



# Mental Rotation Ability and Preferences in Vocational Education

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**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].

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 latter 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 (TI) 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<sup>d</sup> 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/sm<sup>3</sup>) on the data from Internet site NASA, as well as parameters of the geomagnetic field - planetary index Ks, index of “equivalent amplitude” A.

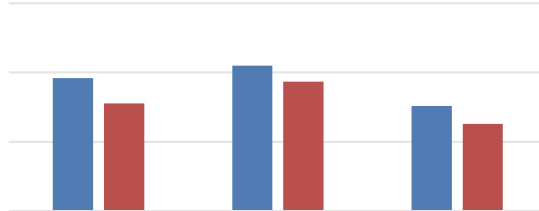
Subjects: 19 young medical and psychologist researchers, 24 PhD students in math.

### 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<sup>th</sup> grad and changed in 10<sup>th</sup> and 11<sup>th</sup> 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



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).

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

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