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МАГИСТЕРСКАЯ ДИССЕРТАЦИЯ

ИНДИВИДУАЛЬНЫЕ ОСОБЕННОСТИ СТУДЕНТОВ РАЗНЫХ НАПРАВЛЕНИЙ В РЕШЕНИИ ПРОСТРАНСТВЕННЫХ ЗАДАЧ

по основной образовательной программе подготовки магистров
направление подготовки 37.04.01 – Психология

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«__20___»___June_____2022

MASTER'S THESIS

INDIVIDUAL CHARACTERISTICS OF STUDENTS FROM DIFFERENT FIELDS OF STUDY IN SOLVING SPATIAL TASKS

for Main Educational Programme of Master's Training
Training Direction 37.04.01 – Psychology

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Российской Федерации
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ЗАДАНИЕ

на выполнение выпускной квалификационной работы студента Жигмытовой Карины Баировны обучающемуся по направлению подготовки 37.04.01 «Психология», профиль «Развитие человека: генетика, нейронаука и психология»

1 Тема выпускной квалификационной работы
Индивидуальные особенности студентов разных направлений в решении пространственных задач

2 Срок сдачи обучающимся выполненной выпускной квалификационной работы:
а) в деканат – 17.06.2022 б) в ГЭК – 20.06.2022
3 Исходные данные к работе:
Объект исследования – пространственные способности
Предмет исследования – индивидуальные особенности студентов при решении пространственных задач
Цель исследования – изучить индивидуальные особенности студентов разных направлений в решении пространственных задач
Задачи:
- Изучить связи между тремя пространственными субтестами и индивидуальными особенностями студентов.
- Исследовать различия в показателях самооценки у студентов разных направлений при решении пространственных задач;
- Исследовать различия в показателях пространственной тревожности у студентов разных направлений при решении пространственных задач;
- Исследовать различия в показателях гендерной стереотипизации у студентов разных направлений при решении пространственных задач

Методы исследования:
1. Субтесты на измерение пространственных способностей (часть из OSSAB): оригами; сборка шаблона
2. Субтест на изучение пространственной ориентации
3. Опросник на самооценку пространственных способностей
4. Опросник на пространственную тревожность
5. Опроник на изучение склонности к гендерным стереотипам

Организация или отрасль, по тематике которой выполняется работа.

Психология, Экспериментальная психология.

4 Краткое содержание работы

С целью исследования индивидуальных особенностей студентов разных направлений при решении пространственных задач разработан дизайн исследования. Исследование реализовывается онлайн. Выборка исследования включает студентов разных направлений обучения. Дизайн исследования включает сбор данных по трем пространственным субтестам и трем опросникам, оценивающих уровень самооценки, пространственной тревожности и склонности к гендерным стереотипам. Используются два субтеста из батареи OSSAB (оригами, сборка шаблона), которые относятся к пространственным способностям малого масштаба, и субтест по изучению пространственной ориентации, который относится к пространственным способностям крупного масштаба. Полученные результаты по данному исследованию дополнят представления о роли индивидуальных особенностей в решение пространственных задач.

Руководитель выпускной квалификационной работы
Доцент каф. генетической и клинической психологии / Е.А. Есипенко
Факультет психологии НИ ТГУ

Задание принял к исполнению
Студент, ТГУ / К.Б. Жигмытова
должность, место работы

The Ministry of Science and Higher Education of the Russian Federation
NATIONAL RESEARCH
TOMSK STATE UNIVERSITY (NR TSU)
Psychology Department

APPROVED
MSc Programme Director
PhD, Professor
_____ Y.V. Smetana (Kovas)
«___15__»_____02___2022

ASSIGNMENT

for the MSc graduation thesis to the student Karina Bairovna Zhigmytova in the field of study 37.04.01 «Psychology», training direction «Human Development: Genetics, Neuroscience and Psychology»

1 Title of the graduation thesis
Individual characteristics of students from different fields of study in solving spatial tasks

2 Submission dates of the completed graduation thesis by the student:
a) to the Dean's office – 17.06.2022 b) to the State Examination Board – 20.06.2022

3 Baseline information for MSc thesis:

Object of research – spatial ability
Subject of research – individual characteristics of students in solving spatial tasks
Purpose of research – to study individual characteristics of students from different fields of study in solving spatial tasks
Tasks:
- to study relations between three spatial ability subtests and individual characteristics of students;
- to study the differences in self-esteem indicators of students from different fields of study in solving spatial tasks;
- to study the differences in spatial anxiety indicators of students from different fields of study in solving spatial tasks;
- to study the differences in gender stereotype indicators of students from different fields of study in solving spatial tasks

Research methods:
- Spatial ability subtests (part of OSSAB) – Paper Folding and Pattern Assembly
- Spatial orientation subtest
- Self-esteem questionnaire
- Spatial anxiety scale
- Gender stereotype questionnaire

Organization or field in which the work is being completed
Psychology, Experimental Psychology

4 Summary of the graduation thesis

For the purpose to study individual characteristics of students from different fields of study in solving spatial ability tasks research design has been developed. The study is conducted online. The sample of the study includes students from different fields of study. Design of the research includes data collection on three spatial subtests and three questionnaires assessing levels of self-esteem, spatial anxiety and gender stereotype tendency. Two subtests are chosen from OSSAB (Paper folding and Pattern assembly) which relate to small scale spatial ability and a test that relates to large scale spatial ability. The study results will add the ideas about the role of individual characteristics in solving spatial tasks.

Supervisor of the MSc graduation thesis

Associate Professor of the Department of Genetic and Clinical Psychology of the Faculty of Psychology of NR TSU _____/ E.A. Esipenko

Assignment is accepted for completion by
MSc student, TSU _____/ K.B. Zhigmytova

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Abstract

The current study explores individuals characteristics which have an impact on solving spatial tasks. In particular, the emphasis is laid on specific fields of study STEM and Humanities. First, the main findings regarding to the theoretical structure of spatial ability, individual factors (self-esteem, spatial anxiety and gender stereotypes) and fields of study are described. Sixty-eight students (24 males, 44 females) from different universities and fields of study took part in our study. The age of the participants ranged from 18 (1st year students) to 37 years (2nd year MSc students). They performed following tasks: Spatial ability subtests (Paper folding, Pattern Assembly, Spatial orientation tests), then self-esteem questionnaire, spatial anxiety scale, gender stereotype questionnaire and additional inventories at the beginning and at the end of the experiment. The results chapter revealed a discussion of obtained results which include individual characteristics in spatial ability, differences between fields of study in spatial ability, limitations of the study and conclusion.

Acknowledgement

I would like to express my sincere gratitude to Yulia Kovas and Olga Bogdanova for creation and organization of this MSc programme – Human development: genetics, neuroscience and psychology. My sincere thanks to my supervisor Elena Esipenko for her help with my MSc thesis. A am also grateful to the lab team members who provided supportive and inspiring online environment for us.

Chapter 1. INTRODUCTION AND LITERATURE REVIEW

This chapter describes the main results of empirical research of factors that influence on solving spatial tasks. It also summarizes main findings regarding to the theoretical structure of spatial ability, individual factors (self-esteem, spatial anxiety and gender stereotypes) and fields of study. In the end of the section research questions and hypothesis of the current study are stated.

1.1. Spatial ability

Spatial ability is a separate intellectual ability which is differentiated from verbal, quantitative and reasoning ability. The importance of using spatial ability in everyday life is determined by situations of navigating in large space or environment, orienting and defining the trajectories of approaching objects. It is also has its power in intellectual activities, for example, solving problems in engineering and mathematics (Hegarty et. al., 2006). There are different definitions of spatial ability. For example, Carroll described spatial ability as the ability "in manipulating visual patterns, as indicated by level of difficulty and complexity in visual stimulus material that can be handled successfully, without regard to the speed of task solution" (Carroll, 1993, p. 303). In National Academies of Sciences, Engineering, and Medicine the role of spatial ability was defined as "important for understanding an individual's spatial relationship to and within surroundings (e.g., orienteering) and also for understanding representations of multidimensional figures in one-dimensional displays (e.g., data visualization)" (2015, p. 66). Spatial ability can also be characterized as "the ability to understand the relationships among different positions in space or imagined movements of two-three-dimensional objects" (Yuan et. al., 2019).

Spatial ability is one of the most significant cognitive abilities of human being which has been the focus of researchers for several decades (Carroll, 1993). The investigation roots of spatial ability as an intelligence research began in 1800s. The earliest work of spatial ability was conducted by Frances Galton who discovered "mental disposition" of individuals using mental imagery. The researcher explained mental imagery as "the different degrees of vividness with which different persons have the faculty of recalling familiar scenes under the form of mental pictures and the peculiarities of the mental visions of different persons" (Harle & Towns, 2010, p.351). He tested participants using "breakfast table" method where individuals had to think of an object and tell the experimenter about the images in their minds. This considered to be as the first steps of spatial ability.

Spatial ability was assumed as a general intelligence till 1900s, only in 1920s it was isolated and designated as a spatial factor. 1930s characterized as a period of identification of other spatial

factors. Unfortunately, different factors and terminology which were investigated during this long period did not show a clear "picture" of spatial ability. Only in 1947 the main factors – Spatial Visualization and Spatial Orientation were discovered by Guilford and Lacy (Harle & Towns, 2010). In those same years Guilford and Lacey (1947) in their major study identified two factors: Spatial Relations and Visualization. Later on a group of researchers conducted a study on over 8000 aviation students using 65 aptitude battery and yielded five factors: two of the factors were the same as in previous study (Spatial Relations and Visualization), Spatial Orientation was characterized by participant's involvement in orientation tasks; in Spatial scanning were checked individuals' ability of planning and visually mapping; Perceptual speed – rapid identification of a letter in a letter string (Guilford & Lacey, 1947). This cognitive ability is multi-faceted and to test differences in spatial ability researchers have to choose methods which will separate its facets between this ability and from general intelligence. For instance, spatial ability can measure abilities (practical and mechanical) that important for technical degrees; psychological factors, e.g. attention which is important for maintaining and transforming images (Smith, 1964; Horn, 1989; Kyllogen & Christal, 1990).

Factors of spatial ability (Spatial Visualization, Spatial Relations, Closure Speed, Flexibility of Closure, Perceptual Speed) which were identified by Carroll in 1993 are considered as the most valid (Höffler et. al., 2010). Spatial Visualization is characterized as the ability to perceive, encode and mentally transform spatial forms, for example paper folding – a paper is folded in a different way, then pierce a hole into it, the participants' task is to find the right unfolded paper out of several variants. Spatial relations are also represent mental transformations including rotations of 2D objects and time period is short. It differ from Spatial Visualization by its simplicity of tasks, for example, "card rotation task" where individuals have to decide whether the cards rotated or mirrored. These two factors are called the main and were widely investigated in many studies (Battista, 1990; Garderen 2006; Kozhevnikov et. al., 2007). Miyake et. al. (2001) explained Closure Speed and Flexibility of Closure as they have an impact on speed of apprehending and identifying visual pattern. In Flexibility Closure, individuals know about testing pattern, but in Closure of Speed situations they do not and in this situation they should take an information from long-term memory. Closure of Speed test are usually measured using tasks with partially hidden objects where participants have to find the hidden part of picture. Flexibility speed tests consists of hidden model figures in more complex figure. Perceptual speed relates to rapidness of identifying objects visually (Höffler et. al., 2010).

Finally, spatial ability was categorized into two major blocks – Large scale and Small scale (Yuan et. al, 2019; Wang et. al, 2014; Hegarty et. al, 2006; Jansen et. al., 2009). Large scale spatial ability focuses on the ability to use spatial ability in large space/environment. Tasks of this

category of spatial ability are generally concern egocentric spatial transformation (Wang et. al., 2014) during which participants' attitude changes towards large environment. Navigation and spatial orientation (way-finding) are the main types of Large scale spatial ability (Jansen & Heil, 2009; Höffler, 2010; Wang et. al., 2014). Since during environmental navigation and orientation relationships between the objects cannot be captured from a single vantage point, that is why individuals have to take on in egocentric spatial transformations – to perceive the large scale environment as a whole. Wang and Carr (2014) explained Small scale spatial ability as the ability of mental representation and transformation of 2 - 3D images. This scale also called as "paper-and-pencil" tests where individuals manipulate objects, for instance, sheets of paper or blocks (Hegarty et. al., 2006). Solving spatial tasks in small scale engages allocentric spatial transformation and the common types of small scale include spatial visualization, spatial perception, mental rotation. The description of spatial visualization was mentioned above. In spatial perception test individuals' task is to measure spatial relations respecting to the orientation to their own body. For example, Rod and Frame Test instruct to place a rod vertically looking at a frame oriented at 220 (Linn & Petersen, 1985). Mental rotation is defined as the ability to mentally transform representations of objects (Jansen et. al., 2019).

The relationship between two scales is characterized by four main models:

1. The Unitary Model proceeds that spatial ability at both scales is completely overlapping
2. The Total Dissociation Model assumes that skills are depend on distinct cognitive processes
3. The Partial Dissociation Model proposes that two sets of abilities have similarities and differences
4. The Mediation Model states that two the sets of abilities are completely dissociated, but the third ability mediates the relationship between them (Hegarty et. al., 2006; Jansen et. al., 2009).

However most studies of spatial ability indicates either commonalities or dissociations between them. For example, Hegarty et. al. (2006) studied 221 participants on small scale ability which were tested along with spatial updating, verbal abilities and working memory. The researchers also studied large scale ability from a real work in the environment and used two additional media - virtual environment (VE) and a videotape of a walk through an environment. According to the results the real environmental walk showed a separate factor from two other media (VE and video walk) and small scale ability predicted performance on large scale ability, but learning from media were better. So, it means that the relationship between scales in this study

is dissociated partially (Hegarty et. al., 2006). In Wang et. al's (2014) meta-analysis small and large scales are found as two distinct categories. This study include two moderators – gender and age, because they can influence on the results. The results were indicated by common variance which was about 10% and scales' relationship strength - small to medium (r - .269).

Another research was conducted on school-age children (N=72 – 36 boys, 36 boys; mean age = 9.6) by Jasen (2009) and aimed to examine whether the small scale tasks will improve performance in large scale. 9-10 year children were divided into two groups: training and control group. Firstly, participants had direction estimated test, the training group performed the manual rotation training program, the control group - computer games, after that children completed the direction estimated test again. The results did not show the difference between the tests and the scales were not associated with each other. We can conclude that the small and large scales maintain the total dissociation model. Dissociation between small scale and large scale spatial ability is also investigated from neural side (Hegarty et. al., 2006). According to some research studies small scale tasks activate parietal lobe (Kosslyn & Thompson, 2003; Gogos et. al., 2010), while Hugdahl et. al. (2006) found that mostly hippocampus was active during large scale tasks.

Yuan et. al. (2019) in their meta-analysis of neuroimaging studies explored commonalities and differences of two scales. The researchers examined 103 studies over 20 years and found that small scale activated parietal, occipital, frontal, right posterior lobes, left sub-lobar areas and limbic, posterior, occipital, parietal, right anterior frontal lobes, right sub-lobar area. The results of this study revealed that there were no significant difference in two scales. The Unitary Model is described in another Yuan et. al.'s study (2019). It considered a shared neural basis between the scales where there were no significant difference in cognitive strategies used in small and large scale tasks (Yuan et. al., 2019). Summing up, according to all research studies all of four models exist in testing relationship between small and large scales of spatial ability.

In conclusion, spatial ability as one of the main cognitive abilities has a long history of research. The first "steps" of this ability began as a part of intelligence, after its separation the researchers discovered different types (factors) of spatial ability. The further investigation of spatial ability and its types give the researchers to investigate this ability from different sides.

1.1.1. The nature of spatial ability

There are individual and gender differences of spatial ability. Individual characteristics may refer to age, self-assessment (self-esteem), anxiety level, stereotyping tendency, occupation

area, etc. As for gender differences, most studies point on women's inability in spatial tasks as well as their incompetence in many technical fields of study. However the nature of such differences are depend on various theories.

First of all, individual differences are explored from the genetics factors. The previous research studies explored that biological relatives are more similar to each other in spatial ability than non biological (McGee, 1979). It is said that family similarity is more related to genetic factors. According to the research studies, contribution of genetic factors to spatial ability is ranged between 30-50 % (Rimfeld et. al., 2017). Furthermore, the researchers tested 1367 twin pairs (19 – 21 years old) – the sample from the Twins Early Development Study (TEDs). The participants were tested on an online gamified battery "King's Challenge" which is consist of 10 subtests which measures small scale spatial ability. Genetics factors explained 69 % of heritability, while shared environmental factors were defined by a small proportion by 8 % and 23 % for non-shared factors. Besides genetic factors involved in individual differences formation are partially overlap in general intelligence and spatial ability (Rimfeld et. al., 2017). Another study on TEDs sample (Mean age = 11. 56 years, SD = 0. 69) with 4601 twin pairs (1663 MZ, 2938 DZ) revealed that heritability of mathematical and spatial abilities represented 0.27 and 0. 43. Spatial ability was connected to mathematical ability (r = 0. 43) and about 60 % of correlation were defined by genetic factors (Tosto et. al., 2014).

The earliest works about men's superiority in spatial ability were mostly focused on socialization factors, but later on differences between gender lead to existence of biological factors or more accurately hormonal factors. Existence of biological hormones and their role in differentiation between individuals began in prenatal period. It is said that the role of testosterone have its impact on differences between individuals in spatial ability (Silverman et. al., 1996; Falter et. al., 2006). The role of prenatal testosterone in twins was studied in Vuoksimaa et. al.' (2010) study on a sample of 804 twins (Mean age = 22. 39, SD = .62). The researchers were aimed to find the effect of masculinization between female twins with male co-twin and female twins with female co-twin. The participants consisted of such pairs: 351 females and 223 males from same-sex pairs, 120 females and 110 males from opposite-sex pairs. They were tested on the Vandeberg and Kuse Mental Rotation task (MRT) consisted of 12 trials each two parts. The results indicated that male twins from same-sex pairs indicated significantly better results than female twins from same-sex pairs ($F (1, 309) = 75. 66$, $p < . 0001$, $d = 0. 87$). However females with from opposite-sex pairs were better than females from same-sex pairs ($F (1, 302) = 7. 45$, $p < .01$, $d = 0. 30$) while in both males twins pairs the results were not significant ($F (1, 236) = 2. 03$, $p = .16$, $d = 0. 18$).

As we can see, the researchers hypothesis about female twins with opposite-sex pair superiority was proved (Vuoksimaa et. al., 2010).

However Toivanen et. al (2018) had another results from testing prenatal testosterone influences in differences between boys and girls. The researchers hypothesized that gender differ in spatial ability tests where males will outperform females. Moreover it suggests that in twin pairs, females with a male co-twin will score higher than females with a females co-twin. The results proved the first hypothesis and on average males performed better in all spatial tasks. Interestingly, even if gender differences were found in this study, individual differences within males and females indicated more variance in spatial ability than differences between gender. Another hypothesis about the role of prenatal testosterone in sex differences revealed non significant results, because only in 2 items of spatial ability out of 14 the female participants with male co-twin performed better than another female-female twin pair. So that is why the results of this research study showed the opposite results of prenatal testosterone impact of gender differences. Male co-twins did not affect on their female co-twins' spatial ability.

Hromatko and Tadinak (2007) investigated the differences in spatial performance between groups with different level of testosterone. The sample was 320 healthy volunteers (270 males and 50 females) from 18 to 31 years (M = 21. 3, SD = 1. 7). The participants were divided into three groups: 1 group – females with lower testosterone level, 2 group – males with intermediate level of testosterone (in spring) (N = 118) and males with the high level of testosterone (N = 158) in autumn - because the males' seasonal high level of testosterone. The subgroup were created in order to test them twice, it consisted of 77 males who was seen twice: in low testosterone season and in high testosterone season. The methods of the study consisted of four spatial ability tests (Paper folding, Cube comparison, Space relations, Figure rotation) in which previous studies showed men's outperforming. The results of Space relations ($t(318) = 3.97$, $p < .001$), and Figure rotation tests ($t(316) = 2.74$, $p < .01$) showed a significant difference between gender. However Cube comparison ($t(317) = 1.56$) and Paper folding ($t(318) = 1.73$) did not show significant results. There was the significant effect of testosterone level on two spatial tests: Space relations ($F(317.2) = 12.28$, $p < .001$) and Figure rotation ($F(315.2) = 8.01$, $p < .001$). There were no significant effect of testosterone level on Cube comparison ($F(316.2) = 1.43$) and Paper folding ($F(317.2) = 1.83$). Moreover, males with low level of testosterone were better than both groups - males with high testosterone level and females ($F(315.2) = 7.23$, $p < .01$). Another analysis on groups of men during low and high testosterone seasons on spatial ability tests indicated no significant effects of testosterone level and order of testing (except of Space rotation test).

However the males' spatial ability scores were higher during low testosterone season (Hromatko & Tadinak, 2007).

Another research study reveals that the knowledge of Chinese language may influence spatial ability. The group of researchers conducted a study on a sample of Russian and Chinese students. 348 male and 573 female Russian participants (ages 16 to 37, M = 19. 59, SD = 1. 85) were recruited from five different universities. 88 males and 114 females (ages 17 to 30, M = 19. 92, SD = 1. 73) were from Chinese universities. The participants task was to complete King's Challenge gamified interactive battery which is consist of ten main spatial ability dimensions such as mental rotation, spatial visualization, spatial reasoning, perspective-taking and mechanical reasoning. The results of the study showed differences in factor structure between Russian and Chinese students. The researchers explain these differences by cultural and educational contrasts of countries. On average Chinese participants outperformed Russian participants in five spatial tests (Cohen's D - .27 to .58, $p < .001$), while Russian participants were better in Elithorn maze and perspective taking tests (Cohen's D - .30 to .37, p = < . 001). In particularly, Chinese students showed better results in cross-sections and mechanical reasoning (8.06 and 10.75) comparing to Russian (6. 71 and 9. 76). Such superiority may be explained by features of Chinese written language, e.g. "to retrieve part of the information from a unity" is compared to the ability to compose "a Chinese character out of several elements" (Likhanov et. al., 2018, p. 104).

So, according to above research studies we can see that the factors which influence on differentiation in spatial ability is various. Individual or gender difference may be affected by hormonal factors as testosterone (Hromatko & Tadinak, 2007), as well as educational and cultural factors which may show individuals superiority in certain types of spatial ability as it was shown in Likhanov et. al.'s study (2018). The prenatal testosterone role in differences in spatial ability showed controversial results, because in one study the testosterone has the significant impact on differences between females with male co-twin and females with female co-twin, but in another study the role of testosterone in sex differences was not found.

1.1.2. Spatial ability experience

The role of experience in spatial ability may be the cause of differences in this ability. It is assumed that everything began from childhood, even spatial ability. Boys are more interested in exploring environment using it in their games. Additionally to it, some researchers mention that boys are more tend to change their game, or more accurately their games are more various than

girls'. In modern world the exploring large environment changed to exploring virtual reality space. In other words, spatial ability skills is associated with playing video-games. Some researchers highlight that type of spatial ability as visual cognition is the main aspect in playing video-games while spatial attention capacity is important for playing such games. The video-games that are widely played by boys are shooter action games which are aimed to navigate in a certain virtual reality and find as more people as possible before they found the player and achieve the main goal of it.

Jing, Spence and Pratt (2007) in their study investigated the role of action video games on gender differences. The study was conducted on a sample of 48 undergraduates ages from 19 to 30 years. The factors of the study were gender (males, females), experience in video-games and the area of study. The experiment were divided into two stages. The first experiment examined gender differences in spatial attention using the useful-field-of-view task. The results of the first stage reveled that players outperform non players ($F (1. 40) = 34. 38$, $p > .99$, $\eta^2 = .46$). Science students were better than Art students ($F (1. 40) = 6. 99$, $p = .95$, $\eta^2 = .15$) which is may be explained by STEM superiority in spatial ability (it will be discussed below in "Field of study" section). The last gender group revealed that males had more points in the task than females ($F (1.40) = 5. 03$, $p = .91$, $\eta^2 = .11$). Gender differences were found in the first experiment, but according to the results this gap was significantly shown in players group than in non players. The second experiment examined only two groups – males and females in spatial attention and cognition. The participants were measured in the previous experiment measure of useful-field-of-view task and in additional mental rotation test. The researchers hypothesized that mental rotation will improve spatial cognition after training and will reduce gender differences. The second stage of the study was conducted on 20 undergraduates, they were divided into two groups – experimental and control. Experimental group was trained on shooter game called Medal of Honor: Pacific Assault and the control group played "Balance" – a 3D puzzle game. The results revealed that after training all the participants improved their skills. As for gender differences, there was a significant improvement in females' skills than males' ($F (1. 8) = 14. 79$, $p = .97$, $\eta^2 = .65$). Overall results indicate that gender difference in spatial attention and mental rotation may be reduced by action-games (Jing et. al, 2007).

Furthermore, spatial ability may be interpreted in relation to virtual and real experiences as it was studied in recent Clemenson et. al.'s research (2020). This study aimed to study spatial relationships between virtual and real environments. The researchers wanted to know whether virtual experience is similar to real world. The participants of the research were 41 females and

36 males (Mean age = 20. 83 years, SD = 2. 78) from the University of California for the first experiment. They were divided into six groups – No pre-exposure and virtual test, no pre-exposure and real test, virtual pre-exposure and virtual test, real pre-exposure and real test, virtual pre-exposure and real test, real pre-exposure and virtual test. All groups consisted of approximately equal number of males and females. The methods consisted of following measures: Object Location task – spatial memory task which is measure both environments; Real-World Object Location task; Virtual-World Object Location task. The results of first experiment showed that both conditions – virtual and real had difficulties, moreover spatial information was transferred between both experiences. Experiment 2 was conducted on a sample of 40 females and 41 males (M age = 22. 72, SD = 5. 71) with the help of Object Location Maze (OLM) measure. And 39 males and 38 females (M. age = 20. 62, SD = 1. 83) for the computer T-maze and 27 males, 23 females (M age = 20. 28, SD = 1. 83) for virtual reality T-maze test in the last experiment. The overall results revealed that spatial information may transfer between environments. However experience did not play an important role in transferring spatial information from real to virtual environment (Clemenson et. al., 2020).

Spatial ability experience was also investigated in Architecture field, where the researchers hypothesized that advanced students will outperform beginners in this field of study. The study was conducted on a large sample of 593 Architecture students (49.7 % females and 50.3 % males, M = 21. 25 years, SD = 2. 82). The results revealed that on average advanced students were better than beginners in some spatial tasks, while beginners also showed their performance in other spatial ability tasks (Berkowitz et. al., 2021). According to the results we can assume that experience may play the role in spatial ability including experience in video-games, in real environment, as well as in their level in some field of study.

1.2. The role of factors influencing spatial ability

1.2.1. Self-esteem and spatial ability

Rosenberg as one of the first researchers of self-esteem explained it as an individual's positive assessment about him/herself (Rosenberg, 1965). Another understanding of this phenomena is "self-evaluation which refer to how people evaluate their abilities and attributes" (Abdel-Khalek, 2016, p.3). Bandura (1977) explained self-esteem as an individual's belief in ability of performing well. In presented and many other definitions of self-esteem, we can see

emotional and evaluative reaction to oneself. Thus, there are three ways of interpreting self-esteem which were identified by Brown et. al. (2001):

- global or trait self-esteem is characterized as person's "feelings" about him/herself, or more accurately, "feelings of affection for oneself";

- self-evaluations state about people's assessment their some abilities and attributes. For example, some scales of measuring self-esteem can have subscales as social self-esteem, spatial self-esteem, academic self-esteem. In other words, self-evaluations refer to how people evaluate their certain abilities and characteristics;

- feelings of self-worth depend on momentary emotional states. These emotional states have two sides – positive when an individual is proud of himself and negative when the individual is ashamed of himself (Brown et. al., 2001).

Self-esteem can indicate attitude toward overall self and or to some specific aspects of an individual such as academic skills, orientation skills, social standing, professional performance. Some researchers found distinguish between trait and state self-esteem, where trait depend on personality and state is more influenced by emotions and life situations (Spielberg et. al., 1970; Gilovich et. al., 2006). Other researchers divided self-esteem into two types - contingent and true. Contingent self-esteem is characterized as a personal assessment which manifested in comparison with other individuals, true self-esteem is more about true/solid sense about him/herself (Deci & Ryan, 1995).

The self-esteem formation is similar to individuals growth which implies a long process. There are intermittent periods in its formation time, transitions from one stage/status to another, for example, in school age when a child change its status of preschooler to schoolchild which lead to changes in his or her duties (Orth et. al., 2010; Abdel-Khalek, 2016).

Furthermore, researchers of self-esteem stated that this psychological aspect is important for mental health, where people can feel more motivation, happiness, satisfaction. Sometimes self-esteem can be redundant (high self-esteem), as well as lack of it (low self-esteem) may be unhelpful. A high self-esteem help to handle with unpleasant situations, to cope with challenges, to improve the strengths. Moreover, people with a high-level of self-esteem are "more persistent in the face of failure" than people with a low self-esteem (Adbel-Khalek, 2016; Brown et. al., 2001). Unfortunately, "dark" side of high self-esteem is also exist. People with high self-esteem show negatives sides such as vanity and arrogance. Individuals who have "dark" side of self-esteem expect to receive only positive and high evaluations from himself or herself, as well as from other people (Baumeister et. al., 1996). Low self-esteem individuals characterized as an

unsecure people who feel worthlessness, inferiority, and emotional instability. People who suffer from low self-esteem is tend to depression, aggression, negative relations toward other people, to cope with difficulties become hard to such people (MacKinnon, 2015; Stavropoulus et. al., 2015)

Self-esteem plays an essential role in cognitive abilities such as numerical, verbal, spatial and mechanical. Many of studies were focused on mathematical (numerical) (e.g. Lent et. al., 1997; Pajares & Miller, 1994) or verbal abilities such as writing and reading (e.g. Shell et. al., 1995, Bong., 2002). Paunonen & Hong (2010) conducted a research study to evaluate contribution of self-esteem in predicting performance of four specific cognitive abilities: numerical, verbal, spatial and mechanical. Moreover, they aimed to determine how self-esteem beliefs compare to cross-domain ability in predicting performance within specific domain. 176 undergraduate students (53 men, 123 women) took part in the study. The methods include self-efficacy measures and timed ability tests. The researchers concluded that self-esteem beliefs highlight what individual know about his or her competence, that is why high self-esteem is the result of real self-assessment of overall cognitive abilities. In addition, self-esteem reflect a particular attitude to performance in verbal, numerical and spatial domains, but not in mechanical because this did not show significant results (Paunnoen & Hong, 2010).

Garside et. al. (2012) tested two groups - 182 teenagers (47 males, 132 females) and 377 adults (127 males, 250 females) and studied interaction of gender, stereotypes and self-esteem on one's own spatial ability. The participants had four tests on math fluency, spatial ability, visually-coordinated patterns and test which contains sequence of patterns. Adult participants who rate their spatial ability in high level revealed better results in all tests than participants who had low self-esteem. However the results of teenagers did not show the same results in math fluency test (Garside et. al., 2012).

Wayfinding as one of the main subscales of Large scale ability was investigated in Pazzaglia et. al.' study (2018). The researchers hypothesized that different types of factors such as personal, motivational, cognitive affective would predict wayfinding tasks. The experiment were conducted only on female participants. Firstly the participants had a virtual route, then they were asked to follow the same route again and lastly, females had to find the short way from the beginning point to the end. It was found that wayfinding tasks were related differently to the factors and it also important to mention that high level of spatial anxiety was correlated to low self-esteem in spatial tasks (Pazzaglia et. al., 2018).

Self-esteem is also closely related to gender stereotypes of spatial ability. For instance, in Papageorgiou et. al.' (2012) study males and females who evaluated their spatial and mathematical ability low were worse in spatial ability tasks. Moreover males also was worse in spatial ability

tasks than females although they usually tend to stereotype “males outperform females in spatial ability” (Papageorgiou et. al., 2012).

So, the research studies above state that self-esteem as a psychological and motivational factor influence on many cognitive abilities. These findings indicates that self-esteem have a crucial role in spatial ability.

1.2.2. Anxiety and spatial ability

Anxiety disorders are widely spread phenomena than any other disorder in the whole world. Therefore, the study of anxiety is an important issue which have its great impact on emotional and social part of an individual. In addition to emotional regulations, anxiety manifests itself in difficulties in concentrating and individuals with anxiety feel distracted which may have a negative impact on their career performance. Given this, the study of the relationship between anxiety and performance efficiency is relevant and this connection may interpreted differently. It is noted, individuals with high level of anxiety are better in light-duty tasks, while people with low anxiety is successful in solving complex tasks. The reason of it – personal anxiety turns into actual state of anxiety that is why solves complex tasks (Druzhinin & Ushakov, 2002).

It is well known that every individual differ as well as in their anxiety level towards certain abilities, in our situation - in spatial ability. Spatial anxiety characterized as the fear of performing tasks which contain spatial components (Malanchini et. al., 2017). Lawton, Hund and Minarik linked spatial anxiety to a reduced effectiveness of orientation strategies and increased number of errors in the navigation tasks (Lawton, 1994; Hund & Minarik, 2006).

Spatial anxiety, individual characteristics in spatial ability, the relationship between general, mathematics and spatial anxiety were investigated in Malanchini et. al.’ study (2017). The study was conducted on a sample of 2928 twins from the Twins Early Development study (TEDs). Navigation anxiety and rotation / visualization anxiety are considered to be the main constructs of spatial anxiety in this study and they do not have significant relations to general and mathematics anxieties. Heritability of navigation anxiety was moderate, but rotation/visualization anxiety was explained as less heritable. Another study by Esipenko et. al. (2018) also tested the relationship between trait and spatial anxiety and success in solving spatial ability tasks. The gender aspect played an important role on the results where girls had high level of spatial anxiety in both types of anxiety (trait and spatial), but those results did not depend on performance of solving spatial ability tasks. However boys’ results revealed that both types of anxiety were related to spatial ability results (Esipenko et. al., 2018).

Some researchers investigate the spatial anxiety question from gender difference, navigation an orientation side. For example, Lawton examined whether gender differences in wayfinding strategies and anxiety are similar in Hungarian and American participants (Lawton & Kallai, 2002). The investigate this question Lawton and Kallai (2002) tested American (185 women and 114 men) and Hungarian (110 women and 104 men) participants on 24 items of Lawston's Wayfinding Strategy scale and Indoor Wayfinding Strategy Scale, 8 wayfinding tasks in Lawston's Spatial Anxiety Scale and 10 trait anxiety items of Spielberg's State-Trait Personality Inventory. The results showed that men prefer to orient using wayfinding strategy more than women who prefer route strategy. Furthermore, it was found that women feel more anxiety than men. As for country differences irrespective to sex between countries there were no significant differences in orientation / route strategy, but Americans demonstrated higher wayfinding anxiety than Hungarians. Another study by Alvarez-Vargas et al. (2020) tested 517 students (357 females and 160 males) between 18 to 33 years old on the Modified Spatial Anxiety Scale (M-SAS) and Mental Rotation test (MRT). According to the results only navigation and mental rotation anxiety significantly mediated the relation between sex and mental rotation. Interestingly, in Lawton's previous research study (1994) older participants showed less spatial anxiety comparing to younger participants. The researcher describe these results as the age experience of way finding. Moreover increasing spatial anxiety had an impact on choice of using cognitive maps. Alvarez-Vargas et. al. (2020) considered that spatial anxiety is a barrier to spatial thinking and if spatial anxiety would reduce it would improve spatial skills thus reduce gender differences in spatial tasks (i.e. mental rotation test performance).

Spatial activities, spatial anxiety, way-finding strategy and their relations to each other were investigated in Martin's study (2017). The researchers point that spatial activities in childhood and in adulthood is essential in cognitive abilities which means that boys are more tend to spatial activities (exploring large areas) than girls who usually prefer "feminine-defined" activities (e.g., ballet). Furthermore, it was stated that using cognitive maps decreases when individual feel spatial anxiety and this feelings are more feminine. As if in most studies females showed less spatial ability and more spatial anxiety, the author decided to conduct a study only a female sample. The participants were tested through Spatial Anxiety Scale, Way-finding strategy Scale, Childhood Activities questionnaire, Spatial Activities questionnaire. The results of Spatial Activity questionnaire was from 1.00 to 4.47 (possible total – 7.00) and for Childhood Activities questionnaire the total was 1.33 – 5.05 (possible total – 7.00). There was a strong significant correlation between Adolescents spatial activity participation and Childhood spatial activity

participation (r (86) = .68, p < .001). The adolescents spatial activities were significantly correlated to route strategy scores r (86) = . 03, p = . 002, the childhood spatial activities aslso had a significant correlation to map strategy r (86) = .31, p = . 002. Spatial anxiety scores was from 1.00 to 4.50, so it did not have a significant with other variables. The results indicated that spatial anxiety is not related to way-findng strategy (route and map), as well as the relations to adolescents or childhood spatial acidities were not found.

Ramirez et. al. (2012) explored relationship of spatial anxiety about spatial tasks and spatial ability itself. The study was conducted on a sample of 162 students (87 girls, 75 boys) with average age 7.05 years. Participants had two stages: 1) in achievement assessment session, children played number, shape and word games; 2) anxiety assessment session consisted of question-and-answer game using flashcards with types of emotions (calm, seminervous, obviously nervous faces). The results revealed that spatial anxiety can develop in young age (first and second grade children). This study also provided that girls feel more spatial anxiety than males in spatial ability tasks. According to the results some participants feel nervous during spatial ability tasks, while others not (Ramirez et. al., 2012).

Spatial anxiety was also investigated from cross-cultural side in Wei et. al.'s study (Wei et. al., 2018). The researchers studied association between spatial performance and anxiety. According to the results Chinese students showed more spatial anxiety than Russian, moreover males' outperforming in three spatial tasks while females felt more spatial anxiety. The results proved previous research studies the essential role of spatial anxiety and gender in spatial ability.

Finally, there is a limited number of literature on exploring spatial anxiety in spatial ability. Nevertheless, we can see that spatial anxiety exist as an emotional feature of an individual, which have an impact on the results of solving spatial ability tasks. Moreover, spatial anxiety was expressed more in female participants, than male. It can be characterized that females feel more anxiety during spatial ability tasks, as well as they feel low self-esteem of their spatial ability. High level of spatial anxiety may lead to a lack of motivation in everyday spatial ability (e.g. to explore new environment) or concentration on main aspects of e.g. navigation will become to the individual. Experience which increased with age and culture differences of spatial anxiety were also mentioned in research studies above.

1.2.3. Gender stereotypes about spatial ability

Throughout the history it was assumed that males and females are different not only in appearance, but also in their minds. The significant gender difference were found in many aspects of our life, including cognitive abilities. For example, some researchers find out that males and females are different in mathematics (Else-Quest et. al., 2010; Halpern et. al., 2007; Guiso et. al., 2008; Wei et. al., 2016). Females outperform males in exact mathematic and this advantage is depend on girls' language processing (Wei at. al., 2012). Another explanation of mathematical advantages in gender – it is said that while girls are good at exact arithmetic, boys are good at approximate arithmetic and this hypothesis was proved in investigation of spatial ability (Wei et. al., 2016).

In Wei at el.'s (2016) study the participants were 11.0-15.9 years old children that took mathematical tests and ac cording to multilevel model analysis, the boys showed their strength in approximate arithmetic and mental rotation, but girls were stronger in word semantic processing and Raven's Progressive Matrices. In spatial working memory there was any gender differences. The same results were in experiment with adults. Researchers mentioned that approximate arithmetic relies on spatial ability but conducted experiments didn't prove this evidence. Moreover spatial working memory task showed no gender difference.

According Silverman et al.'s (2007) study different regions play an important role in spatial ability where males and females behave differently. Silverman et. al (2007) conducted a study on more than 250 000 participants from 40 different countries. The results showed that men significantly outperform females in 3DMR test, this difference was shown in all 40 countries and 7 ethnic groups. It was an interesting finding that females scored higher than man in OLM test, these results were found in 35 countries out of 40. Silverman et. al. (2007) explain these findings that 3DMR test measures specific spatial abilities that is used in navigation, but OLM test is called as contrived measure. So if we talking about Gender differences in Spatial Ability men outperform females anyway. One more interesting finding refers to Behavioral Genetics which look at the behavior through nature and nurture. In childhood boys usually use larger areas to play, while girls can use a small environment and stay there for a long time. According to this topic a group of researches indicates that the gender gap in spatial abilities in the task interacts with culture and these results show the importance of nurture in the gender gap in spatial abilities (Hoffman et. al., 2011).

In the research studies above we find out that males, on average, outperform females in spatial abilities. The reason of gender differences in spatial ability may be interpreted by the spatial

experience, for example, boys' spatial toys preference, e.g. puzzles and blocks (Jirout and Newcombe, 2015). Gender stereotypes – one more social aspect which explores gender difference in spatial ability.

Like any other social stereotypes, gender stereotypes determine the process of perception of people around and influence the active construction of social reality using the information embedded in them.The most common manifestations of gender stereotypes are:

1) Sexism - a prejudiced opinion about representatives of a particular gender, accompanied by their discrimination, as well as a certain institutional practice, which is expressed in the fact that representatives of one or another gender are forced into a subordinate position;

2) Faceism - the tendency to distinguish the face and body in the images of men and women to varying degrees;

3) Gender segregation - preference for different types of activities and communication, different friends, different social roles, emphasizing gender differences, the formation of a biased attitude towards one's gender and prejudices towards another, the emergence of gender conflicts (Kovaleva V. V. & Kadatskikh I. Yu., 2017).

According to some studies stereotyping has its advantages – positive effect of ability which depend on gender increases someone's self-esteem and confidence and disadvantages where individuals feel stress, low confidence which lead to decreasing of performance (Heyden et. al., 2016). Stereotype threat requires that negative stereotype may lead to low performance (Steele & Aronson., 1995; Garside et. al., 2012).

Mostly negative threat leads to females which characterize that women's performance is lower in cognitive ability tasks. Moreover, people who tend to environmental opinion may feel uncertainty according to which success in solving task will decrease. Even if individuals did not know about stereotypes they can be under stereotype threat because of negative stimuli during solving tasks (Aronson et. al., 1999; Nosek et. al., 2002).

There are two methods of measuring gender stereotypes: explicit and implicit measures. According to Neuburger et. al. (2015) explicit method includes self-report questionnaires with questions about individuals' thoughts on some abilities/activities whether they more related to males or females. The participants' answers on explicit methods show conscious thoughts which is the result of their knowledge/awareness of stereotypes. In implicit measures participants do not know in which concepts they are participating. It is more about automatic reactions and personal attitude towards stereotypes. As the result of such methods the participants with stronger stereotype beliefs react faster to stereotype congruent than to stereotype incongruent conditions (Heyden et. al, 2016). Anyway, it is better to use both types of measure in studying stereotypes.

Stereotype activation that men are stronger in mathematics than women decreases women's performance in solving tasks (Nguyen & Rayan, 2008). However in this conclusion some nuances are still exist. First of all, it depends on how woman associate herself to mathematics – the effect is weak for women who associate themselves less to mathematics, as well as it is maximal when women associate with it in a moderate degree. Secondly, the strength of the effect depends on severity of anxiety. It is high for implicit method and less in explicit method. Thirdly, performance efficiency is positively affected by the experimentator's instruction about the equal well performance by both men and women.

Numerous studies tested gender stereotyping of spatial ability and some of them have an evidence of existing it. For instance, Neuburger et. al. (2015) conducted a study on 10-year children. The participants task was to answer on gender stereotype questions using five-point scale (e.g. only girls—more girls than boys—as many girls as boys—more boys than girls—only boys). The results showed that both (boys and girls) consider boys' superiority in spatial ability (in mental rotation). Heyden et. al (2016) also investigated the presence of gender stereotype beliefs on spatial ability using explicit and implicit measures. In explicit measure results of spatial ability was more associated with boys than with girls and as for implicit measure results boys associated spatial ability to boys and girls were neutral in gender differentiation.

The importance of stereotypes and spatial ability were demonstrated in Moè & Pazzaglia's study (2006). In particular, the study was aimed to check how motivational aspects as beliefs about spatial ability stereotypes can have an impact on the results. The study consisted of two experiments: 1 – only women, 2 – only men. In the first experiment women had a self-evaluation questionnaire about spatial ability. Then they were instructed to complete Mental Rotation task (MRT) in four minutes, when time was over the participants had an instruction: "Research showed that men perform better than women in this test, probably for genetic reasons. This means that women score lower than men" – for first group; "Research showed that women perform better than men in this test, probably for genetic reasons. This means that men score lower than women" – for the second group; general information for third group "Research showed that spatial ability is very important in everyday life…" (Moè & Pazzaglia's, 2006, p. 371). After stimuli participants completed the next part of MRT. The second experiment had the same tasks and instructions, but the sample included only men. The overall results revealed that performance increases when participants' gender was proved as better and decreases when instructions were about opposite gender superiority. The groups which were not manipulated did not show the difference between

the tests. The researchers suggest that instructions about men's superiority motivate males, while instructions about women's superiority reduce their anxiety.

Garside et. al. (2012) were aimed to study the influence of stereotype on the success in solving tasks. The first sample consisted of 182 students (47 males, M = 16. 43 and 135 females, M = 16. 27) from different high schools of London and the second sample was 377 adults (127 males, M = 31. 04 and 250 females, M = 28. 17). The results revealed that impact of stereotypes and gender was found in only one out of four measures. Males who were under stereotype impact were more successful in solving spatial ability tasks than females under stereotype impact (Garside et. al., 2012).

1.3. Fields of study and spatial ability

There is a growing number of studies which investigate the importance of technical fields of study such as science, technology, mathematics and technology (STEM). The increasing interest in these fields is characterized by fast technological and scientific advances. Furthermore, the development in these areas is one of the factors of the economic well-being of human. The number of graduate STEM students increased over four years (2009-2013), whereas humanities decreased (Vaziri et. al., 2019). In the report by American Academy and Science, students who had bachelor degree in humanities was 10.2 %, where share of sciences – 36.7 % (2013). Women's inability, weakness in STEM field of study is considered to be a widespread phenomenon (Ceci et. al., 2009; Kokot, 2009; Cheryan et. al., 2017). However Stoet & Geary (2018) stated that females perform similar, in some cases even better than males in Science.

STEM is focused mostly in engineering new technology based on scientific knowledge. As for humanities, they usually aimed to understand human being by exploring arts and ethics. The advantages of STEM degree are include development of mathematical, problem-solving, thinking skills which help to understand world's functioning and create new techniques. Humanities are more about understanding human culture and expressing human experience which achieved with the help of critical thinking, analytical skills, empathy. While these fields of study show different characteristics, we are interested in differences in STEM and humanities that were investigated in some research studies.

Spatial ability as one of the main cognitive abilities which is play an important role in educational and occupational areas where work with some complex figures and shapes are fundamental. Some researchers associate spatial ability to technical specialties and point on students' strength in this ability (Uttal et. al., 2013; Rodan et. al., 2016; Shakeshaft et. al., 2016).

There is a strong correlational evidence between spatial ability and STEM with its sub-disciplines (mathematics, chemistry, physics, engineering, geometry, biology). The research studies suggest that individuals who get education in STEM area distinguish by their notable level in spatial ability.

Shea et. al. (2001) looked on these differences through a long period. The researchers analyzed the difference in spatial ability level between adolescents who take STEM degree and adolescents who go to other occupations. The participants were recruited from Study of Mathematically Precocious Youth (SMPY) who were investigated through three time period 5, 10 and 20 years at ages 18, 23 and 33. Even if all participants were identified as intellectually talented at first stage, the results revealed that they differ in their abilities which are related to their professional area at 33. For example, adolescents who chose STEM career showed their strength in spatial ability, while others – in verbal or mathematical ability (Shea et. al., 2001).

The individuals' strength in spatial ability may influence on choice of future field of study. Furthermore, this strength in specific area of cognitive ability may further increase in STEM field because the study in such education area include work with spatial objects such as visualization, mental rotation, etc., while Humanity degrees experience them less. For example, in Peters et. al's research study (1995) were shown spatial ability difference between two different fields of study. The study was conducted on 636 undergraduate students from different academic programs: "Science" which consisted of such sciences as engineering, biological, physical and "Arts" which included social sciences, arts, humanities. The participants were 132 Science students (177 males and 135 females) and 324 Art students (102 males and 222 females) with average age 21.3 (males) and 20.5 (females). The results revealed that Science students perform better in Mental Rotation tests than Art students (Peters et. al., 1995). The difference between the study areas may be explored by chemists' ability to visualize a molecular structure which is one of the important disciplines in this field (Harle & Towns, 2010).

Another study by Esipenko et. al. (2018) also investigated study field differences in spatial ability. The sample included two groups of students from different degrees: 446 participants from STEM degree and 406 from Humanities. They were tested on 10 different domains of spatial ability (2 D and 3 D visualization, mental rotation, spatial relations, spatial planning, mechanical reasoning, spatial orientation, spatial decision making). The results indicated that STEM and Humanities groups differ significantly in all tests of spatial ability. Moreover, STEM students showed more success in 2 D and 3 D visualization tests. According to the researchers, the

professional skills of STEM students such as design and simulation of objects lead to high results in this specific spatial ability domain (Esipenko et. al., 2018).

Furthermore, the differences between fields of study and spatial ability may be interpreted by stereotyping. Hausmann (2014) studied whether gender stereotypes influence on cognitive sex difference in STEM and arts students. Firstly, in experiment 1 participants had two tests – mental rotation and verbal fluency, then they were stimuled gender stereotypes. As in many studies, males were better in spatial task (mental rotation), while females in verbal tasks. The stereotype stimuli "Men rotate better" did not have an impact on men, but decreases arts female students performance and increases STEM female's performance. In other words, arts female students sought to prove the stereotype, when STEM female students tried to prove the opposite. Another stimuli about females' superiority in verbal fluency did not affect females, but males' performance raised. The second experiment focused on only field of study. Stereotype "STEM students are better in mental rotation" increased Science men's performance, but Science women's performance decreased significantly in this stimuli. The researchers interpret such results as Science women instead of field of study stereotype activate their gender stereotype "Science equals men" which lead to the inconsistency herself to profession. Here we can find implicit stereotyping of gender. Stereotype "STEM are better in mental rotation than Arts" showed the same results in Arts students – decreasing performance. Arts students' superiority in verbal fluency increased significantly Arts males performance. So, we can see that difference in fields of study were studied from gender stereotyping side which showed its significant impact on participants performance and anxiety level (Hausmann, 2014).

1.4. Research goals of the present study

The current study explores individuals characteristics which have an impact on solving spatial tasks. In particular, the emphasis is laid on specific fields of study.

Object of research – spatial ability

Subject of research – individual characteristics of students in solving spatial tasks

Purpose of research – to study individual characteristics of students from different fields of study in solving spatial tasks

In order to achieve our purpose we had the following tasks:

- to study relations between three Spatial ability subtests and individual characteristics of students;

- to study the differences in self-esteem indicators of students from different fields of study in solving spatial tasks;

- to study the differences in spatial anxiety indicators of students from different fields of study in solving spatial tasks;

- to study the differences in gender stereotype indicators of students from different fields of study in solving spatial tasks.

We hypothesized that:

- Participants who better assess their spatial ability will better in spatial ability tasks;

- Participants who feel spatial anxiety will perform worse in spatial ability tasks;

- Participants who study in STEM field will perform better in spatial ability tasks than Humanity students.

Chapter 2. METHODS

This chapter is divided into four main sections. Section 2.1. include a brief statement of the design of research study. Section 2.2. describes the sample of the current study. In section 2.3. description of the procedure of study. Section 2.4. include the description of study materials.

2.1. Design

Our design had the following structure: Spatial ability subtests (Paper folding, Pattern Assembly, Spatial orientation tests), then self-esteem questionnaire, spatial anxiety scale and gender stereotype questionnaire. The current structure was created in order not to "arouse" feelings of self-esteem and spatial anxiety before spatial tasks.

There are different designs of investigating gender stereotypes. For example, in Moè & Pazzaglia's (2006) study participants were instructed to complete MRT and after four minutes they were stopped, during which the experimenter gave them stereotyping stimuli "Research showed that women perform better than men in this test", after which the participants proceed their MRT (Moè & Pazzaglia, 2006). In some cases the researchers include stimuli at beginning of the procedure. However in our study we examine gender stereotypes with a help of self-created questionnaire (it will be described below). This measure was conducted at the end of our study because we wanted to test how participants' solve spatial tasks without stereotype stimuli as it was mentioned in the example above. We were interested in how the participants' own attitude toward gender stereotypes will affect or not on spatial ability answers.

One more important point in our study was that we examine spatial ability in students from different faculties. It is widely used phenomenon that individuals who study or work in STEM field are better in spatial ability (Uttal et. al., 2013; Rodan et. al., 2016; Shakeshaft et. al., 2016, etc). So that is why our sample consisted of two fields of study STEM and Humanities which have more verbal ability than spatial.

2.2. Participants

Sixty-eight students (24 males, 44 females; M = .56, SD = .50) took part in the current study. The age ranged from 18 (1st year students) years to 37 years (2nd year MsC students) (Mean = 21.75, SD = 3.76). The participants were from different fields of study such as psychology, pedagogic, mathematics, computer science, physics, chemistry, geography, biology, history, journalism, foreign and oriental languages, medicine, fashion design, jurisprudence. The proportion difference of faculties was the reason of dividing them into two large blocks: STEM

(Science, Technology, Engineering and Mathematics) and Humanities which lead to study of human culture and how people express human experience. STEM groups consisted of thirty-eight students and Humanities – thirty students (see Table 1 for sample composition). The participants were recruited on the Internet using Google-Forms. Geography of students varied across Russia (Republic of Buryatia, Tomsk oblast, Novosibirskaya oblast, Amurskaya oblast, Vladivostok, Yakutskaya oblast, Irkutskaya oblast, Krasnoyarsk kray, Moskovskaya oblast, Republic of Dagestan), Belarus, Mongolia and Kazakhstan.

Table 1.

Sample Composition

Field of study	N	Percent
Humanities	30	44.12
STEM	38	55.88
Total	68	100.00

2.3. Procedure of research study

All study procedures were compiled based on code of ethics of the Russian psychological society. The study was approved by Interdisciplinary Ethics Committee at Tomsk State University. Only adult students could participate in our study (over 18 years of age). The data was collected online in Google-Forms. The participants received the description of our experimental procedure. Before taking part in our investigation the participants had the information that their participation is voluntary and they can withdraw from the research at any time if they want to. All information and answers was treated strongly confidentially and we did not have any personal information about them. They also had the information about approximate time that the participants would spend to solve the tasks and questionnaires. After the participants had read all information about the experiment they were able to move on to the tests and questionnaire portion of the study. Above all students had to click or not to click on bottom of getting acquainted with the experiment and participant's decision of taking part in our study. Then participants had to create their anonymous id, then filled out general information about their gender, age, region of residence, faculty and field of study, the year of study (1-5 bachelor and 1-2 master degrees). The next stage was the Spatial ability tests. The first subtest was "Paper folding" which consists of 15 questions, the tasks varies

from easy to more complex ways of folding papers. The second subtest was “Pattern Assembly”, the participants were aimed to find the general figure of combined parts, the combining sides were labeled by letters. This task was also ranged from light-duty figures to complex. In Spatial orientation test participants were aimed to find the shortest way to a certain building using street plan or maps, to move according instructions and find the closest building in their new take place, etc. The task is a kind of large scale which is adapted to a computerized version. After solving spatial tasks students had to assess their spatial ability in a Self-esteem questionnaire. They had to choose from “absolutely agree” to “absolutely disagree” with the statements about space, e.g. “It is hard for me to mentally rotate objects”. Next was measuring the level of participants’ anxiety in spatial ability situations. For example, “Rate from 1 (not at all) to 5 (at all) how anxious or nervous you are when you trying to find a right way in an unknown place”. The last questionnaire was about gender stereotypes’ tendency where individuals had to choose does the statement more girlish or boyish or it does not depend on gender. Students filled self-esteem, spatial anxiety, gender stereotypes questionnaires and performed spatial ability and spatial orientation tasks in their own pace without time limit.

2.4. Materials

Before completing spatial ability tests, the participants filled demographic inventory. The inventory collect the information about participants’ age, gender, region, faculty/institute of study, field of study and the year of study (see below):

1) What is your gender? (Укажите ваш пол)

Options: male, female, prefer not to answer

2) How old are you? (Сколько вам лет?)

Options: 18 – 21, 22 – 25, 26 – 29, 30 – 33, 34 – 37, 38 – 40

3) What region do you live in? (В каком регионе проживаете?) *Own answer*

4) Do you live in an urban or rural area? (Вы проживаете в городской или сельской местности?)

Options: in urban, in rural

4) What faculty or institute do you study? (На каком факультете/институте вы учитесь?)

Options: psychology, pedagogics, mathematics/computer science, physics/chemistry, geography/biology, history, journalism, foreign/oriental languages, other – own answer.

5) Choose your field of study (Укажите ваше направление обучения)

Options: STEM, technical, humanities.

The experiment consisted of 5 surveys (methods) and had the following structure: OSSAB which is consist of two subtests “Paper folding” and “Pattern Assembly”; Spatial orientation test; self-esteem questionnaire; spatial anxiety scale; gender stereotype questionnaire.

1. Spatial ability tests

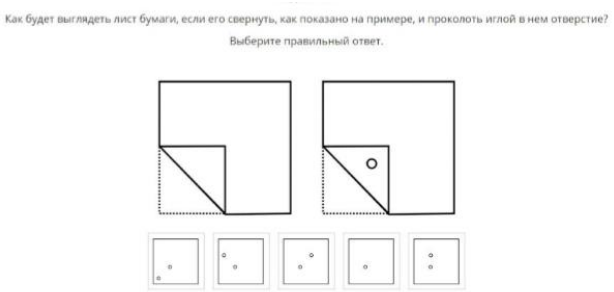
To assess participants’ spatial ability we used part of Online Short Spatial Ability Battery (OSSAB) (Likhanov et. al., 2021). These group of tests are aimed to determine the level of spatial ability (high or low level of spatial ability). These methods were tested and used in Russian and foreign research studies (Rimfeld et. al., 2017; Likhanov et. al., 2018; Likhanov et. al., 2021). OSSAB assesses four domains of spatial ability: first – Mechanical reasoning – multiple-choice naive physics questions, second – Pattern assembly – combination pieces of figures together to make a whole, third – Shape rotation – rotation objects, fourth - Paper folding – visualizing holes of unfolded paper (Rimfeld et. al., 2017). In our study students did not have limit of time during solving the tasks, each individual completed the tests in their own pace. The tasks in this test were divided into two blocks. Before each of them the participants had a detailed information for the tests. Thus, participants were asked to perform a number of tasks to measure ability to do such things as: to visualize objects and assemble the number of small figures into a large one. The characteristics of each blocks are following:

- Paper folding

During the task the participants were instructed to imagine the pattern made by holes which were punched through folded sheets of paper, when the paper was opened out again. In each trial participants could see how a square sheet of paper was folded step by step. The last picture had a black dot – it was a needle-punched hole that passes through the layers of paper located underneath it. The participants were asked to choose from five options the correct location of the holes of that unfolded sheet (see Figure 1.). The final scores were calculated as a number of correctly answered tasks. There were fifteen tasks of Paper folding, the minimum score was 0 and maximum 15.

Figure 1

Example of Paper Folding Test

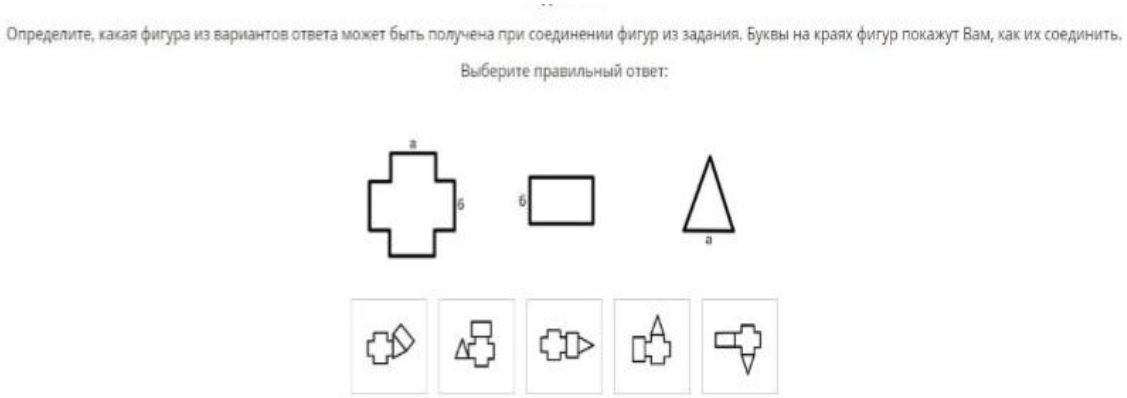


- Pattern Assembly

Groups of figures were presented to the participants. They had to identify which larger figure can be made by combining them. The letters at the edges of the figures showed the participants how to connect them (see Figure 2.). The score was calculated as a sum of correct answers (minimum 0, maximum 15).

Figure 2

Example of Pattern Assembly Test



2. Spatial orientation test is aimed to measure “spatial awareness and the ability for reading and using simple maps for navigation”. This test was taken from Aptitude test website in order to check whether such a test which is used in emergency services, military, and law enforcements jobs will work in testing students’ spatial orientation. The original test is available in a website of Aptitude test https://www.aptitude-test.com/. The initial test consists of fifty spatial orientation questions, but in our study we took only six light-duty questions, translated them into Russian and added two more questions created by me based on these question task. Spatial orientation (or way-

finding) refers to Large scale of spatial ability, but in our situation individuals did not orient in real environment, they used computerized version. Anyway we thought that it is depend on large scale ability and were interested in will this test from another scale work in our experiment.

The participants were instructed to solve the tasks using picture where they could see street plans and maps. This test had tasks such as to find the shortest way to a certain building, to follow the instruction of navigation and find the closest building to a new location (see figure 3.). It also includes knowledge of parts of world because the participants used them in navigation tasks. The final scores were calculated as a number of correctly solved tasks. The maximum score which participants could recruit was 8 and the minimum – 0. The total high score revealed the participants' ability to orient in space mentally using maps, the total minimum score – participants' low ability.

Figure 3

Example of Spatial Orientation Test

3. Self-esteem and spatial anxiety (described below) questionnaires were developed by Malanchini et. al. (2017) to measure how individuals assess their spatial ability. These questionnaires were translated and adapted into Russian by researchers from Tomsk state university. The self-esteem questionnaire consist of 8 statements regarding to self-esteem. The participants were asked to estimate each statement on a 5 – point scale, where 1 = "strongly agree",

2 – “agree”, 3 – “hard to answer”, 4 – “disagree”, 5 – “strongly disagree”. The scale has 3 items with inverted scoring.

1) I am good at navigating in the environment

(Я хорошо ориентируюсь на местности)

2) I am good at mental imagining 2D objects in 3D.

(Я хорошо представляю, как 2D объекты выглядят в 3D).

3) I memorize orientation points well when I walk somewhere for the first time

(Я хорошо запоминаю ориентиры, когда гуляю где-то в первый раз).

4) It is hard for me to imagine how objects/buildings will look from another angle

(Мне трудно представить, как будут выглядеть объекты с другого ракурса).

5) I rarely get lost when I walk somewhere for the first time.

(Я редко теряюсь, когда где-то гуляю в первый раз).

6) It is hard for me to mentally rotate objects

(Мне сложно мысленно вращать объекты)

7) I have good spatial ability

(У меня хорошие пространственные способности)

8) I usually don't know where I am in relation to the nearest landmarks

(Обычно я не знаю, где я нахожусь относительно ближайших ориентиров).

The total score for all 8 questions in this questionnaire was the level of self-esteem of each participants’ own spatial skills. The higher the score the higher the confidence of the participant. The minimum number of points that can be scored is 8, the maximum is 40.

4. Spatial anxiety scale

10-item questionnaire of spatial anxiety was designed to measure how anxious individuals’ in some everyday situations (Malanchini et. al., 2017). The participants were instructed to rate their anxiety level in situations related to navigation, mental rotation and visualization skills on a 5-point scale where 1 – “not at all”, 2 – “a bit”, 3 – “a little”, 4 – “notably”, 5 – “very much”.

1) Look for a way in the complex street weave

(Ищете дорогу в сложном переплетении улиц)

2) Show someone the direction to the certain place in a room without windows

(Указываете кому-то направление к интересующему его месту в помещении без окон)

3) Look for your transport vehicle (bicycle, car, motorbike) in a very large parking or garage. (Ищете своё транспортное средство (велосипед, машину, мотоцикл и др.) на очень большой парковке или в гараже).

4) Assemble a complex puzzle.

(Когда собираете сложный паззл).

5) Search for a way in an unfamiliar place

(Когда ищете дорогу в незнакомом месте).

6) Try to "cut" the path without using a map.

Пробуете "срезать" путь без использования карты.

7) Search for a way with someone's instruction

(Ищете дорогу по чьей-то инструкции)

8) Imagine 3 D objects from a 2 D drawing

(Представляете 3 D объекты по 2 D рисунку)

9) Mentally rotate objects (Мысленно вращаете объекты)

10) Look for a product in a local supermarket when the it was moved

(Ищете товар в местном супермаркете, когда товар переместили)

The minimum number of scores – 10 which shows the lowest level of spatial anxiety, maximum – 50 describes the highest level of spatial anxiety of the participants.

5. Gender stereotypes questionnaire

We created gender stereotype questionnaire in order to reveal whether the participants have gender stereotype tendency. The aim of our questionnaire was not to give a stimuli during solving spatial ability test, it was more to check students stereotyping thinking. We analyzed gender and spatial related statements and combined them in a short questionnaire. In research studies usually point on women's failure in cognitive ability, e.g. "Women perform worse in spatial ability", "Men outperformed women in mental rotation task", "Females are tend to orient by visual memory of objects/buildings", "Males are better in reading maps", "STEM is for boys" and so on (Silverman et. al., 2007; Neuburger et. al., 2015; Wei et. al., 2016, etc).

The participants task was to read the statement and choose to whom it is more related in their opinion. The more the students choose gender bottom "males" or "females" the more they leaned towards gender stereotyping. The participants' task in this test was to choose one point out of three: "males" – the statement is more related to men, "females" - the statement is more related to women, "both" – both men and women are tend to do this action.

1) Who finds it easier to mentally pave the way to a destination?

(Кому легче мысленно проложить путь к пункту назначения?)

2) Who often break the traffic rules?

(Кто чаще нарушает правила дорожного движения?)

3) Who is better in spatial navigation?

(Кто лучше ориентируется в пространстве?)

4) Who is more face difficulties while navigate using maps?

(Кто чаще испытывает трудности при ориентировке по картам?)

5) Who is better in visual memory navigating?

(Кто больше ориентируется по зрительной памяти?)

6) Who is more likely to get lost in a wood?

(У кого больше вероятность заблудиться в лесу?)

7) Who is better in reading maps?

(Кто лучше читает карту?)

8) Who pay more attention to the color characteristics of objects?

(Кто больше обращает внимание на цветовые характеристики объектов?)

The button “males” or “females” gives the participants 1 point, button “both” – 0. The maximum score which participants could get was 8, minimum – 0.

At the end of the experiment the participants also had a finalizing inventory which consisted of five questions.

1) Do you drive a car? (Водите ли вы машину?)

2) Do you easily navigate using 2 gis or GPS navigation?

(Легко ли вы ориентируетесь по 2 gis/GPS навигации?)

3) Do you easily navigate in the city? (Легко ли вы ориентируетесь по городу?)

4) Do/Did you engage in such activities where you had to orient in space or read maps (for example, sport orientation)?.

(Занимаетесь/занимались ли (например, в школьные времена) вы деятельностью, где нужно было ориентироваться в пространстве и читать карты (например, спортивное ориентирование)?)

Chapter 3. RESULTS

The results chapter is divided into several sections. Section 3.1. describes the types of statistical analysis used in the study. In section 3.2. we presented descriptive statistics of the study variables. Section 3.3. Correlation analysis is presented. 3.4. Analysis of Variance (ANOVA). 3.5. Analysis of additional inventory

3.1. Statistical analysis

All statistical analyses were conducted using JASP (Version 0.14). Descriptive statistics, ANOVA and Correlation analyses were used. Sample was normally distributed. Pearson's correlations were calculated to estimate associations between all spatial subtests (Paper folding, Pattern assembly, Spatial orientation test). Furthermore we checked associations between factors – self-esteem, spatial anxiety, gender stereotypes and spatial subtests. We also calculated one – way ANOVAs to investigate differences in indicators of spatial ability in students from different fields. Individual characteristics of students from STEM and Humanities were analyzed.

3.2. Descriptive statistics

The description of a sample (N = 68), where age of 38 STEM students (M = 21.55, SD = 5.35) and 30 students from Humanities (M = 21.27, SD = 3.43). Descriptive statistics for all measures are presented in Table 2.

Table 2

Descriptive Statistics of All Measures

	Paper folding	Pattern Assembly	Spatial orientation	Self - esteem	Spatial Anxiety	Gender stereotypes
Valid	68	68	68	68	68	68
Missing	0	0	0	0	0	0
Mean	12. 60	11. 13	4. 65	26. 19	22. 24	4. 46
Std. Deviation	2. 67	3. 49	2. 16	6. 73	7. 99	2. 67
Minimum	4. 00	1. 00	.00	.00	.00	.00
Maximum	15. 00	15. 00	8. 00	40. 00	41. 00	8. 00

3.3. Correlation analysis

1. Associations between spatial ability subtests

It is important to check how all spatial subtests are related to each other because in the current study we used the methods which is not included to OSSAB. For this goal we conducted a correlation analysis (Table 3). We created Spatial orientation test that is why we were aimed to check the associations with OSSAB subtests (Paper folding and Pattern assembly) which were validated earlier.

Table 3

Pearson's Correlations Between Three Spatial Subtests (Paper folding, Pattern Assembly, Spatial orientation)

Variable		Paper folding	Pattern assembly	Spatial orientation
1. Paper folding	Pearson's r	—		
	p-value	—		
2. Pattern assembly	Pearson's r	.64	—	
	p-value	< .001	—	
3. Spatial orientation	Pearson's r	.38	.44	—
	p-value	1.36e -3	< .001	—

The subtests Paper folding and Pattern Assembly correlation is $r = .64$ ($p < .001$), Spatial orientation and Paper folding is $r = .38$ ($p < .001$), Pattern assembly and Spatial orientation $r = .44$ ($p < .001$). According to the obtained results, the association strength between the developed subtest and subtests from OSSAB have a moderate correlation. It can depend on the reason that the current Spatial orientation test may measure slightly different aspects of spatial ability which is more relevant to the large scale.

2. Association between self-esteem and solving spatial tasks performance

To study the relationship between self-esteem and solving spatial tasks performance we also carried out correlation analysis (Table 4). It revealed positive correlation of moderate strength between spatial self-esteem and all analyzed subtests. The results of this analysis was following: between self-esteem and Paper folding subtest $r = .37$ ($p < .001$), between self-esteem and Pattern assembly subtest $r = .36$ ($p < .001$), between self-esteem and Spatial orientation subtest $r = .45$ ($p < .001$).

Table 4

Association Between Self-esteem and Solving Spatial Tasks Performance

Variable		Paper folding	Pattern assembly	Spatial orientation	Self-esteem
1. Paper folding	Pearson's r	—			
	p-value	—			
2. Pattern assembly	Pearson's r	.64	—		
	p-value	< .001	—		
3. Spatial orientation	Pearson's r	.38	.44	—	
	p-value	1.36e -3	< .001	—	
4. Self-esteem	Pearson's r	.37	.36	.45	—
	p-value	1.84e -3	2.43e -3	< .001	—

3. Association between spatial anxiety and solving spatial tasks performance

The correlation analysis showed significant negative correlation between spatial anxiety and OSSAB subtests (Table 5). Thus the results obtained between indicators of spatial anxiety and Paper folding subtest was r = - .28 (p = .02), between indicators of spatial anxiety and Pattern assembly r = - .32 (p < .001). There were no significant results between spatial anxiety and Spatial orientation (p = .12).

Table 5

Association Between Spatial Anxiety and Solving Spatial Task Performance

Variable		Paper folding	Pattern assembly	Spatial orientation	Spatial anxiety
1. Paper folding	Pearson's r	—			
	p-value	—			
2. Pattern assembly	Pearson's r	.64	—		
	p-value	< .001	—		
3. Spatial orientation	Pearson's r	.38	.44	—	
	p-value	1.36e -3	< .001	—	
4. Spatial anxiety	Pearson's r	-.28	-.32	-.19	—
	p-value	.02	7.70e -3	.12	—

4. Association between gender stereotypes and solving spatial ability performance

The results of Correlation analysis indicate that there were no significant differences between gender stereotypes tendency and spatial ability tasks (Table 6)

Table 6

Association Between Gender Stereotypes and Solving Spatial Ability Performance

Variable		Paper folding	Pattern assembly	Spatial orientation	Gender stereotypes
1. Paper folding	Pearson's r	—			
	p-value	—			
2.Pattern assembly	Pearson's r	.64	—		
	p-value	< .001	—		
3.Spatial orientation	Pearson's r	.38	.44	—	
	p-value	1.36e -3	< .001	—	
4.Gender stereotypes	Pearson's r	-.04	-.05	.21	—
	p-value	.75	.69	.08	—

3. 4. Analysis of Variance (ANOVA)

In order to check our hypothesis that STEM students perform better in spatial ability tasks than Humanities students we conducted one-way ANOVA. Levene's test showed homogeneity of variances in all indicators ($p > .05$).

The results of one-way ANOVA showed that in Spatial orientation test STEM and Humanities students did not differ significantly (see Table 7).

Table 7

ANOVA – Spatial Orientation

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Field of study	12.39	1	12.39	2.72	.10	.04
Residuals	301.14	66	4.56			

Cases	Sum of Squares	df	Mean Square	F	p	η^2

Note. Type III Sum of Squares

The results of one-way ANOVA showed that in Paper folding test STEM and Humanities students did not differ significantly (see Table 8).

Table 8

ANOVA - Paper Folding

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Field of study	3.00	1	3.00	.42	.52	6.27e -3
Residuals	475.28	66	7.20			

Note. Type III Sum of Squares

However Pattern assembly test had a significant differences F = 6.07, p =.02 with η^2 = .08 between the groups (see Table 9) whereby STEM students scored higher (M = 12.03, SD = 3.41) than Humanities students (M = 10.00, SD = 3.31).

Table 9

ANOVA – Pattern Assembly

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Field of study	68.84	1	68.84	6.07	.02	.08
Residuals	748.97	66	11.35			

Note. Type III Sum of Squares

The homogeneity of variances in Pattern assembly is p = .82. Post hoc test showed significant differences (t = -2.46, p = .02).

We also analyzed individual characteristics of students from different fields of study. The results revealed that groups did not significantly differ in spatial self-esteem scale (F = 2. 22, p = .14) (see Table 10).

Table 10

ANOVA – self-esteem

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Field of study	98.98	1	98.98	2.22	.14	.03
Residuals	2937.54	66	44.51			

Note. Type III Sum of Squares

However in spatial anxiety scale students differ F = 6. 12, p = .02, η^2 = .08, where Humanities students scored higher (M = 24.83, SD = 6.79) than STEM students (M = 20.18, SD = 8.34) (Table 11).

Table 11

ANOVA – Spatial Anxiety

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Field of study	362.36	1	362.36	6.12	.02	.08
Residuals	3909.88	66	59.24			

Note. Type III Sum of Squares

The homogeneity of variances in Pattern assembly is p = .23. Post hoc test showed significant differences (t = 2.47, p = .02).

Furthermore, STEM students have more gender stereotype tendency (F = 5.44, p = .02, η^2 = .08) than Humanities students (Table 12).

Table 12

ANOVA – Gender Stereotypes

df	Mean Square	F	p	η^2
1	36.32	5.44	.02	.08
66	6.67			

Note. Type III Sum of Squares

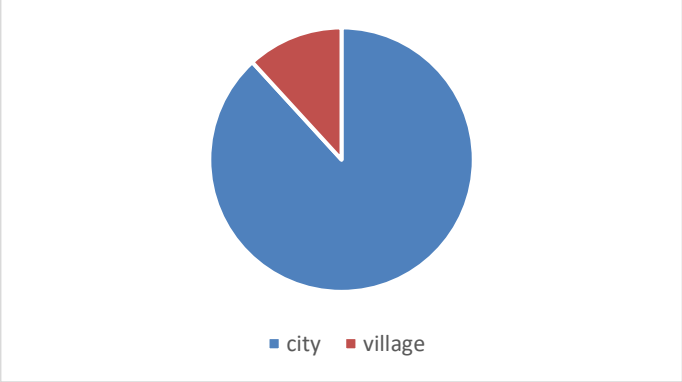
The homogeneity of variances in Pattern assembly is p = .65. Post hoc test showed significant differences (t = -2.33, p = .02).

3.5. Analysis of the additional inventory

Additional data were collected regarding to individual experience in solving spatial tasks which is associated with solution large scale tasks. In our study the large scale task is Spatial orientation test. We hypothesized that participants who live in rural areas have different skills than those who live in urban areas, as well as those who drive a car may differ in this subtest. For this purpose the participants of our research answered on a short inventory questions: “Do you live in an urban or rural place?” 11.8 % participants live in the rural area and the other 88.2 % in urban (see Figure 4.).

Figure 4.

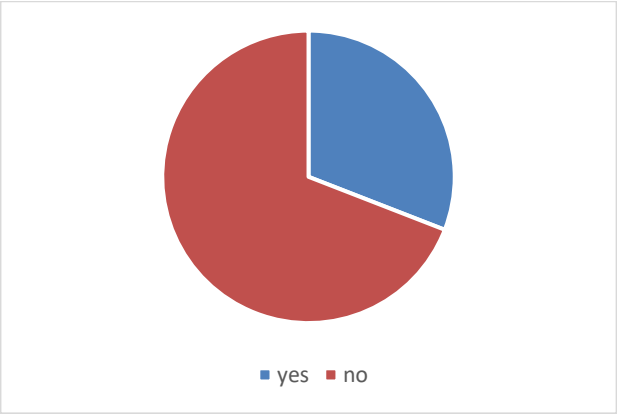
Urban and rural inhabitants



Unfortunately, the lack of a sufficient sample of the group who live in the rural area did not allow us to provide further analysis. The answers on the questions “Do you drive a car?” revealed that 30.9 % participants drive the car, while 69.1 % do not (see Table 5).

Figure 5

Car drivers



However while conducting statistical analysis of mean comparison, no significant differences in Spatial orientation subtest were indicated. In order to clarify these findings, we asked some more questions such as “Do you easily navigate using 2 gis or GPS navigation?” where 82.4% of students stated that they navigate easily, but 17.6 % - do not (see Figure 6).

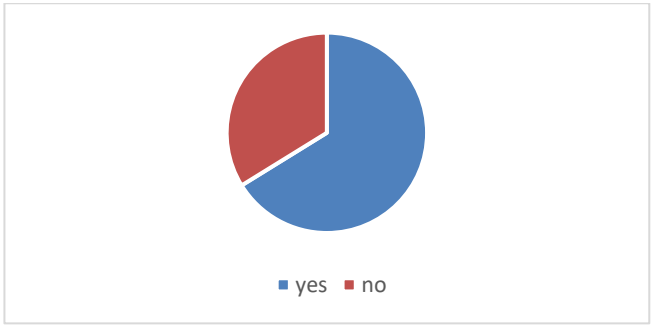
Figure 6

Navigation skills

This results also did not allow us to proceed the analysis. Other answers indicated that 66.2 % students can easily navigate in the city and 33.8% feel some troubles (see Figure 7).

Figure 7

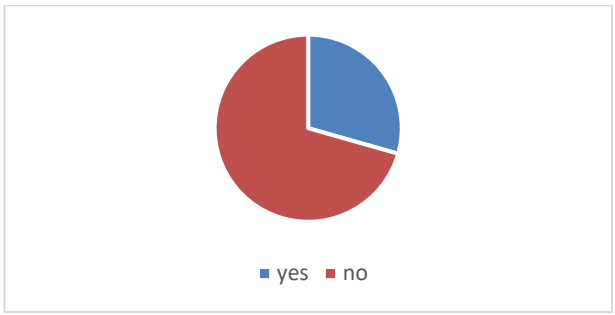
Navigation skills in a city



The last question about participants' engaging in spatial orientation or reading maps activities showed the following results: 29.4 % of students have/had such experience, 70.6% do not (see Figure 8).

Figure 8.

Additional activities



According to these results we did not reveal significant differences between the participants which were in different groups.

Chapter 4. DISCUSSION

The aim of the current study was to study individual characteristics of students from different fields of study in solving spatial tasks. This chapter provides a discussion of obtained results. The structure of this chapter is following: 4.1. Individual characteristics in spatial ability; 4.2. Differences between fields of study in spatial ability; 4.3. Limitations of the study

4.1. Individual characteristics in spatial ability

In order to prove the hypothesis "Participants who better assess their spatial ability will be better in spatial ability tasks", we investigated the relationship between all spatial tasks and self-esteem of spatial ability. Thus, significant positive relationships of moderate strength were obtained r = .36 - .45, and the maximum value was between self-esteem indicators and scores on Spatial orientation subtest. So hypothesis was proved. These results suggest that high self-esteem has a positive effect on the indicators of spatial ability, which does not contradict the literature data. For example, according to the results (Paunnoen & Hong, 2010), it was shown that self-esteem reflects a special attitude towards performance in the spatial domain (along with the verbal, numerical domains). In addition, these results are confirmed in Garside et. al' study (2012), where adult participants who rated their spatial ability at a high level performed better on all tests than participants with low self-esteem (Garside et. al., 2012). So, in our sample, the role of self-esteem (according to one's own spatial ability) in solving spatial tasks was confirmed.

To support the hypothesis: "Participants who feel spatial anxiety will perform worse in spatial ability tasks" associations between all spatial tasks and spatial anxiety were examined and significant negative correlations of weak to moderate strength were obtained r = - .28 - .32 for subtests which related to OSSAB battery, but not for the Spatial orientation subtest (p = .12). Our hypothesis was partially proved. Although we confirmed the overall finding of the negative impact of high anxiety on spatial problem solving (Alvarez-Vargas et.al., 2020), in Lawton, Hund, and Minarik found an association between spatial anxiety and increased errors in navigational tasks (Lawton, 1994; Hund & Minarik, 2006).

Additionally, we analyzed the relationship between self-esteem and spatial anxiety. Our results (r Persons = - .38; p=.002) are consistent with data that were shown in Pazzaglia et. al.' study where high level of spatial anxiety correlated with low self-esteem in spatial tasks (Pazzaglia et. al., 2018).

As for gender stereotype tendency, we did not find significant correlations between all spatial ability subtests and gender stereotype tendency. However, there was a small tendency (r Persons = .21, p = .08) between Spatial navigation subtest and stereotype tendency. These differences may depend on explicit approach with the help of which it was tested. This approach is characterized by self-report questionnaires with questions about individuals' thoughts towards certain abilities/activities, whether they more related to males or females (Neuburger et. al., 2015). No significant differences were found between gender stereotypes tendency and such indicators as spatial anxiety and self-esteem of one's own spatial ability. However, in previously described literature results showed that self-esteem was closely associated with gender stereotypes of spatial ability (Papageorgiou et. al., 2012).

So according to the results some significant results were found, which manifested on tendency level and distinctive strength of relations between Spatial orientation subtest and almost all studied indicators of individual characteristics.

According to the correlation analysis in comparing all spatial tests which were used in our study we can assume that our developed Spatial orientation test has positive significant correlations (r = .38, - .44) with moderate effect with other spatial subtests. These relations suggest that the subtests are related but have certain differences. On the other hand, the relation strength differs from studies (Wang et. al., 2014), which showed moderate relationship between large scale and small scale groups (r = .27). In any case, our results can be designed as pilot and they require verification of obtained results in a larger sample. When we studied the relationship between all spatial subtests self-esteem we revealed significant positive relationships between from weak to moderate strength. These results suggest that high self-esteem has a positive effect on spatial ability measures.

4.2. Differences between fields of study in spatial ability

To test the hypothesis "Participants who study in STEM field will perform better in spatial ability tasks than Humanities students" we studied the differences in solving spatial ability tasks. Additionally we tested individual characteristics of students using one-way ANOVA. According to the results only Pattern assembly subtest showed significant results where STEM students outperformed Humanities students in this spatial ability subtest (with effect size 8 %). So we can assume that our hypothesis was partially proved. Esipenko et. al. (2018) indicated the similar results where significant differences between fields of study were found in favor to STEM group. It is also important to mention that in Esipenko et. al.' (2018) study 10 subtests were used, while in the current study we used two subtests from OSSAB battery. However in our study we did not found significant results in Paper folding subtest. Perhaps depend on a small modernization of this

subtests in our study – time was not measured and students solve the spatial tasks in their own pace.

As for analyses of individual characteristics, students from different fields of study did not differ in spatial ability self-esteem indicators, but the differences were found in spatial anxiety indicators (F = 6.12, p = .02, effect size = 9 %) and in gender stereotypes tendency (F = 5.44, p =.02, effect size = 8 %). Indeed students from STEM field scored less in spatial anxiety (20.2) in comparison to Humanities students (24. 8). The reason of such results may be the fact that Humanities group consisted of 25 female students out of overall 30 students. STEM group sample had similar number of males and females. According to the literature review, females feel more spatial anxiety in solving spatial ability tasks than males. The results showed that some participants feel nervous during solving spatial tasks and others do not (Ramirez et. al., 2012).

Interesting results revealed comparison of two groups (STEM group and Humanities group) in gender stereotype tendency. We assumed that participants who scored higher in this questionnaire will tend to gender stereotype, that is why we thought that they will score worse in spatial ability tests. However STEM students scored higher in gender stereotypes questionnaire (M = 5.11, SD = 2. 53), which solved all spatial ability tests better than Humanities students (M = 3. 63, SD = 2. 66), but significant differences were found only for one pattern assembly subtest. So, in Paper folding subtest STEM group had such results – M = 12. 79, SD = 2. 66 nd Humanities group M = 12.37, SD = 2.71. In Pattern assembly subtest STEM students scored - M = 12.03, SD = 3.41 and Humanities students M = 10.00, SD = 3.31. For Spatial orientation subtest STEM students scored - M = 5.03, SD = 2.46, while Humanities students - M = 4.17, SD = 1.64. According to some research studies, stereotyping may have some advantages such as positive effect of abilities which is depend on gender and raising self-esteem and self-confidence (Heyden et. al., 2016). It is important to know that gender stereotypes have not only negative side, it can impact on the individuals from a positive side as well. Thus, if someone is afraid to confirm negative stereotype, his cognitive abilities may decrease – this phenomenon called “stereotypical threat” (Steele & Aronson, 1995 by Hausmann, 2014). In contrast, when individual meet positive stereotype about someone’s group identity, cognitive abilities may slightly improve, in other words – “stereotypical lift” or significantly improve – “stereotype boost”. Furthermore, cognitive abilities may improve in facing with a negative stereotype of out-group – “stereotype susceptibility” or when the negative stereotype about the in-group is assessed as “stereotype reactance” (Hausmann, 2014).

4.3. Limitations of the study

Some limitations of the present study should be mentioned. First of all, our sample was small, which did not give us a fully description of our study. Furthermore not all subtests from Online Short Spatial Ability Battery was not used. It is also important to mention that in our experiment there were no time limit, the participants solved the tasks in their own pace. If we put time limit, the results would show different results.

4.4. Conclusion

Spatial ability play an essential role in our life. They are useful in adapting to the new environment, building relationships or solving various tasks in our life. Besides, it is well known that spatial ability is closely related to a such science block as STEM and help to choose professional area for students who want to study in technical and natural science fields.

Individual characteristics is crucial in solving cognitive tasks, that is why they also have the impact on spatial ability. For the purpose to study individual characteristics of students from different fields of study in solving spatial ability tasks we created research design which was approved by Interdisciplinary Ethics Committee at Tomsk State University. As the results, we conducted a pilot study. The design of research included 2 subtests on spatial ability (Paper folding and Pattern assembly) and the self-created Spatial orientation test, the participants also were asked to complete self-esteem of spatial ability questionnaire, spatial anxiety scale and gender stereotype tendency questionnaire. Stereotype was studied explicitly. All questionnaires were given at the end of spatial ability tests in order not to “awake” the feelings of self-esteem and spatial anxiety before spatial ability tasks.

We were interested in how such individual characteristics as self-esteem, spatial anxiety and gender stereotypes tendency are linked to solving spatial tasks, as well as how such results will manifest in our sample where were students from different years of study and fields of study. Despite that such research studies on students from different fields of study were conducted at Tomsk State University. There was only one study which investigated complex of factors such as spatial anxiety, working memory, intelligence, gender stereotype (Esipenko et. al., 2020). However in our study the complex of factors which may have an impact on solving spatial ability performance included self-esteem, spatial anxiety and gender stereotypes. Furthermore, we performed a little modernization of two small scale subtests (without time limit) and developed a subtest that measures large-scale performance. During solving the research tasks as to compare the participants from different fields of study in self-esteem, spatial anxiety and gender stereotypes tendency indicators sample of 68 individuals (30 students from Humanities field and 38 - STEM)

were recruited. We also hypothesized that the participants who better assess their spatial ability will better in solving spatial ability tasks; the participants who feel spatial anxiety will perform worse in solving spatial ability tasks and the participants who study at STEM field will perform better in spatial ability tasks than Humanities students. As a result of the study, it turned out that high self-esteem has a positive effect on the indicators of spatial ability, which is consistent with the literature. We had a significant positive correlation results ($r = .36 - .45$) between self-esteem and scores of all spatial subtests indicators. As for spatial anxiety we also confirmed the literature results. We obtained significant negative correlations of weak and moderate strength $r = - .28 - .32$ for the subtests related to the OSSAB battery, but not for Spatial orientation subtest ($p = .12$).

Significant results were also obtained comparing the indicators of students from different fields of study in terms of gender stereotype tendency, and the scores of students in the STEM field were higher ($M = 5.11$, $SD = 2.53$), compared with the Humanities students ($M = 3.63$, $SD = 2.66$). The gender stereotypes tendency depending on who is under its influence, can disimprove or improve the results of spatial tasks, for this additional definitions are introduced in the scientific community: 'stereotype threat', 'stereotype lift', 'stereotype susceptibility', 'stereotype reactance'. So as for hypotheses, one hypothesis proved, but others proved partially. All the obtained results are of great value for understanding the role of various factors in solving spatial tasks, as well as individual characteristics contribution.

Summing up, the following research tasks were studied:

- to study relations between three spatial ability subtests and individual characteristics of students;

- to study the differences in self-esteem indicators of students from different fields of study in solving spatial tasks.

- to study the differences in spatial anxiety indicators of students from different fields of study in solving spatial tasks.

- to study the differences in gender stereotype indicators of students from different fields of study in solving spatial tasks.

The results revealed that the students from different fields of study did not differ in self-esteem indicators. However the participants differ in spatial anxiety indicators, where Humanities scored higher, than STEM. Furthermore STEM students were more tend to gender stereotypes.

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АНТИПЛАГИАТ
ОБНАРУЖЕНИЕ ЗАИМСТВОВАНИЙ

Отчет о проверке на заимствования №1

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Организация: Томский Государственный Университет

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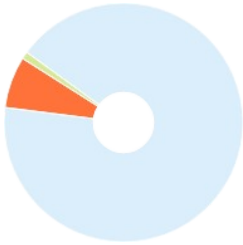

ЗАИМСТВОВАНИЯ	САМОЦИТИРОВАНИЯ	ЦИТИРОВАНИЯ	ОРИГИНАЛЬНОСТЬ
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Заимствования, самоцитирования, цитирования и оригинальность являются отдельными показателями и в сумме дают 100%, что соответствует всему тексту проверяемого документа.
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[02]	0%	Articles http://psychologyinrussia.com	20 Июн 2022	Интернет Плюс	
[03]	0%	Articles http://psychologyinrussia.com	20 Июн 2022	Интернет Плюс	
[04]	1,44%	http://vital.lib.tsu.ru/vital/access/services/Download/vital:9357/SOURCE01 http://vital.lib.tsu.ru	15 Июн 2022	Интернет Плюс	
[05]	0%	Articles http://psychologyinrussia.com	17 Мая 2019	Интернет Плюс	
[06]	0,85%	Te Factorial Structure of Spatial Abilities in Russian and Chinese Students http://psychologyinrussia.com	18 Июн 2022	Интернет Плюс	
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