

indices of those indices with variation (inter-individual) of the time of test performance had different levels and vectors of priority.

Firstly, it is necessary to highlight that individuals among medical psychologists/medicals demonstrated the higher correlation with external factors (solar radiation, SW density, r = 0,5), though all of them were selected for military service according to the professional protocols of health level.

Secondly, these results corresponded findings of high relationship between cognitive performance and its physiological maintenance, especially important in adaptive learning [13].

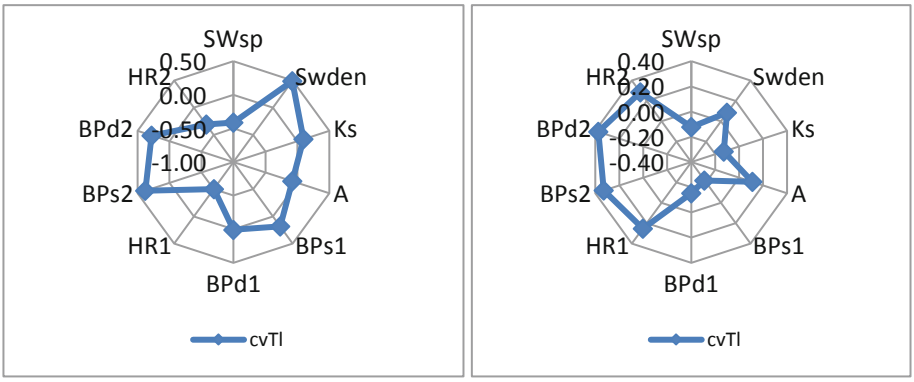

Fig. 3. Correlograms of variation of the test performance rate in psychologists (left) and mathematicians (right)

4 Conclusion

The paper considers differences in mental rotation abilities in vocational proficiency (mathematics, IT and social and humanitarian) in schoolchildren and university students, as well as a different nature of the relationship in cognitive stability under impact of internal and external factors in math and humanitarian young graduated specialists.

Significance of the Proposed Presentation. The results can be applied to optimize the use of AR/VR tools in education process depending on student individual/typological abilities to mental rotation. The goal of optimization is to reduce a risk of cybersickness when using virtual reality.

Acknowledgments. This work is supported by the grant 0118U003160 "System of Computer Modeling of Cognitive Tasks for the Formation of Competencies of Students in Natural and Mathematical Subjects".

References

1. Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution, 2020 WEF. https://www3.weforum.org/docs/WEF_Schools_of_the_Future_Report_2019.pdf
2. Guterres, A.: The future of education is here. Launch of the policy brief: education during COVID-19 and beyond, United Nations. https://www.un.org/en/coronavirus/future-education-here. Accessed 04 Aug 2020
3. Iatsyshyn, A.V., et al.: Application of augmented reality technologies for preparation of specialists of new technological era. In: Augmented Reality in Education : Proceedings of the 2nd International Workshop (AREdu 2019), Kryvyi Rih, Ukraine, 22 March 2019, pp. 181–200 (2020). https://ceur-ws.org/Vol-2547/paper14.pdf. ISSN 1613-0073
4. Barrett, J.: Side effects of virtual environments: a review of the literature. Australian Defence Science and Technology Organisation, DSTO-TR-1419, May 2004 (2004)
5. Burov, O., et al.: Cognitive performance degradation in high school students as the response to the psychophysiological changes. In: International Conference on Applied Human Factors and Ergonomics, pp. 83–88. Springer, Cham (2020)
6. Pinchuk, O.P., et al.: Digital transformation of learning environment: aspect of cognitive activity of students. In: Proceedings of the 6th Workshop on Cloud Technologies in Education (CTE 2018), Kryvyi Rih, Ukraine, 21 December 2018. CEUR Workshop Proceedings, # 2433, pp. 90–101 (2019)
7. Wikipedia: Virtual reality sickness (2020). https://en.wikipedia.org/wiki/Virtual_reality_sickness. Accessed 24 Mar 2020
8. Fernández-Méndez, L.M., Contreras, M.J., Elosúa, M.R.: From what age is mental rotation training effective? Differences in preschool age but not in sex. Front. Psychol. **9**, 753 (2018). https://doi.org/10.3389/fpsyg.2018.00753
9. Parsons, T.D., Larson, P., Krat, K., Thiebaux, M., Brendon Bluestein, J., Buckwalter, G., Rizzo, A.A.: Sex differences in mental rotation and spatial rotation in a virtual environment. Neuropsychologia **42**(2004), 555–562 (2004)
10. Young, C.J., Levine, S.C., Mix, K.S.: The connection between spatial and mathematical ability across development. Front. Psychol. **9**, 755 (2018). https://doi.org/10.3389/fpsyg.2018.00755
11. Lavrov, E., Lavrova, O.: Intelligent adaptation method for human-machine interaction in modular E-learning systems. In: Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer, Volume II: Workshops, Kherson, Ukraine, 12–15 June 2019, pp. 1000–1010 (2019)
12. Burov, O.Yu.: Profile mathematical training: particular qualities of intellect structure of high school students. Phys. Math. Educ. **1**(15), 108–112 (2018)
13. Mulder, L.J.M., Van Roon, A., Veldman, H., Laumann, K., Burov, A., Quispel, L., Hoogeboom, P.J.: How to use cardiovascular state changes in adaptive automation. In: Hockey, G.R.J., Gaillard, A.W.K., Burov, O. (eds.) Operator Functional State, The Assessment and Prediction of Human Performance Degradation in Complex Tasks. NATO Science Series, pp. 260–272. IOS Press, Amsterdam (2004)

Author Index

D. Russo et al. (Eds.): IHSI 2021, AISC 1322, pp. 907–911, 2021.
https://doi.org/10.1007/978-3-030-68017-6