Custom made android game applied for assessment the attention and concentration in epileptic patient

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Abstract. The potential of the use of modern mobile devices for medical purposes is huge. Different Android applications are used in internal medicine, pediatric neonatal care, and especially in mental health for the assessment of depression, anxiety, and risk behavior in youth etc. In this context, we made an android application, named "neurogame" for assessment/training the attention, concentration trough reaction time in different people. The first step of this research was to obtain data for normal clients which will serve as a data basis for the further evaluation. The aim of this article is to present obtained results of "neurogame" application in a group of epileptic patients in the assessment of attention, concentration and reaction time. We showed that all tested parameters depends on age and gender (ANOVA was significant).Additionally, all tested parameters are significantly different for epileptic group vs. healthy people. Student t-test for epileptic vs. healthy people shows significant differences for total tries and total misses, while total hits and average time reaction do not differs significantly. In comparison with other psychometric assessments, this approach using mobile phones seem us more practical, available in different places (nor only in medical settings), little time consuming and interesting for all ages.

Key words: mobile phones, epilepsy, attention, concentration.

1. Introduction

The potential for use of modern mobile devices for medical purposes is huge. In our recent publication [Pop-Jordanova et al., 2018] we evaluated the possibilities of mobile phone uses in different fields of medicine analyzing data published in Medline. Mobile phones are used in internal medicine (cardiology, pulmology, nephrology, rheumatology, for gastrointestinal problems etc.), pediatric neonatal care, and especially in mental health for the assessment of depression, anxiety, and risk behavior in youth etc.

In this context, we made an android application, we named "neurogame" for assessment/training the attention, concentration trough reaction time in different people.

The first step of this research was to obtain data for normal clients which will serve as a data basis for the further evaluation. In our article [Loleski et al, 2018] we discussed the obtained results for healthy examinees (N=201) divided in several groups - schoolers, athletes, scientists and others. In this article we showed that reaction time is strongly dependent on age, but no significant differences for both gender and type of profession are obtained. Surprisingly, we obtained that any sport activities do not influence on the reaction time. In other words, sportive activities do not ameliorate the reaction time. Generally, in this study we confirmed the availability and practical values of Android applications in testing attention and concentration measured by reaction time in healthy people.

After this first phase, we applied the android system in different neuropsychiatric disorder for testing attention, concentration through reaction time and other parameters included in the system. As it known, these psychological abilities are directly dependent on the functioning of the executive system in the brain, located in prefrontal cortex [Shulman et al, 2000].

Epilepsy is a chronic disorder, the hallmark of which is recurrent, unprovoked seizures, having different causes. Neurocognitive impairment is frequent in epilepsy patients. Causes are multiple, and may be influenced by several factors including the antiepileptic drug (AED). Cognition can be defined as the capacity of the brain to process information accurately and to program adaptive behaviour. Cognition involves the ability to solve problems, to memorize information, or to focus attention. Most cognitive complaints in adult patients are mental slowness, memory difficulties and attention deficits. In children, cognitive problems are more diffuse, responsible for language troubles, learning difficulties, poor academic outcome, behavior problems and finally unfortunate socio-professional prognosis [Oostrom et al, 2003].

Research in the Cochrane data basis shows more than 20.000 articles, while in Science Direct more than 10.000 articles related to the cognitive impairment due to epilepsy and its treatment. In this aspect, establishing balance between the beneficial (i.e., complete control of epileptic seizures) and potentially detrimental effects (i.e., cognitive impairments) remains an unresolved priority of every antiepileptic drug treatment. In a study of [Gjoneska et al. 2018], a multimodal approach is proposed, combining a Montreal Cognitive Assessment questionnaire (MOCA) for mild cognitive impairment, and an Amsterdam Neuropsychological computerized tasks (ANT) for evaluation of the following cognitive functions: memory, attention, visuo-spatial coordination and executive functions. In this study, authors showed that MOCA can be utilized for fast, coarse-grained differentiation (between healthy subjects and patients) of higher-order cognitive functions, while ANT is useful for fine-grained discrimination (between the mono- and poly-therapeutic group of patients) including more basic cognitive functions.

The aim of this article is to present obtained results of "neurogame" application in a group of epileptic patients in the assessment of attention, concentration and reaction time.

2. Sample and methodology

The evaluated sample comprised 35 subjects with epilepsy, patients at the Neurological

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Clinic in Skopje Medical Faculty. Mean age of examinees is 34, 87 ± 16, 23 years, both genders included. The diagnosis is made following ICD 10 criteria by specialized neurologist. All examinees obtained regularly antiepileptic drugs (mono or multidrug included), and were free of seizures minimum for one year before this testing.

Control group consists of 50 healthy people, aged 40 ± 1, 0 years, including both sexes, free of any health problem.

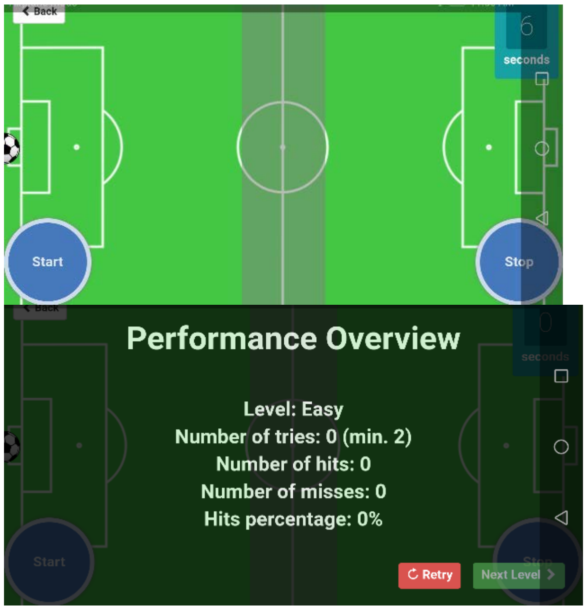
Prior consent was obtained for all examinees. The ethical rules following Helsinki 2000 declaration are incorporated in this research.

Our original Android application was used for testing reaction time, number of hits, misses and total tries following five levels of the game (very easy, easy, normal, hard and very hard). Every level has a duration of 40 sec., each next level being more difficult i.e. the ball moves faster. The client must press the start with the left thumb and as fast as he/she can to press the stop with the right thumb not allowing the ball to pass the median circle. The examination with "neurogame" android application was performed during ambulatory control of the patients.

Obtained results for all examinees are presented in tables and figures. Statistic parameters are calculated using Statistic package 8.

3. Results

The screen of our original application is shown on Fig. 1.



Left thumb Right thumb

Fig 1. The "Neurogame" screens

Tables 1 and 2 show some results for descriptive statistic for both evaluated groups. For clarification, tT means total tries; tH means total hits; tM means total misses; th means total time.

Table 1. Descriptive statistic for all parameters of epileptic patients

Variable	Number of examinees	Mean	Minimum	Maximum	Std. Deviation
Age	35	34, 87	14, 00	77, 00	16, 23
Total Tries (tT)	35	153, 35	5, 00	272, 00	60, 75
Total Hits (tH)	35	30, 77	0, 00	105, 00	27, 69
Total Misse	35	122, 58	5, 00	245, 00	48, 66

s (tM)					
Average Time (th)	35	323, 03	0, 00	527, 00	140, 61

Table 2. Descriptive statistics for healthy people

Variable	Number of examinees	Mean	Minimum	Maximum	Std. Deviation
Age	50	40,00	25,00	74,00	1,0
Total Tries (tT)	50	390, 90	52,00	191,54	27,36
Total Hits (tH)	50	208, 26	0,00	102,04	14,57
Total Misses (tM)	50	382, 07	45,00	187,21	26,74
Average Time (th)	50	380, 76	0, 00	186,57	26,65

Calculated one way ANOVA for gender influence on parameters is presented on Table 3. In addition, table 4 shows ANOVA for age influence to all parameters.

Table 3. One way ANOVA for GENDER and all parameters

(tT= total tries; tH= total hits; tM=total misses;th=total time)

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	672261.3	1	672261.3	2520980	0.000000
tT	141	57	0.2	1	0.604929
Error	40	15	0.3		

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	537889.1	1	537889.1	1753666	0.000000
tH	7.7	38	0.2	1	0.895733
Error	104	34	0.3		

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	668630.5	1	668630.5	3209426	0.000000
tM	147	56	0.3	1	0.311136
Error	33	16	0.2		

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	623990.9	1	623990.9	2634628	0.000000
th	136	53	0.3	1	0.442062
Error	45	19	0.2		

Table 4 One way ANOVA for AGE and all parameters

(tT= total tries; tH= total hits; tM=total misses;th=total time)

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	47925.88	1	47925.88	171.0321	0.000000
t h	12473.93	53	235.36	0.8399	0.699746
Error	5324.10	19	280.22		

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	36938.00	1	36938.00	144.3301	0.000000
tH	9096.50	38	239.38	0.9353	0.581260
Error	8701.53	34	255.93		

Effect	SS	Degr. of Freedom	MS	F	
Intercept	5764.522	1	5764.522	28.84825	0.00
tT	14800.69	57	259.66	1.2995	0.29
Error	2997.33	15	199.82		

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	5499.033	1	5499.033	19.56154	0.00
tM	13300.19	56	237.50	0.8449	0.69
Error	4497.83	16	281.11		

Calculated Student t-test for differences between healthy vs. epileptic patients is shown on Table 5.

Table 5. T-test for healthy vs. epilepsy

(**t**T= total tries; tH= total hits; tM=total misses;th=total time)

Group 1 vs. Group 2	Mean Group	Mean Group	t-val
t T (healthy) vs. t T (ep	195.47	153.35	2.8
t H (healthy) vs. t H (ep	45.56	30.77	1.9
t M (healthy) vs. t M (e	149.91	122.61	2.3
t h (healthy) vs. t h (ep	346.37	323.03	0.9

As can be seen, significant differences between groups are obtained for number of total tries, as well as for total misses; however, for total hits and for average time reaction, statistical significance is not obtained.

Table 6 presents one way ANOVA for parameters in both groups (healthy vs. epilepsy). As can be seen, statistical significance is obtained for all calculated parameters.

Table 6. ANOVA Healthy vs Epilepsy (comparison by t T, t H, t M and t h)

Effect	ANOVA (healthy vs epilepsy)				
	SS	Degr. of Freedom	MS	F	p
Intercept	1202561	1	1202561	1808.023	0.00
t T (epilepsy)	138729	26	5336	8.022	0.02
Error	2661	4	665		

Effect	ANOVA (healthy vs epilepsy)				
	SS	Degr. of Freedom	MS	F	
Intercept	65479.63	1	65479.63	37.70059	0.0
t H (epilepsy)	29900.51	19	1573.71	0.90608	0.5
Error	19105.17	11	1736.83		

Effect	ANOVA (healthy vs epilepsy)				
	SS	Degr. of Freedom	MS	F	
Intercept	650281.0	1	650281.0	254.0656	0.0
t M (epilepsy)	67965.4	26	2614.1	1.0213	0.5
Error	10238.0	4	2559.5		

Effect	ANOVA (healthy vs epilepsy)				
	SS	Degr. of Freedom	MS	F	p
Intercept	3339180	1	3339180	784.4321	0.00
t h (epilepsy)	277410	26	10670	2.5065	0.19
Error	17027	4	4257		

4. Discussion

As can be seen, obtained results confirmed significant differences in parameters measured with "neurogame" app. for both groups, being more unfavorable for epileptic patients. It means that executive function (attention, concentration, average time of reaction) are diminished either by the disorder, or by the AED.

Results are in agreement with the results obtained with MOCA and ANT presented in [Gjoneska et al, 2018]. An ANOVA with the group (control/mono/poly-therapy) as between-subjects variable, revealed significant differences between control/experimental group for the following MOCA-assesed executive functions: visuo-spatial coordination ($F(2, 85)=4.63$, $p < .05$), conceptualization ($F(2,85)=5.99$, $p < .01$), verbal fluency ($F(2, 85)=6.02$, $p < .01$), memory-retrieval of words ($F(2,85)=7.78$, $p < .001$).

The ANOVA for ANT-analysis revealed differences between mono- and poly-therapeutic group on:visuo-motor coordination ($F(2, 85)=6.29$, $p < .01$), sustained attention ($F(2, 85)=15.42$, $p < .001$)and short-term memory ($F(2, 83)=12.88$, $p < .001$).

A study of Guy Vingerhoets, (2006) suggested that people with severe epilepsy who continue to experience seizures were more likely to have difficulties with cognitive ability and brain function. Longer periods of remission were linked with fewer cognitive problems. A review published in 2006 concluded that there may be a "mild but measurable" decline in some people in intellectual performance" of adults and children [K.van Rijckevorsel.2006]. Similar findings are shown in [Dodrill, C. (2004)], [Greener M. 2013] and [Elger, C., Helmstaedter, C., and Kurthen, M. (2004)]. The latest authors point out that cognitive profiles in epilepsy are as heterogenous as the epileptic syndromes themselves; causes, topography of epileptogenic areas, pathogenetic mechanisms, and the diverse features characterising the clinical course all contribute to the effect on cognition. Chronic epilepsy generally impairs cognition, but it also induces processes of functional reorganisation and behavioural compensation.

However, the researchers point out that there is little reliable studies in this area, and that due to many confounding variables, the effect of seizures per se is difficult to estimate, and appears limited. Still, recent studies devoted to the cognitive changes in children with epilepsy, suggest that epilepsy is associated with worse cognitive outcomes. It is unclear whether epilepsy causes the impairment, or antiepileptic drugs have a negative effect. This is an area that needs further research.

Additionally, epilepsy can affect various aspects of a person's life, including emotions and behavior, social development and interaction, ability to study and work. The impact on these areas of life will depend largely on the frequency and severity of seizures. Research in this area are important having in mind that only in 2015, epilepsy affected 1.2 percent of the population in the United States, or 3.4 million people, including 3 million adults and 470,000 children. Thus the quality of life of these patients is important not only for themselves, their families, but for the all social environment.

5. Conclusion

Our model of the application is used for testing reaction time for epileptic patient compared with healthy people. Reaction time is related to the level of attention and concentration as two very important psychological functions.

We showed that all tested parameters depends on age and gender (ANOVA was significant).

All tested parameters are significantly different for epileptic group vs. healthy people.

T-test for epileptic vs. healthy people showed significant differences for total tries and total misses, while total hits and average time reaction did not differs significantly.

In comparison with other psychometric assessment, this approach using mobile phones seems us more practical, available in different places (nor only in medical settings), little time consuming and interesting for all ages.

Further research in this way is needed.

References

[1] Bakker A, .Albert MS, Krauss G,Speck CL,Gallagher M. Response of the medial temporal lobe network in amnestic mild cognitive impairment to therapeutic intervention assessed by fMRI and memory task performance, *Neuroimage Clin*. 2015 Feb 21;7:688-98.

[2] Dodrill, C. Neuropsychological effects of seizures. *Epilepsy Behav*. 2004, 5: 21–24.

[3] Elger, C., Helmstaedter, C., and Kurthen, M. Chronic epilepsy and cognition. *Lancet Neurol*. 2004; 3: 663–672.

[4] Gjoneska B, Kiteva-Trencevska G, Pop-Jordanova N. Multimodal analysis of cognitive functions in patients with epilepsy, 13th European Congress on Epileptology, 2018.

[5] Greener M. Beyond seizures: understanding cognitive deficits in epilepsy. *Progress in Neurology and Psychiatry*; May/June 2013: 31-32

[6] Loleski M, Loleska S, Pop-Jordanova N. Mobile application "neurogame" for assessment the attention, focus and concentration. *Contributions*. Sec. of Med. Sci., xxxviii 3, 2017: 9-18

[7] Loleski M, Loleska S, Pop-Jordanova N.Mobile application development for assessment and training. *International Journal of Scientific Engineering and Applied Science* (IJSEAS). 2017, Vol. 3, issue 10, pp. 1–8.

[8] Oostrom KJ, Smeets-Schouten A, Kruitwagen CL, et al. Not only a matter of epilepsy: early problems of cognition and behavior in children with ''epilepsy only''a prospective, longitudinal, controlled study starting at diagnosis. *Pediatrics* 2003;112:1338—44.

[9] Pop-Jordanova N, Loleski M, Loleska S. The use of Smartphone in medical practice (Review), *Prilozi*, *Contributions* / Macedonian Academy of Sciences and Arts, Section of Biological and Medical Sciences, 2017; No 3 : 55-63.

[10] Shulman MB. The frontal lobes, epilepsy and behavior. *Epilepsy Behav* 2000;1:384—95.

[11] van Rijckevorsel K. Cognitive problems related to epilepsy syndromes, especially malignant epilepsies. *Seizure*; 2006, 15 (4) : 227-234.

[12] Vingerhoets G. Cognitive effects of seizures. *Seizure*, 2015; 15 (4): 221-226.