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DIFFERENCE IN PSYCHOMOTOR SKILLS WHILE WORKING ON TABLETS PC AND SMARTPHONES

Svetlana Čičević[1,a], Momčilo Dobrodolac[1,b] Aleksandar Trifunović[1,c] and Dragan Lazarević [1,d]
[1]Faculty of Transport and Traffic Engineering, Belgrade, Serbia
[a]s.cicevic@sf.bg.ac.rs, [b]m.dobrodolac@sf.bg.ac.rs, [c]a.trifunovic@sf.bg.ac.rs, [d]d.lazarevic@sf.bg.ac.rs

Abstract This paper analyzes the differences in psychomotor abilities of users while working on tablet PC and smartphone. The first set of input data for analysis includes lap times that were obtained through an experiment in which subjects were tested using the tablet PC and smartphone for playing games Labyrinth 3D Maze, based on the Android platform. The second group of input data was obtained through the same answers of the respondents to the questionnaire on spatial abilities - "Santa Barbara". Analysis of obtained results indicates that the performance achieved are better when using a smartphone compared to the tablet PC, which means that it is more accurate and faster to control a device of smaller dimensions. In addition, the results of Spearman's correlation show the link between achievement on the maze test, conducted on a tablet PC with a touch screen, and results of the questionnaire Santa Barbara. Specifically, respondents who had lower scores on the test maze have a lower ability to navigate in space.

Keywords: Tablet PC; smartphone; psychomotor skills; spatial ability.

1. INTRODUCTION

Using of modern technologies through a variety of available devices and media has become an integral part of everyday life. The estimated budgeted and territorial availability of different offline and online IT services has caused them to become almost an indispensable part of business and private life for both individuals and society as a whole. The development of the representation of the service was followed with the technical development and IT devices. A wide range of different devices appeared on the market, both in terms of configuration and performance, and in terms of design. Due to its simplicity and ergonomic design, smartphones and tablet PC are devices that are commonly used. Their use is widespread in many areas, such as business, education, entertainment and other personal needs and activities. One of many indicators of their presence is the fact that smartphones and tablet PCs are the most common gift that 10-year-olds receive in the UK. This data is certainly encouraging for device manufacturers and progress for the entire IT industry, but may be of concern due to potential negative consequences that their use may cause.

In the context of private and commercial communications roles of smartphones and tablet PCs is very important because it allows connection of subjects while maintaining mobility. When we talk about education, many developed and developing countries are granted significant financial and other necessary resources, to implement to the greatest possible extent IT technologies in their systems of education and thus develop a new generation of students turned to the efficient use of these technologies and their development [1, 2]. Use of smartphones and tablet PCs for entertainment, especially relating to the use of free time of individuals or groups of people, access to a variety of online and offline content, such as video and audio material, games, browsing the Internet and etc. The results of forecasts indicate that by the year 2019, on the market there will be in use almost 924 million tablet PCs [3, 4].

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In accordance with these facts, in the future we can definitely expect increase of the needs for these types of mobile devices. For this reason, it is important to analyze the performance of work which is achieved on tablet PC and smartphone. The interaction of the user and the device is based on tactile mode of communication through touch screen and position sensor. This form of communication is the closest to a natural way of research and communication with the environment [5, 6]. Accordingly, it can be concluded that during active use of the devices primarily are expressed perceptual and psychomotor skills of users. In this case, the active use of the device involves constant interaction between users and devices through a specific application, which means that the use of such devices trough watching video content represents a passive activity, because it does not require constant interaction. In the literature, we can find many papers that analyze different aspects of the use of tablet PCs and smartphones. In their study, Giammarco et al. have investigated the use of tablet PCs in assessing the ability of finding figures and association with psychological (visual perceptual processes, cognitive processes, handwriting skills) and physiological (body mass index, isometric strength of arms) parameters in children of school age [7]. Yamada et al. analyze the assessment of risk of falling, trough the case of dual-tasking ability in the use of smartphones and walking, in the elderly population [8].

If we look technical characteristics of tablet PCs and smartphones, there are no big differences. Generally, tablet PCs are mobile devices with screen size usually from 5 to 14 in., which of the basic equipment have touch screen interface, the processor, operating memory and internal storage, optional slot for 3/4G connectivity and Wi-Fi receiver. The interface between the hardware and applications is operating system, usually Google Android, Windows or Apple iOS. Tablet PCs are designed primarily for the use of applications, which listed operating systems support. Smartphones also possess all of these characteristics, provided that their primary function is to communicate via telecommunications networks, but these activities are increasingly carried out by specialized applications. One of the major differences between tablet PCs and smartphones refers to the diagonal of the display, which is with phones slightly shorter, and therefore there is a difference in design and ergonomics, which may have an impact on performance during use by the user.

The aim of the paper is differentiating differences in psychomotor abilities of users while using tablet PC and smartphone. Accordingly, the test subjects were tested through playing android gaming applications Labyrinth 3D Maze. The aim of the game is that in the shortest possible time find a way out of the 3D maze. The recorded results are of all testing participants, for different alternatives navigating through a maze (touch screen joystick and gravity sensor). In addition, respondents were working, known in the literature, test for spatial analysis capabilities, "Santa Barbara". Spatial ability has a vital role in our daily interaction with the environment, such as navigation, identification and manipulation of objects, solving specific tasks and the like. Joint analysis of the data obtained has resulted in certain conclusions [9].

3D maze and similar games are mostly intended for entertainment, but have extreme potential for application in education, development of spatial perception, memory, decision-making abilities and acceptance of risk and etc. [2]. The challenge of finding the right path through the 3D maze was chosen for a reason because it requires active use of equipment, and the necessary use of all the above mentioned skills. According to Greek mythology, the labyrinth was the first structure designed by Daedal for King Minos of Crete with the aim to keep a mythical creature - the Minotaur. The design and structure of the maze were such that Daedal himself very difficult manage to find their way to the

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exit. Since the creation of this myth, the very notion of the labyrinth has a significant symbolic meaning in the collective consciousness. Basically this is a complex problem that is difficult to find the right solution and the output, because it consists of a number of corridors, barriers and “blind alleys”. Throughout the centuries, labyrinths have been exposed to a number of transformations, but their essence remained the same. Their structure can be constructed of concrete, metal, processed wood, plastic, plants... However, in the modern world is particularly popular type of maze which is the basic building block is a bit, which is used in this paper for the testing and analysis of psychomotor skills of users while working on tablet PC and smartphone.

2. METHODOLOGY

For the purpose of the analysis, the respondents answered to the questionnaire on spatial abilities - "Santa Barbara" Sense-of-Direction Scale [10], and they were part of an experiment in which they are tested through playing games Labyrinth 3D Maze. As the experiments based on the questionnaire Santa Barbara are widespread, the principles of drawing out the conclusions based on it in the literature are well-known and available. Accordingly, this paper will describe in detail the test based on application Labyrinth 3D Maze.

Labyrinth 3D Maze is gaming applications developed on android platform and as a free version is available on the Play Store (https://play.google.com/store/apps/details?id=labyrinth.d3D.maze).

Conceptual design is based on the principle of the maze, through which the guidance of the sphere, it is necessary to find the right path to getting out of the maze as fast as possible. Technically three ways are enabled, by which the user can guide a ball through a maze:

- Navigation based on the change in orientation of the device and activating gravity sensor;
- Navigation based on the left joystick on the touch screen;
- Navigation based on the right joystick on the touch screen.

The game consists of many levels, which vary in severity and design (structure, color). In the context of completion of the test, we used a level, which is characterized by medium-complex structure and green maze. Sphere which is to be moved through a maze consists of a number of different colors, which can be seen in Figure 1.

The test consisted of 6 iterations, where each of the participants in the experiment, was doing the test on smartphone and tablet PC, individually for each navigation mode (Figure 2). At the end of each iteration, the timer within the app showed lap time. Respondents were entering lap times in the online survey created on Google Drive platform, where the first part of the survey, related to the demographics of respondents and questions from "Santa Barbara" questionnaire.

In the experiment were used tablet PC Huawei MediaPad T1 7.0 and smartphone Sony Xperia M2 Aqua, whose comparative characteristics are shown in Table 1.

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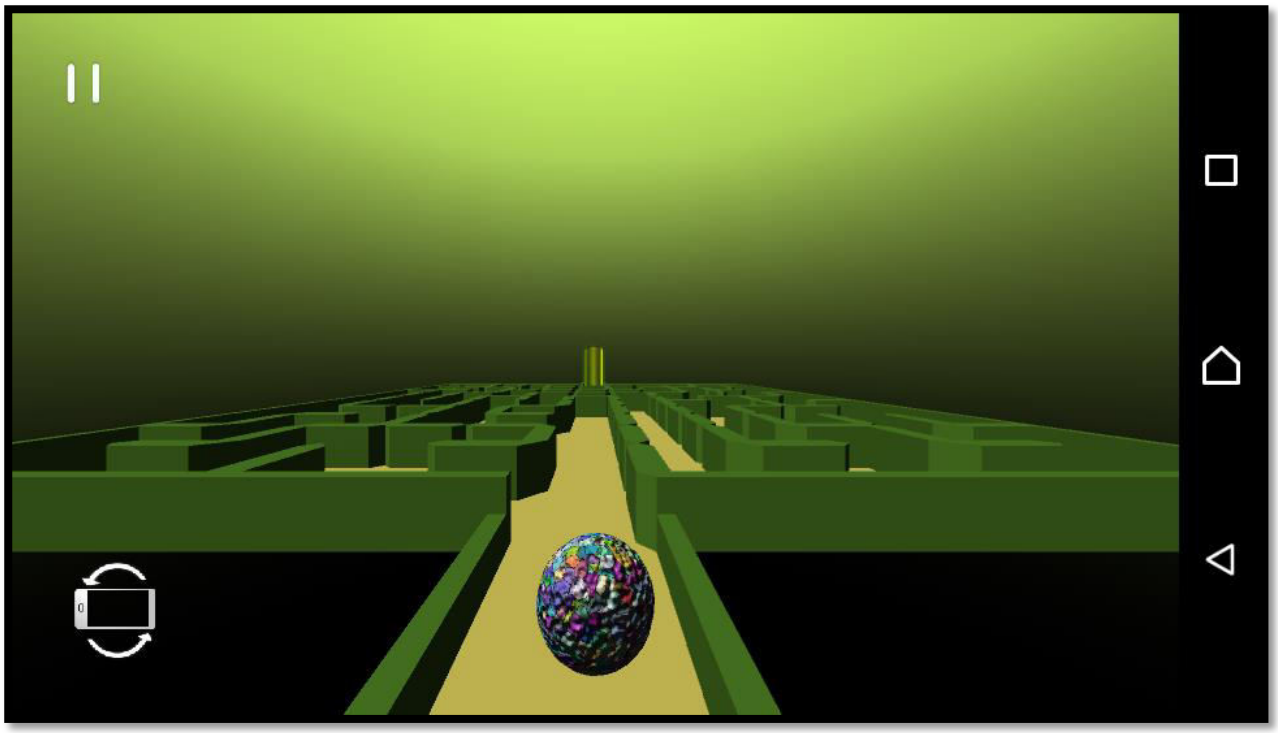

Figure 1. Representation of the level which is used for testing on smartphone and tablet PC.

a) **b)**

Figure 2. Testing on tablet PC (a) and smartphone (b).

Based on the technical characteristics, it can be concluded that the configurations of the devices are very similar, with marked differences in dimensional characteristics. This fact is significant because are dominant ergonomic differences, which can lead to more valid results in the analysis of psychomotor skills.

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Table 1. Technical characteristics of used devices.

Technical segment	Component	Huawei MediaPad T1 7.0	Sony Xperia M2 Aqua
Platform	Chipset	Spreadtrum SC7731G	Qualcomm MSM8926-2 Snapdragon 400
	OS	Android OS, v4.4.2 (KitKat)	Android OS, v4.4.2 (KitKat)
	CPU	Quad-core 1.2 GHz	Quad-core 1.2 GHz
Memory	RAM	1GB	1GB
	Internal memory	8GB	8GB
Display	Type	IPS LCD capacitive touchscreen, 16M colors	IPS LCD capacitive touchscreen, 16M colors
	Size	7.0 inches (~67.2% screen-to-body ratio)	4.8 inches (~63.0% screen-to-body ratio)
	Resolution	600 x 1024 pixels (~170 ppi pixel density)	540 x 960 pixels (~229 ppi pixel density)
	Multitouch	Yes	Yes
Body	Dimensions	140 x 72 x 8.6 mm (5.51 x 2.83 x 0.34 in)	140 x 72 x 8.6 mm (5.51 x 2.83 x 0.34 in)
	Weight	278g	149g

2.1. Method of collecting and processing data

The results of the test and the answers to the questionnaire Santa Barbara, respondents enter directly into the online survey. The survey is set to Google Drive platform to facilitate data collection and processing. Statistical analysis was performed by the statistical software package IBM SPSS Statistics in. 21. Based on the results of descriptive statistics and cross tabulation it was presented the basic statistical analysis of data obtained in the experiment. Normality distribution was tested by inspection of histograms and the Kolmogorov-Smirnov test. Since the distribution of all interval variables significantly deviate from the normal distribution, we used the nonparametric method. To assess the significance of differences it was used Friedman test of repeated measurements. To test the strength and direction of a linear relationship between the maze of tests and questionnaires Santa Barbara it was used Spearman's rank correlation (ρ). All tests were carried out on the basis of the recommendations of the textbook "SPSS Survival Manual" [11]. The threshold of statistical significance (α) is set at 5%.

3. RESULTS OF TESTING WITH DISCUSSION

In the experiment 21 respondents participated. Of the total number of respondents, 9 (42.9%) were females and 12 males (57.1%). All subjects were doing an experiment on a tablet PC and mobile phone, as well as three different modes of navigation using Gravity Sensor, the Left and Right Joystick on touch screen.

Respondents solved more quickly the maze test when the task was done on the smartphone (mean = 31.06 s), as opposed to the test on the tablet PC (mean = 34.10 s), when they needed more time. These results show that respondents more accurately and quickly manage the device of smaller dimensions, which means that is easier to cope with a smartphone, but the tablet PC.

From Figure 3 it can be concluded that the shorter execution, for all three methods of execution, when the subjects solved the task on smartphone (Gravity Sensor mean = 28.34 s, Left Joystick mean = 33.42 and the Right Joystick mean = 31.43 s) unlike when the task was done on tablet PC (Gravity

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Sensor mean = 29.5 s, Left Joystick mean = 37.61 s, and Right Joystick mean = 35.18 s). In the same figure it can be seen that the respondents had the fastest time when the test was solved by using Gravity Sensor, then use the Joystick Right, while the longest time was when the test was resolved by using the Left Joystick. This result supports the fact that respondents manipulate (manage) device easiest and most accurate by using Gravity Sensor.

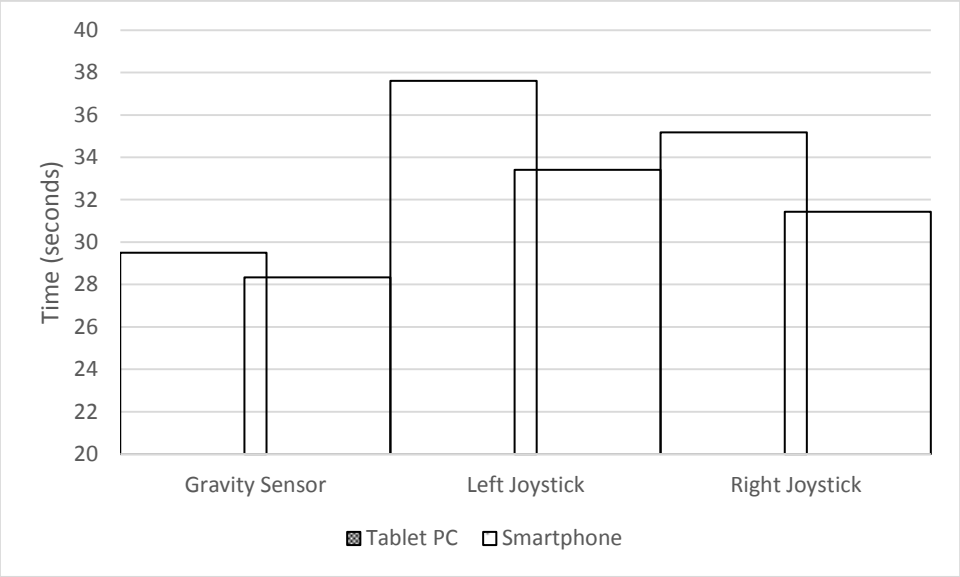

Figure 3. Time for execution of tasks on the test, for tablet PC and smartphone, for 3 manners of resolving (Gravity Sensor, Left and Right Joystick).

Friedman test results (Table 2) between the three manners of resolving show significant statistical differences for tablet PC ($\chi 2 = 8.02$, df = 2, p = 0.018) between Gravity Sensor (mean rank = 1.50), Left Joystick (mean rank = 2.21) and Right Joystick (mean rank = 2.29). Statistically significant differences exist with smartphone ($\chi 2 = 6.819$, df = 2, p = 0.033) between Gravity Sensor (mean rank = 1.69), Left Joystick (mean rank = 2:45) and Right Joystick (mean rank = 1.86).

Table 2. Results of Friedman test for three manners of resolving (Gravity Sensor, Left and Right Joystick), for tablet PC and smartphone.

Tablet PC				**Smartphone**			
N	21		**Mean Rank**	**N**	21		**Mean Rank**
Chi-Square	8.02	Gravity Sensor	1.50	**Chi-Square**	6.819	Gravity Sensor	1.69
df	2	Left Joystick	2.21	**df**	2	Left Joystick	2.45
Asymp. Sig.	0.018	Right Joystick	2.29	**Asymp. Sig.**	0.033	Right Joystick	1.86

In terms of gender differences, males have better results on the tablet PC, all three manners of solving the task (Gravity Sensor mean = 28.16 s, Left Joystick mean = 36.13 and the Right Joystick mean = 34.53 s) compared to females (Gravity Sensor mean = 31.30 s, Left Joystick mean = 39.58 and the Right Joystick mean = 36.05 s). For smartphone, males have better results for Gravity Sensor (mean = 25.39 s) and Left Joystick (mean = 26.09 s), as opposed to females (Gravity Sensor mean = 32.28 s,

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Left Joystick mean = 43.19 s). Females have a better achievement on smartphone when using the Joystick Right (Female mean = 26.59 s, Male mean = 35.06 s) (Figure 4).

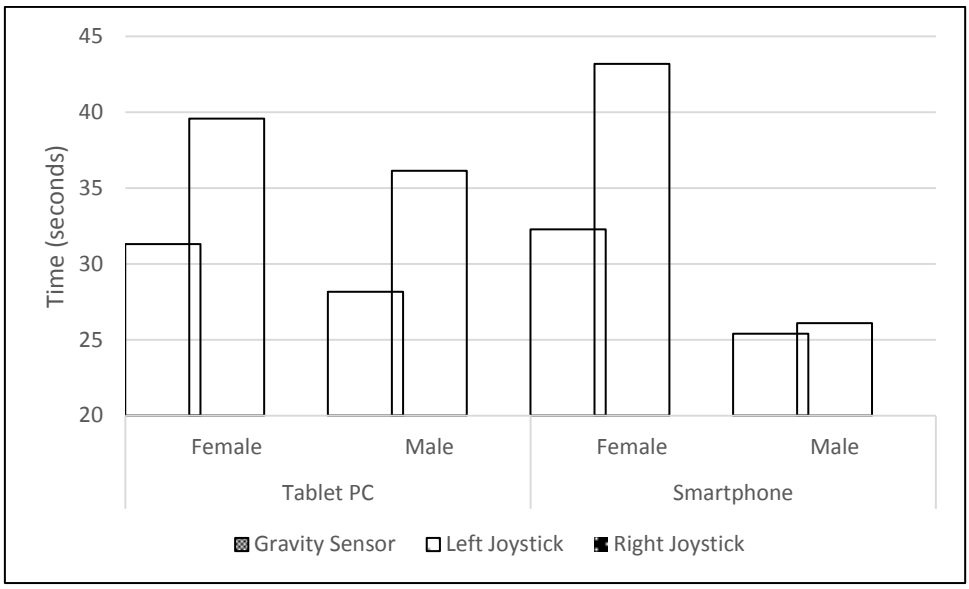

Figure 4. Gender differences in time of execution of tasks on the test for tablet PC and smartphone, for three manners of resolving (Gravity Sensor, Left and Right Joystick).

The results of Spearman's correlation demonstrate a link between achievements in the maze test, based on a tablet PC, and the results of the questionnaire Santa Barbara, when the test was done Left Joystick ($\rho = 0.563$, $N = 21$, $p = 0.008$) and Right Joystick ($\rho = 0.467$, $N = 21$, $p = 0.033$). These results show a positive correlation between respondents who had lower scores on a test of the maze; they consider themselves to have lower spatial orientation. The correlation did not reach statistical significance when the test subjects solved via smartphone. The lack of correlation between achievements in the maze test using a smartphone and questionnaires Santa Barbara, can be interpreted by the fact that a larger screen (tablet PC) better reflect the real situation, as opposed to the small screen (smartphone).

4. CONCLUSION

Based on the data collected and analyzed in our research, it can be derived general conclusions:

- Respondents more quickly solve the test on the smartphone (mean = 31.06 s) than the tablet PC (mean = 34.10 s);

- Respondents on both devices (tablet PC and smartphone) solve test fastest by using Gravity Sensor, then using the Right Joystick and for Left Joystick it is slowest;

- Better results in both devices have the male respondents, for all controls (except for the Right Joystick on smartphone);

- Statistically significant differences exist when the task is solved on smartphone between Gravity Sensor, Left Joystick and Right Joystick;

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- Statistically significant differences exist when the task is solved by the tablet PC between Gravity Sensor, Left Joystick and Right Joystick;

- There is a correlation between achievements in the maze test, done on a tablet PC, and the results of the questionnaire Santa Barbara, when the test was done with the help of Left Joystick and Right Joystick.

The results of the research presented in this paper show that respondents more accurately and quickly manage the device of smaller dimensions, i.e. it is easier to cope with a smartphone, than the tablet PC. Also, results show that respondents most easily and most accurately manipulate the (manage) device using Gravity Sensor, then use the Right Joystick and weakest using Left Joystick. The results of Spearman's correlation demonstrate a link between achievements in the maze test, based on a tablet PC, and the results of the questionnaire Santa Barbara, i.e. respondents who had lower scores on a test of the maze, consider themselves to have lower level of spatial orientation. The lack of correlation between achievements in the maze test using a smartphone and questionnaires Santa Barbara, can be interpreted by the fact that a larger screen (tablet PC) better reflects the real situation, as opposed to the small screen (smartphone). Future research could include the difference between the number of devices of different diagonal sizes, but also different tasks that would test subjects in order to find the connection between screen size and types of tasks.

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References

[1] World Bank, 1995, Priorities and strategies for education: A World Bank review. Washington, DC: World Bank.

[2] Dündar H., and Akçayır M., 2014, Implementing tablet PCs in schools: Students' attitudes and opinions, *Computers in Human Behavior*, 32, pp.40-46.

[3] Lee S., Lee S., and Chan-Olmsted S., 2017, An empirical analysis of tablet PC diffusion, *Telematics and Informatics*, 34(2), pp.518-527.

[4] Gartner, 2015, Gartner Market Statistics. http://www.gartner.com/technology/home.jsp

[5] Čičević S., Trifunović A., and Živanović M., 2014, Primena interneta za testiranje prepoznavanja geometrijskih oblika predškolske dece (in Serbian). *Proceedings of International Conference Sinteza 2014 - The Impact of the Internet on Business Activities in Serbia and Worldwide*, pp. 407-411, University International Scientific Conference, Belgrade, Serbia.

[6] Agostinho S., Tindall-Ford S., Ginns P., Howard S.J., Leahy W., and Paas F., 2015, Giving learning a helping hand: finger tracing of temperature graphs on an iPad, *Educational Psychology Review*, 27(3), pp.427-443.

[7] Giammarco E., Di Sano S., Aureli T., Cerratti P., Fanò-Illic G., and Pietrangelo T., 2016, Psychological and Physiological Processes in Figure-Tracing Abilities Measured Using a Tablet Computer: A Study with 7 and 9 Years Old Children, *Frontiers in Psychology*, 7, pp. 1-11.

[8] Yamada M., Aoyama T., Okamoto K., Nagai K., Tanaka B. and Takemura T., 2011, Using a Smartphone while walking: a measure of dual-tasking ability as a falls risk assessment tool, *Age and ageing*, 40(4), pp. 516-519.

[9] Tzuriel D., and Egozi G., 2010, Gender differences in spatial ability of young children: The effects of training and processing strategies, *Child development*, 81(5), pp.1417-1430.

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[10] Hegarty M., Richardson A. E., Montello D. R., Lovelace K., and Subbiah I., 2002, Development of a self-report measure of environmental spatial ability, *Intelligence*, 30, pp. 425-448.
[11] Pallantv J., 2013, SPSS survival manual. McGraw-Hill Education, UK.