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WEB PLATFORM FOR GATHERING AND ANALYZING DATA FROM THE NEUROGAME MOBILE APPLICATION

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ABSTRACT

Today's cell phones are now smartphones, providing a wide range of possibilities for their use, much more than just simple phones. The custom application for the Android operating system, based on an open-source platform for mobile devices is intended for the examination of cognitive functions: attention, concentration and fine motor skills in children of different age groups. The Neurogame application for mobile devices and web platform development is used for retrieving and analyzing mobile application data, providing relevant indicators for the executive functions of the respondents.

Material and methods: The research included 50 children with the developmental disorders ADHD and dyslexia (study group) and 50 healthy children (control group), randomly selected, evenly represented by gender and age. Using the application, we determine attention, concentration and motor skills (reaction speed) as part of the executive functions of the respondents.

The web platform has the purpose of gathering and processing the data from the mobile application, as well as their automatic visual representation.

Results: The ANOVA test showed that there are no gender differences in all the studied groups. A statistical correlation analysis showed that age does not affect the results in healthy school children. In children with dyslexia, age affects positively for total hits and negatively for total misses. In children with ADHD, there is a positive correlation with age for all variables except total hits (t H). Student's T-test showed that there were significant differences for the variables' total hits (t H) and total reaction time (t h) in milliseconds between healthy school children and children with dyslexia. Additionally, Student's t-test indicated that there were significant differences for the variables' total tries (t T) and total hits (t H) between healthy school children and children with ADHD. Finally, Student's t-test indicated that there were significant differences for the variable total tries (t T) between children with dyslexia and children with ADHD. Multiple Regression Results showed a significant difference between healthy school children, children with ADHD and children with dyslexia for all variables (total tries (t T), total hits (t H), total misses (t M) and total reaction time in milliseconds (t h)).

Conclusion: The Neurogame application provides a opportunity to assess the motor skills and concentration level, as well as the focus of the target population by measuring the total number of tries, the total number of hits, the total number of misses and the reaction time expressed in milliseconds which are defined as monitoring variables. The development of the web platform and the connection to the application enabled easier access and distribution of the analyzed results to the stakeholders (parents, teachers, therapists or health professionals) in order to further treat the ascertained condition.

Keywords: mobile device, android, Neurogame, web-platform, healthy children, ADHD, dyslexia

INTRODUCTION

Mobile phones and their applications play an enormous role in medical purposes. The best way to utilize the technical capacities that today's smart devices offer is in a combined concept of organization of their application usage with a methodological approach that includes the acquisition and interpretation of the derivative data that the device can provide. Of great importance are the hardware capabilities of today's smart devices. It is not only the powerful processor that they possess, but also how much memory they have, the quality and the integration of the sensor components (light sensor, motion sensor, GPS receiver, audio output interface, etc.). The development of the software solution implies knowledge not only of the methodology for the development of standard software solutions for mobile applications, but also the use of concepts for extracting data from the activity of the hardware capacities of the device through the use of methods based on digital forensics.

The potential offered by these components can provide a basic application in medical purposes (assessment, treatment and monitoring of activities and results) to a larger group of subjects and increase the efficiency in the statistical calculation of the obtained data.

In this context, authors Peacock E. Krousel-Wood M. (2017) [1] noted that promising strategies in improving adherence to antihypertensive medications and control of blood pressure include regimen simplification, cost reduction, use of involved health professionals to deliver interventions, and self- monitoring of blood pressure level with technology-related interventions, especially through the use of mobile phones. A newer intelligent system is designed to increase adherence to treatment of hypertensive patients, which aims to enable communication between patients, doctors and families to determine each patient's medication intake as well as self-monitoring of blood pressure levels.

The blood pressure monitoring system uses commercial electronic devices and can be replicated in any home equipped with a standard personal computer and Internet access. In addition, the system communicates with users through smartphones (anywhere and at any time) and smart TVs (in the patient's home) using the infrastructure of 3G/4G and WiFi (Figure 1). The interaction is automatic through social networks, connecting doctors and relatives if changes or errors are detected in receiving medications and mean blood pressure values [Vandermi João da Silva et al., 2019] [2].

Triantafyllidis AK. et al., (2017) [3] proposed a design for a platform for sensor-based health monitoring systems in order to provide additional usable monitoring services within comprehensive patient care. Portable or sensitive wearable devices can measure the physiological parameters of the patient. While the smart mobile device collects and analyzes the sensor data, the medical center receives the notifications of the detected health condition through the designed system, and the health care platform is used by certain nurses or doctors in order to have an overview of the patient's condition and configure monitoring schemes.

Combined with internet devices, mHealth (Figure 2) offers new ways to diagnose, monitor and control infectious diseases in order to improve the efficiency of the health system [Christopher S. Wood et al., 2019] [4].

The study by Leming Zhou et al., (2019)5 shows the application of a user approach, based on a self-use mobile application, through a personal health record system that encourages patients to be involved in their health care, offering them the opportunity to manage and to monitor their health data (Figure 3).

The study by Leming Zhou et al., (2019)5 shows the application of a user approach, based on a self-use mobile application, through a personal health record system that encourages patients to be involved in their health care, offering them the opportunity to manage and to monitor their health data (Figure 3).

Figure 1. *Blood pressure monitoring system (Resource: https://doi.org/10.3390/s19204539)*

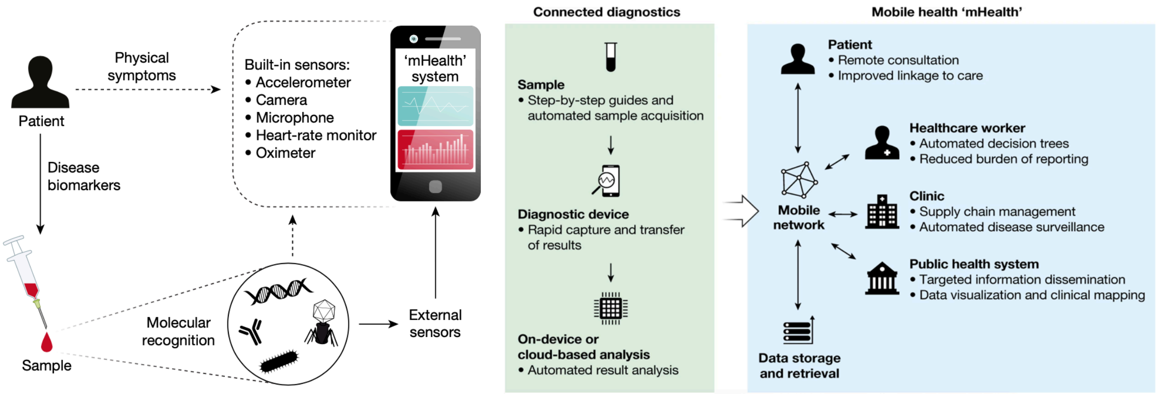


Figure 2. *mHealth application for diagnosis, monitoring and control of infectious diseases (Resource: https://doi.org/10.1038/s41586-019-0956-2)*

Figure 3. *Personal Health Card System*

(Resource: https://www.researchgate.net/publication/334272323_Applying_a_User-Centered_Approach_to_Building_a_Mobile_Personal_Health_Record_App_Development_and_Usability_Study)

COGNITIVE FUNCTIONS

The widespread use of modern mobile phones and web applications in medical practice is shown as per the above examples, where they are used mainly in psycho-educational strategies based on therapeutic orientations, developed and validated outside of digital health 6,7.

In the next section of this paper, we will refer to the functions - concentration, attention and motor skills as more important cognitive skills.

Cognitive functions represent skills based on brain activity that are necessary for acquiring knowledge, manipulating information received from the outside world, and reasoning.

Cognitive functions include multiple mental abilities, including perception, attention, memory, learning, thinking, reasoning, decision-making, and language abilities.

Figure 4. *Executive functions*

(Resource: https://empoweringlocallearners.weebly.com/executive-function.html)

Figure 4 represents the most important executive functions: working memory, cognitive flexibility, and the ability to control impulses.

MATERIAL AND METHODS

This research includes 50 children with developmental disorders the ADHD and dyslexia, and 50 healthy children (control group), randomly selected, evenly represented by gender and age from the territory of the city of Skopje. Children with developmental disorders are selected through the associations for children with special needs, and healthy children in primary schools from the territory of the city of Skopje.

The research was carried out during 2021/22 and consists additionally of the creation of a web platform. The web platform has the purpose of gathering and processing the data from the mobile application, as well as an automatic display of the results from the processed data. Through the platform, the health professional, parent or teacher can upload the data from the mobile application and the same will be automatically processed and displayed in the web platform in order to see the results of the game "Neurogame".

Using the application, the attention, concentration and motor skills (reaction speed) are determined as part of the executive functions of the respondents. The game provides an insight of the variables total Tries (tT), total Misses (t M), total Hits (t H) and total time (t h) in milliseconds, which are used in the statistical analysis. The variables are tested according to the gender and age of the children.

The provision of derivative data from the application takes place under strictly controlled conditions, on the basis of which their relevance will not be questioned.

After the technical verification of the possibilities provided by the program module, data acquisition is started in order to create a reference database. After providing the reference base (healthy school children without any health problem), the acquisition of data from respondents who have some kind of disorder (ADHD and dyslexia) was performed.

Data processing from the mobile application "Neurogame", their automatic display and the results can be viewed by the health professional, parent or teacher on the web platform.

RESULTS

The application for mobile devices on Android operating system, which we called "Neurogame", is based on an "open source" platform, to enable assessment and therapeutic stimulation, focus and concentration with the possibility of further monitoring on the progress of the results in a large group of users, healthy people and people with developmental disorders, while the web platform is used to collect and analyze data from the game itself.

In general, the web platform is used to assess cognitive functions such as attention, concentration and motor skills (reaction speed), analyze them and collect data from the Neurogame application, in healthy children and children with developmental disorders (ADHD and dyslexia).

In schools, we met children for whom the process of learning, reading and writing takes place significantly slower than other children, with much more effort and less success. Regarding students with average intellectual abilities, dyslexia may be the cause. Dyslexia (dys - weak, bad; lexis - language, word) is a language-based difficulty of constitutional origin, characterized by difficulties in decoding the word being read (reading - understanding). Key difficulties in children with dyslexia are in the processes of combining letters and syllables and automatic reading of whole words, which is often accompanied by insufficient reading comprehension and difficulties in oral expression. Dyslexia itself is not only a reading problem, but also a speech and psychomotor problem [8]`.

Attention deficit/hyperactivity disorder (ADHD) is a widespread and serious disorder in children. It refers to a neurodevelopmental disorder characterized by reduced attention/inattention, impulsivity and/or hyperactivity. Additionally, ADHD is a disorder of self-control. The key difficulties in children with ADHD are in the processes of attention regulation, supplemented by impulsive behavior, designated psychomotor activity – hyperactivity and inhibition. In some children, short-term attention may be dominant, in others hyperactivity and impulsivity, and in some with equal frequency and intensity, difficulties with attention and hyperactivity may occur. This syndrome occurs in subtypes, depending on whether the main symptoms are related to hyperactivity and impulsivity or inattention/impaired attention [9].

3.1. A functional web platform for gathering and analyzing data from the Neurogame application

The centralized application data gathering and analysis module consists of the following functionalities: collection, loading, analysis and display of game results.

Data processing through the web platform is done, initially by generating a file (.json file) which is exported from the mobile device on which the application is installed. That file is then uploaded to the web platform (Figure 5).

After logging into the platform, it is necessary to click on the button "Download results (json)" in order to pull the background data from the previously attached file (Figure 6).

The next step is to add the data to the platform database on the “plus” button (Figure 7).

After the data is inserted, the platform displays an additional field in which the data is displayed in its raw format, and which should be loaded by the platform in order for the results to be readable and understandable in human format (Figure 8).

Results display after loading the data from the file (Figure 9).

As a last step, a calculation of results is made, meaning that for the respondent who previously played the game, the mean values of all parameters are obtained as well as the calculations for all parameters of each level (0-4 levels i.e very easy to hard), i.e., total Tries (tT), total Miss (t M), total Hits (t H) and reaction time or total time (t h) in milliseconds (Figure 10).

Results of healthy school children (N=50)

In the research, the mean value of the variables Total Tries (LnT), Total Hits (Ln H) and total reaction time in milliseconds Total time (Ln h) obtained from healthy school children (N=50) were taken as reference values, and gender representation which are also shown in Table 1 below.

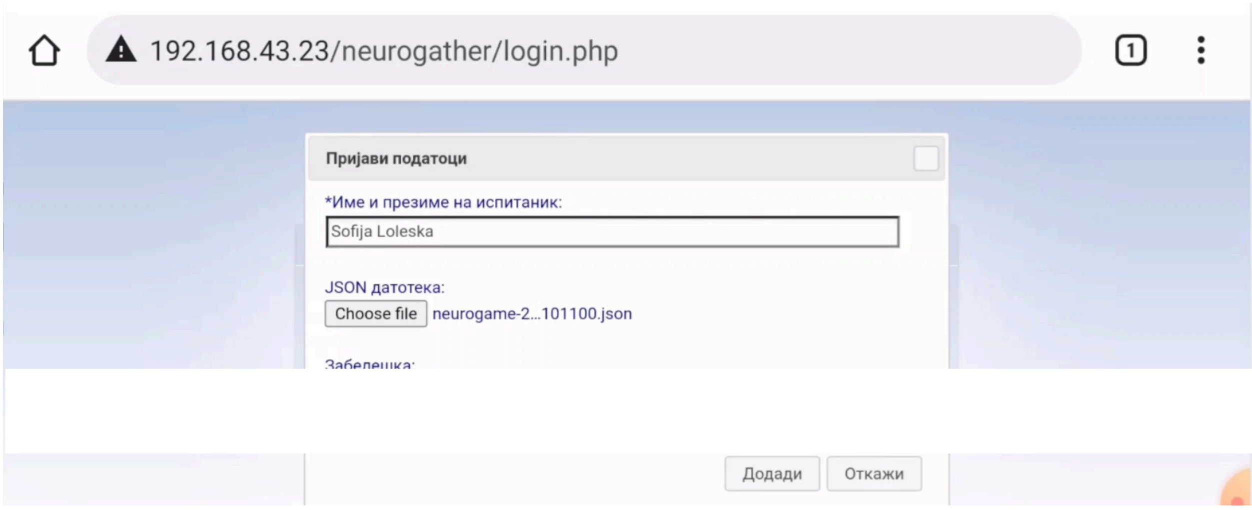


Figure 5. *Uploading a file to the web platform*

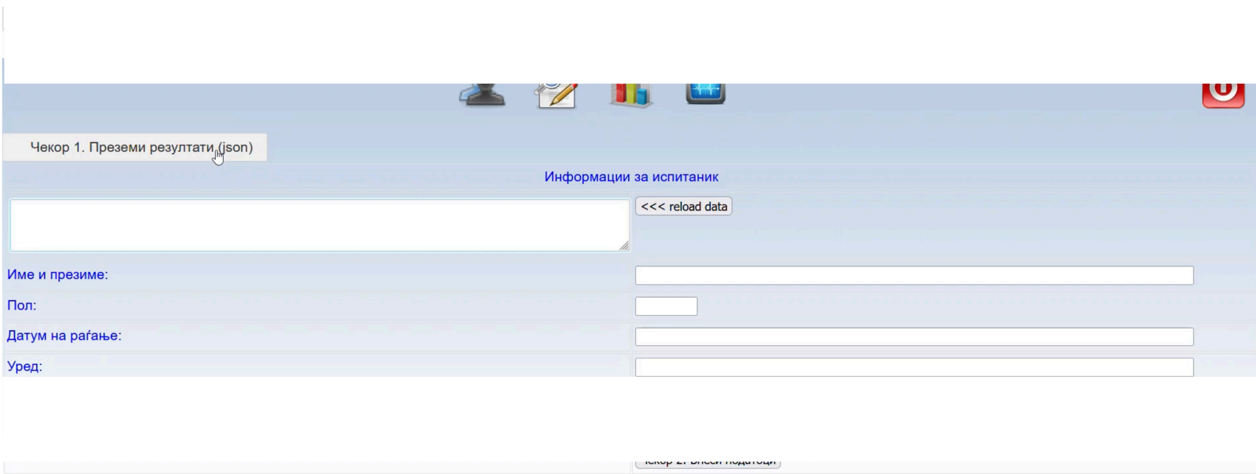


Figure 6. *Retrieving results from a json file*

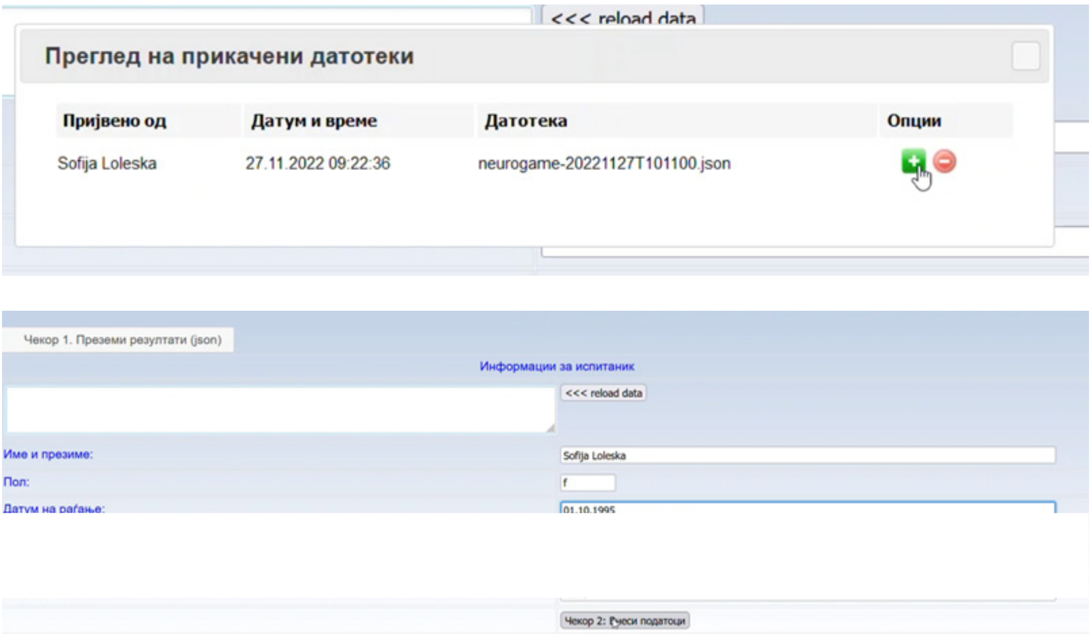


Figure 7. *Data entry*

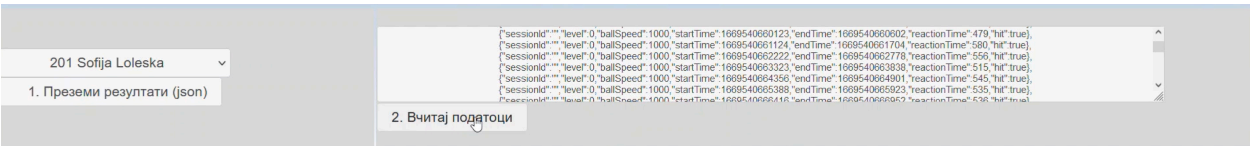
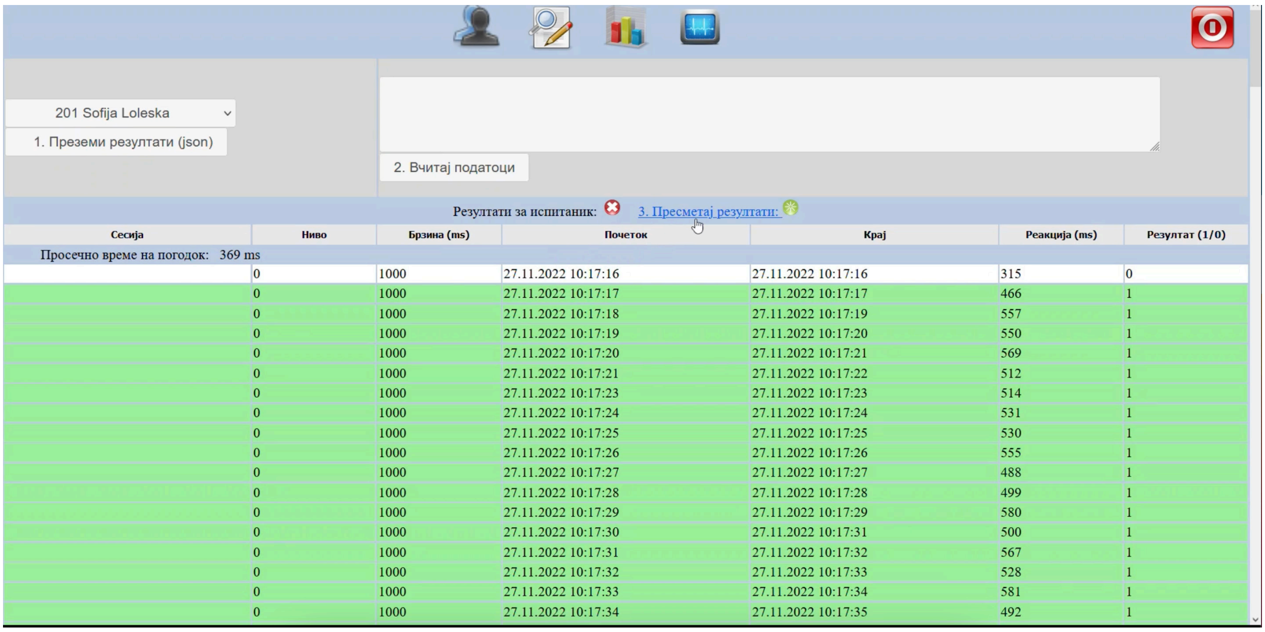


Figure 8. *Loading of data*



Сесија	Ниво	Брзина (ms)	Почеток	Крај	Реакција (ms)	Резултат (1/0)
Просечно време на погодок: 369 ms						
	0	1000	27.11.2022 10:17:16	27.11.2022 10:17:16	315	0
	0	1000	27.11.2022 10:17:17	27.11.2022 10:17:17	466	1
	0	1000	27.11.2022 10:17:18	27.11.2022 10:17:19	557	1
	0	1000	27.11.2022 10:17:19	27.11.2022 10:17:20	550	1
	0	1000	27.11.2022 10:17:20	27.11.2022 10:17:21	569	1
	0	1000	27.11.2022 10:17:21	27.11.2022 10:17:22	512	1
	0	1000	27.11.2022 10:17:23	27.11.2022 10:17:23	514	1
	0	1000	27.11.2022 10:17:24	27.11.2022 10:17:24	531	1
	0	1000	27.11.2022 10:17:25	27.11.2022 10:17:25	530	1
	0	1000	27.11.2022 10:17:26	27.11.2022 10:17:26	555	1
	0	1000	27.11.2022 10:17:27	27.11.2022 10:17:27	488	1
	0	1000	27.11.2022 10:17:28	27.11.2022 10:17:28	499	1
	0	1000	27.11.2022 10:17:29	27.11.2022 10:17:29	580	1
	0	1000	27.11.2022 10:17:30	27.11.2022 10:17:31	500	1
	0	1000	27.11.2022 10:17:31	27.11.2022 10:17:32	567	1
	0	1000	27.11.2022 10:17:32	27.11.2022 10:17:33	528	1
	0	1000	27.11.2022 10:17:33	27.11.2022 10:17:34	581	1
	0	1000	27.11.2022 10:17:34	27.11.2022 10:17:35	492	1

Figure 9. *Display of results*

Figure 10. *Results calculation and mean values*

Table 1. *Representation of respondents by age and gender*

School age	Number	percentage
7.11 y.	5	10%
8.11 y.	5	10%
9.11 y.	5	10%
10.11 y.	6	12%
11.11 y.	5	10%
12.11 y.	6	12%
13.11 y.	6	12%
14.11 y.	6	12%
15.11 y.	6	12%
total	**50**	**100%**
gender	**number**	**percentage**
males	25	50%
females	25	50%
total	**50**	**100%**

According to Table 2, it can be concluded that the average value of normal total attempts (t T) is 185 (185.1) for healthy children from age 7 to 15 years, total hits (t H) is 50 (49.6), total misses (t M) is 135 (135.4), while the average value of normal total reaction time (t h) is 332 (331.8) milliseconds for the same age group.

In the statistical analysis using Correlation Matrices it was confirmed that there are no significant differences, i.e. there is no correlation with gender and age between healthy school children for all variables (total Tries (t T), total Hits (t H), total Miss (t M) and total reaction time (t h) in milliseconds).

Also, the ANOVA test showed that there were no significant gender and age differences between healthy school children for all variables.

3.3. Results from children with ADHD (N=25)

Table 3 shows the percentage representation of children with ADHD (N=25), and their gender representation.

According to table 4, it can be concluded that the average value of total tries (t T) is 148 (147.85) for children with ADHD from age 7 to 15 years, total hits (t H) is 23 (22.97), total misses (t M) is 125 (124.86), while the average value of the total time (t h) is 366 (365.93) milliseconds for the same age group.

In the statistical analysis using Correlation Matrices for all (variables total tries (t T), total hits (t H), total misses (t M) and total reaction time (t h) in milliseconds with age), a comparison between children with ADHD and children with dyslexia and healthy school children, showed that there were significant positive correlations with age for all variables except total hits (t H) (Fig.11).

While, the comparison between children with ADHD by gender in the data analysis using ANOVA test for all variables showed that there are no significant differences.

3.4. Results from children with dyslexia (N=25)

Table 5 shows the percentage representation of children with dyslexia (N=25), and their gender representation.

Table 5. *Representation of respondents by age and gender*

School age	number	percentage
7.11 y.	2	8%
8.11 y.	3	12%
9.11 y.	2	8%
10.11 y.	4	16%
11.11 y.	3	12%
12.11 y.	2	8%
13.11 y.	3	12%
14.11 y.	3	12%
15.11 y.	3	12%
total	25	100%
Gender	**Number**	**percentage**
males	12	48%
females	13	52%
total	25	100%

Table 2. *Mean value of total tries, hits, misses and time (milliseconds) by Age (years)*

Age	Total Tries (t T	Total Hits (t H)	Total Miss (t M)	Total reaction time in milliseconds (t h)
7 years old	193.8	60.8	133	325.6
8 years old	195	60.2	134.8	253.8
9 years old	160	34.2	125.8	343
10 years old	190.6	34.1	156.5	372
11 years old	174	37	137	302.6
12 years old	178.6	48.1	130.5	362.8
14 years old	209.6	55.8	153.8	347

Table 3. *Representation of respondents by age and gender*

School age	number	percentage
7.11 y	3	12%
8.11 y.	2	8%
9.11 y.	4	16%
10.11 y.	3	12%
11.11 y.	4	16%
12.11 y.	3	12%
13.11 y.	2	8%
14.11 y.	2	8%
15.11 y.	2	8%
total	25	100%

gender	number	percentage
males	15	60%
females	10	40%
total	25	100%

Table 4. *Mean value of total tries, hits and time (milliseconds) in relation to age*

Age	Total Tries (t T)	Total Hits (t H)	Total Miss (t M)	Total reaction time in milliseconds (t h)
7 years old	101.6	21.3	80.3	225.3
8 years old	150.5	30	120.5	391.5
9 years old	148.2	27.5	120.7	369
10 years old	145.6	14.3	131.3	392.6
11 years old	141	26.7	114.2	290
12 years old	172.3	23	149.3	386
13 years old	142.5	23.5	119	389
14 years old	147	6	141	475.5
15 years old	182	34.5	147.5	374.5
Mean value	**147.85**	**22.97**	**124.86**	**365.93**

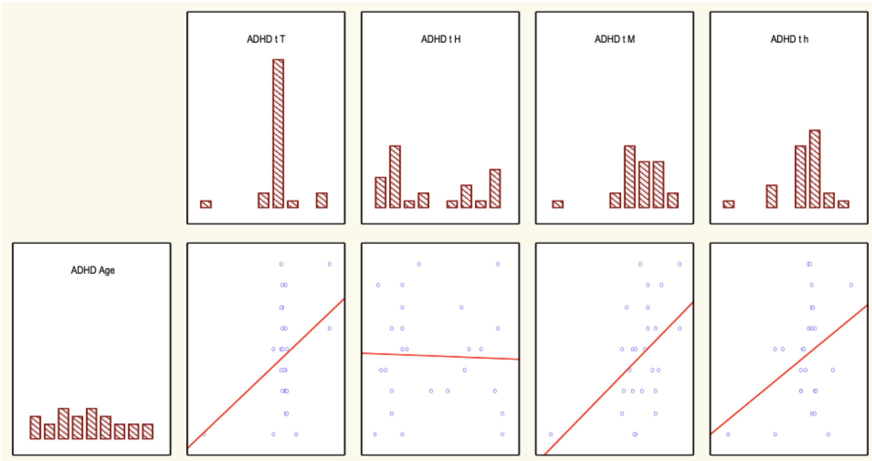


Figure 11. *Correlation of all variables in children with ADHD and age*

According to table 6, it can be concluded that the average value of total tries (t T) is 171 (170.51) for children with dyslexia from age of 7 to 15 years, total hits (t H) is 35 (34.54), total misses (t M) is 140 (139.95), while the average value of the normal total time (t h) is 372 (372.18) milliseconds for the same age group.

In the statistical analysis using Correlation Matrices, it was detected that there are no significant differences between children with dyslexia for the variables total Tries (t T) and total reaction time (t h) in milliseconds.

The comparison, however, for children with dyslexia between the variables total Hits (t H) and age, showed that there is a significant positive correlation at the $p < .050$ level.

Additionally, from the comparison between children with dyslexia for the variable total Miss (t M) with age, it is shown that there is a negative correlation at the $p < .050$ level.

A comparison between children with dyslexia by gender as per the data analysis using ANOVA test between all variables showed that there are no significant differences.

T-test Comparison between healthy children and children with developmental disorders

A comparison between healthy school children and children with dyslexia is shown in the data analysis via a Student t-test (differences in mean values) between all variables, which showed that there were significant differences for the variables total hits (t H) and total time of reaction (t h) in milliseconds.

A comparison between healthy school children and children with ADHD is shown in the data analysis through a Student T-test (differences in mean values) between all the variables which showed that there are significant differences for the variables total tries (t T) and total hits (t H).

Table 6. *Mean value of total tries, hits and time (milliseconds) in relation to age*

Age	Total Tries (t T)	Total Hits (t H)	Total Miss (t M)	Total reaction time in milliseconds (t h)
7 years old	158.5	29	129.5	358.5
8 years old	206.3	23	183.3	372.3
9 years old	167.5	10.5	157	485.5
10 years old	170.5	29.7	140.7	441
11 years old	176.6	46.3	130.3	333
12 years old	169	32.5	136.5	318.5
13 years old	147.3	15.3	132	298
14 years old	156.6	62.3	94.3	378.6
15 years old	182.3	62.3	120	364.3
Mean value	**170.51**	**34.54**	**135.95**	**372.18**

Table 7. *Children with dyslexia for the variable total hits (t H) with age*

	Correlations (ZdravivsDyslexia_25.4.2023.sta) Marked correlations are significant at p < .05000 N=25 (Casewise deletion of missing data)			
Variable	Means	Std.Dev.	Dyslexia t H	Dyslexia Age
Dyslexia t H	35.64000	26.60652	1.000000	0.439662
Dyslexia Age	11.16000	2.57682	0.439662	1.000000

Table 8. *Children with dyslexia for the variable total miss (t M) with age*

	Correlations (ZdravivsDyslexia_25.4.2023.sta) Marked correlations are significant at p < .05000 N=25 (Casewise deletion of missing data)			
Variable	Means	Std.Dev.	Dyslexia t M	Dyslexia Age
Dyslexia t M	135.5600	42.84768	1.000000	-0.401999
Dyslexia Age	11.1600	2.57682	-0.401999	1.000000

Table 9. *Student T-test between healthy school children and children with dyslexia for all variables*

	T-test for Independent Samples (ZdravivsDyslexia_25.4.2023.sta) Note: Variables were treated as independent samples									
Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances
Healthy t T vs. Dyslexia t T	185.5400	171.2000	1.5193	73	0.132996	50	25	36.51905	42.34481	1.34450	0.374891
Healthy t T vs. Dyslexia t H	185.5400	35.6400	18.2216	73	0.000000	50	25	36.51905	26.60652	1.88392	0.094741
Healthy t T vs. Dyslexia t M	185.5400	135.5600	5.2705	73	0.000001	50	25	36.51905	42.84768	1.37662	0.339126
Healthy t T vs. Dyslexia t h	185.5400	373.1200	-13.6586	73	0.000000	50	25	36.51905	82.69538	5.12771	0.000001
Healthy t H vs. Dyslexia t T	49.8400	171.2000	-15.7253	73	0.000000	50	25	24.50769	42.34481	2.98535	0.001169
Healthy t H vs. Dyslexia t H	49.8400	35.6400	2.2989	73	0.024375	50	25	24.50769	26.60652	1.17861	0.611754
Healthy t H vs. Dyslexia t M	49.8400	135.5600	-11.0292	73	0.000000	50	25	24.50769	42.84768	3.05668	0.000912
Healthy t H vs. Dyslexia t h	49.8400	373.1200	-25.6308	73	0.000000	50	25	24.50769	82.69538	11.38565	0.000000
Healthy t M vs. Dyslexia t T	135.7000	171.2000	-3.9605	73	0.000172	50	25	33.41651	42.34481	1.60575	0.159795
Healthy t M vs. Dyslexia t H	135.7000	35.6400	13.0337	73	0.000000	50	25	33.41651	26.60652	1.57742	0.227429
Healthy t M vs. Dyslexia t M	135.7000	135.5600	0.0155	73	0.987646	50	25	33.41651	42.84768	1.64412	0.140172
Healthy t M vs. Dyslexia t h	135.7000	373.1200	-17.7027	73	0.000000	50	25	33.41651	82.69538	6.12407	0.000000
Healthy t h vs. Dyslexia t T	333.8600	171.2000	10.0490	73	0.000000	50	25	75.01592	42.34481	3.13839	0.003409
Healthy t h vs. Dyslexia t H	333.8600	35.6400	19.2259	73	0.000000	50	25	75.01592	26.60652	7.94934	0.000001
Healthy t h vs. Dyslexia t M	333.8600	135.5600	12.2311	73	0.000000	50	25	75.01592	42.84768	3.06515	0.004071
Healthy t h vs. Dyslexia t h	333.8600	373.1200	-2.0648	73	0.042496	50	25	75.01592	82.69538	1.21522	0.551585

The comparison between children with dyslexia and children with ADHD is shown in the data analysis between all variables which showed that there are significant differences for the variable total Tries (t T).

Since the application and the data collection and analysis platform are original and custom made, the results cannot be compared with other similar studies.

Table 10. *Student T-test between healthy school children and children with ADHD for all variables*

T-test for Independent Samples (ZdravivsDyslexia_25.4.2023.sta)
Note: Variables were treated as independent samples

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances
Healthy t T vs. ADHD t T	185.5400	146.4000	4.3670	73	0.000041	50	25	36.51905	36.7333	1.01177	0.941507
Healthy t T vs. ADHD t H	185.5400	23.2400	20.8132	73	0.000000	50	25	36.51905	18.9677	3.70689	0.000921
Healthy t T vs. ADHD t M	185.5400	123.1600	7.3104	73	0.000000	50	25	36.51905	31.1190	1.37717	0.398869
Healthy t T vs. ADHD t h	185.5400	356.3600	-10.4081	73	0.000000	50	25	36.51905	104.5570	8.19722	0.000000
Healthy t H vs. ADHD t T	49.8400	146.4000	-13.5468	73	0.000000	50	25	24.50769	36.7333	2.24654	0.016414
Healthy t H vs. ADHD t H	49.8400	23.2400	4.7556	73	0.000010	50	25	24.50769	18.9677	1.66946	0.174910
Healthy t H vs. ADHD t M	49.8400	123.1600	-11.1434	73	0.000000	50	25	24.50769	31.1190	1.61230	0.156274
Healthy t H vs. ADHD t h	49.8400	356.3600	-19.7925	73	0.000000	50	25	24.50769	104.5570	18.20124	0.000000
Healthy t M vs. ADHD t T	135.6800	146.4000	-1.2665	73	0.209371	50	25	33.43800	36.7333	1.20681	0.565006
Healthy t M vs. ADHD t H	135.6800	23.2400	15.5736	73	0.000000	50	25	33.43800	18.9677	3.10779	0.003670
Healthy t M vs. ADHD t M	135.6800	123.1600	1.5634	73	0.122289	50	25	33.43800	31.1190	1.15460	0.717946
Healthy t M vs. ADHD t h	135.6800	356.3600	-13.6682	73	0.000000	50	25	33.43800	104.5570	9.77744	0.000000
Healthy t h vs. ADHD t T	333.8600	146.4000	11.7796	73	0.000000	50	25	75.01592	36.7333	4.17050	0.000345
Healthy t h vs. ADHD t H	333.8600	23.2400	20.3174	73	0.000000	50	25	75.01592	18.9677	15.64148	0.000000
Healthy t h vs. ADHD t M	333.8600	123.1600	13.4409	73	0.000000	50	25	75.01592	31.1190	5.81108	0.000018
Healthy t h vs. ADHD t h	333.8600	356.3600	-1.0699	73	0.288202	50	25	75.01592	104.5570	1.94267	0.049077

Table 11. Student T-test between children with dyslexia and children with ADHD for all variables

T-test for Independent Samples (ZdravivsDyslexia_25.4.2023.sta)
Note: Variables were treated as independent samples

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances
Dyslexia t T vs. ADHD t T	171.2000	146.4000	2.2120	48	0.031758	25	25	42.34481	36.7333	1.32887	0.491393
Dyslexia t T vs. ADHD t H	171.2000	23.2400	15.9443	48	0.000000	25	25	42.34481	18.9677	4.98393	0.000206
Dyslexia t T vs. ADHD t M	171.2000	123.1600	4.5709	48	0.000034	25	25	42.34481	31.1190	1.85161	0.138353
Dyslexia t T vs. ADHD t h	171.2000	356.3600	-8.2070	48	0.000000	25	25	42.34481	104.5570	6.09685	0.000036
Dyslexia t H vs. ADHD t T	35.6400	146.4000	-12.2099	48	0.000000	25	25	26.60652	36.7333	1.90609	0.121003
Dyslexia t H vs. ADHD t H	35.6400	23.2400	1.8975	48	0.063792	25	25	26.60652	18.9677	1.96765	0.104029
Dyslexia t H vs. ADHD t M	35.6400	123.1600	-10.6881	48	0.000000	25	25	26.60652	31.1190	1.36796	0.448450
Dyslexia t H vs. ADHD t h	35.6400	356.3600	-14.8634	48	0.000000	25	25	26.60652	104.5570	15.44294	0.000000
Dyslexia t M vs. ADHD t T	135.5600	146.4000	-0.9603	48	0.341695	25	25	42.84768	36.7333	1.36062	0.456258
Dyslexia t M vs. ADHD t H	135.5600	23.2400	11.9851	48	0.000000	25	25	42.84768	18.9677	5.10300	0.000169
Dyslexia t M vs. ADHD t M	135.5600	123.1600	1.1708	48	0.247464	25	25	42.84768	31.1190	1.89585	0.124087
Dyslexia t M vs. ADHD t h	135.5600	356.3600	-9.7703	48	0.000000	25	25	42.84768	104.5570	5.95458	0.000044
Dyslexia t h vs. ADHD t T	373.1200	146.4000	12.5278	48	0.000000	25	25	82.69538	36.7333	5.06808	0.000179
Dyslexia t h vs. ADHD t H	373.1200	23.2400	20.6193	48	0.000000	25	25	82.69538	18.9677	19.00788	0.000000
Dyslexia t h vs. ADHD t M	373.1200	123.1600	14.1449	48	0.000000	25	25	82.69538	31.1190	7.06175	0.000009
Dyslexia t h vs. ADHD t h	373.1200	356.3600	0.6286	48	0.532574	25	25	82.69538	104.5570	1.59861	0.257574

CONCLUSION

The use of the Neurogame application enables the assessment of motor skills and the level of concentration, as well as the focus of attention in the young population. The application is a valid tool, while the centralized module for gathering and analyzing data from the application is functional and applicable in daily work. At the same time, a normative data model and data processing through a functional web platform has been established.

Healthy children have a statistically significant difference which is confirmed where they are better in results compared to children with developmental disorders (ADHD and dyslexia).

The statistical calculation for the variable total tries (t T) was made for all age groups between healthy school children, children with ADHD and children with dyslexia, showing that children with ADHD have the worst results compared to other children.

Statistical correlation analysis showed that age does not affect the results in healthy school children. While, in children with dyslexia, age affects positively for total hits and negatively for total misses, and in children with ADHD, there is a positive correlation with age for all variables except total hits (t H).

More frequent use of mobile applications in order to improve the cognitive state can be achieved if application games of this type are practiced regularly. The use of the application causes an improvement in attention, concentration and motor skills in children with ADHD and dyslexia.

In general, the game has a big cost benefit, because after it is created it does not require additional maintenance, it is performed in a short period of time and it provides relevant data.

Finally, the application proved to be interesting and acceptable by all respondents, regardless of age and health status.

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Резиме

ВЕБ-ПЛАТФОРМА ЗА СОБИРАЊЕ И АНАЛИЗА НА ПОДАТОЦИ ОД МОБИЛНАТА АПЛИКАЦИЈА „НЕУРОИГРА“

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Современите мобилни телефони, кои нашироко се користат во форма на паметни уреди (smart devices), обезбедуваат опсежен спектар на можности за нивна употреба, при што денес тие се многу повеќе отколку само телефони.

Апликација за Android оперативен систем базирана на платформа од отворен код (open source) за мобилни уреди наменета за испитување на когнитивните функции: внимание, концентрација и фина моторика кај испитаници од различни возрасни групи. Со примена на апликацијата Неуроигра, како и креирање веб-платформа за преземање и анализа на податоците од мобилната апликација, се добиваат релевантни показатели за егзекутивните функции кај испитаниците.

Материјал и метод: Во проспективното истражување се вклучени 50 деца со развојни нарушувања АДХД и дислексија (испитувана група) и 50 здрави деца (контролна група), избрани по случаен избор, рамномерно застапени по пол и ро возраст. Со примена на апликацијата одредуваме внимание, концентрација и моторика (односно, брзина на реакција) како дел од егзекутивните функции на испитаниците.

Веб-платформата има цел преземање и обработка на податоците од мобилната апликација, како и нивен автоматски приказ.

Резултати: АНОВА-тестот покажа дека не постојат разлики во однос на полот кај сите испитувани групи. Анализата на статистичка корелација покажа дека возраста не влијае на резултатите кај здравите деца. Кај децата со дислексија, возраста позитивно корелира со тоталните погодоци, додека негативно влијае на промашувањата. Кај децата со АДХД постои позитивна корелација со возраста за сите варијабли, освен за тоталните погодоци. Дополнително, stудент Т-тестот покажа сигнификантни разлики за варијаблите за вкупни погодоци меѓу децата со дислексија и оние со АДХД. Конечно, мултипната регресија покажа сигнификантна разлика меѓу здравите школски деца, оние со АДХД и диспелсија во однос на сите варијабли (вкупно погодоци, погрешки, реакционо време во милисекунди).

Заклучок: Апликацијата Неуроигра дава можност за процена на моториката и на нивото на концентрација, како и фокусот на целната популација, а како варијабли за следење се дефинирани според вкупниот број обиди, вкупниот број погодоци, вкупниот број промашувања и времето на реакција изразено во милисекунди. Преку развојот на веб-платформата, која е поврзана со апликацијата, се овозможува анализа и дистрибуција на анализираните резултати до засегнатите страни (родителите, наставниците, терапевтите или здравствените работници) со цел понатамошен третман на констатираната состојба.

Клучни зборови: мобилен уред, android, Неуроигра, веб-платформа, здрави деца, АДХД, дислексија