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**EVALUATION OF THE FRONTAL LOBE FUNCTIONS IN CHILDREN WITH OBSESSIVE-
COMPULSIVE DISORDER**

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ABSTRACT

The present study investigated whether obsessive-compulsive children show a distinguishable profile in tasks considered sensitive to frontal lobe functioning, i.e. executive functions (EF). The evaluated sample comprises 20 children, both genders, mean age 10,33±1, 83 years, diagnosed as OCD using DMS-IV. Psychological evaluation was performed with Child Behavior Check List, Kohs cubes, Beck Depression Inventory, The Schedule for Affective Disorders and Schizophrenia for School-Age Children, Stroop Color Word Test and Wisconsin Card Sorting Test. Neuropsychological evaluation was performed with QEEG, using Visual Continuous Performance Test (VCPT) from which the Event Related Potentials (ERP) components were extracted. Results showed a clear presence of obsessions and/or compulsions, absence of depression, presence of perseverative errors and mild difficulties in mental flexibility. The ERP results cannot be understood as a disturbance of the EF in a direct sense, rather as a disturbed normal functioning caused by the high anxiety level. There is no significant clinical manifestation of cognitive dysfunction among children with OCD in the early stage of the disorder, but it could be expected the same one to be appearing in the later stages of the disorder.

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INTRODUCTION

It is well known that there is no other part of the brain where lesions can cause such a wide variety of symptoms. The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behavior. If we exclude motor function, all other functions are named as executive. Executive functions and self-regulation skills are defined as mental processes that enable us to plan, focus attention, remember instructions, and juggle multiple tasks successfully. The brain needs this skill set to filter distractions, prioritize tasks, set and achieve goals, and control impulses. Executive functions (EF) depend mainly on three types of brain function: working memory, mental flexibility, and self-control. These functions are highly interrelated. Each type of skill draws on elements of the others, and the successful application of executive function skills requires them to operate in coordination with each other. Working memory governs the ability to retain and manipulate distinct pieces of information over short periods of time.

Mental flexibility helps to sustain or shift attention in response to different demands or to apply different rules in different settings. Self-control enables to set priorities and resist impulsive actions or responses. This system is very important for school's children functioning in everyday activities. It is supposed that these functions are not innate; children are born with the potential to develop them. The development of these functions is related mainly to the environmental conditions. If children do not get what they need from their relationships with adults and the conditions in their environments their skill development can be seriously delayed or impaired. Adverse environments resulting from neglect, abuse, or violence may expose children to toxic stress, which disrupts brain architecture and impairs the development of executive functions.

The localization of the executive functions is in the prefrontal cortex, a part of the human brain which reaches its maturity in the adulthood. The Figure 1 shows the development of executive functions during the life cycle. As it can be seen the pick of executive functions is obtained in the period 5-20 years (Olley et al. 2007).

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Obsessive-compulsive disorder (OCD) is a mental disorder where people feel the need to check things repeatedly, have certain thoughts repeatedly, or feel they need to perform certain routines repeatedly. People with this disorder are unable to control either the thoughts or the activities. Common activities include hand washing, counting of things, and checking to see if a door is locked. Often they take up more than an hour a day. The condition could be associated with tics, anxiety disorder, and an increased risk of suicide. In general, such behavior can disturb the normal functioning of the child. It is estimated that OCD affects 1–3% of the general population. The National Comorbidity Survey Replication found a median age of onset in OCD of 19 years, with 21% of cases having onset by age 10 (Kessler *et al.* 2005). The cause of this disorder is unknown. However, it appears to be some genetic components with identical twins more often affected than non-identical twins. Risk factors include a history of child abuse or other stress inducing event. Some cases have been documented to occur following infections. Males and females are affected about equally. Recent volumetric magnetic resonance imaging (MRI) and genotyping of seven polymorphisms in two genes conducted in pediatric OCD patient showed that GRIN2B and SLC1A1 may be associated with regional volumetric alterations in orbit frontal cortex, anterior cingulate cortex and thalamus in children with OCD (Arnold *et al.* 2009).

One third of adults with OCD developed their symptoms when they were children. Unlike adults, children may not always recognize that their symptoms are senseless or that their compulsions are excessive. They also involve their family members in their rituals. The recent interest of researchers is to find some measurable neurobiological characteristics in OCD. In this context the executive functions are frequently evaluated. Aim of this study was to investigate EF among children with OCD by using both, psychometric testing and qEEG recording from which we extracted Event Related Potentials (ERPs) on the Go/No Go tasks.

MATERIALS AND METHODS

The sample comprised 20 children (both genders), between seven and 14 years of age ($M=10, 33\pm 1, 83$), all diagnosed as OCD using DSM-IV. Psychological evaluation was performed with Child Behavior Check List, Kohs cubes for assessment of the intellectual capacities, Beck Depression Inventory, The Schedule for Affective Disorders and Schizophrenia for School-Age Children, Stroop Color Word Test and Wisconsin Card Sorting Test. Neuropsychological evaluation was performed with the Visual Continuous Performance Test (VCPT) from which the Event Related Potentials (ERP) components were extracted. In the study we included 20 healthy subjects as a control group, which at the time of conducting the study did not have any psychological problems. The control group was corresponding to the gender and age of the experimental group. Preliminary, each subject went through detailed interview regarding the course, length and clinical manifestation of the symptoms. Then, a psychometric battery of tests was performed, combined with general scales and scales specific for the EF evaluation. The psychometric scales used in this study were:

Child Behavior Check List (CBCL) - a questionnaire for behavior assessment filled out by the parents of the children. It is combined with 113 questions related to assessment of depression, social communication or withdrawal, somatic complaints, schizoid behavior, hyperactivity, problems in the psychosexual development, delinquent and aggressive conduct, problems in the conduct, problems with the judgment and level of anxiety. This questionnaire is adjusted based on the child's age and gender⁴;

Kohs cubes are used for assessment of the intellectual capacities e. g. analytical, synthetic and logical thinking⁵; Beck Depression Inventory (BDI), is a self describing scale with 21 questions for assessment of the presence and level of depressive moods⁶; The Schedule for Affective Disorders and Schizophrenia for School-Age Children (K-SADS) is a semi structural questionnaire for children between 6 and 18 years old with the aim to generate DSM-IV diagnosis, such as the affective, psychotic and behavior disorders⁷. The neuropsychological assessment of children with OCD was performed with: The Stroop Color Word Test, which measures the mental vitality and flexibility, cognitive abilities to direct the attention, inhibition of automatic responses and initiation of correct ones⁸.

The Wisconsin Card Sorting Test (WCST), neuropsychological test for evaluation of the mental flexibility ("set-shifting") when the stimulus is changed, the attention, the working memory and visual processing⁹. The psychometric evaluation was in a duration of two hours. In the next phase, a neurophysiological assessment was performed with qEEG and Visual Continuous Performance Test (VCPT), from which the ERP components were extracted. Quantitative EEG or qEEG is a collection of quantitative methods designed to process EEG signals. The qEEG includes spectral and wavelet analysis of the EEG signals.

During the qEEG recording, the testing was performed by the Go/NoGo task, where each assignment is associated with a group of selected psychological operations such as detection and recognition of the stimulus, refreshing the working memory, initiation and/or inhibition of the behavior, monitoring of the action results, etc. The Go/NoGo task used in this study is comprised of 400 stimulates designed by the Human Brain Institute in Saint Petersburg, Russia. The stimulates are combined of pairs of pictures which can be in a form of a human being, animal or plant. The pairs are presented every three seconds, and the interval of pair appearance is 1, 1 second. The subject is instructed to press a button as fast as possible when he/she will see that there are two animals in the pair and inhibit his/her own reactions in any other picture combination. The task duration is 20 minutes.

Statistical analysis

The results obtained from the psychometric measuring are presented in a form of scores and compared to adequate test norms, adopted by the age and gender of the examinees. Beside this, we have conducted Student t-test analysis for independent variables to establish if there is a statistical significance between the experimental and the control group.

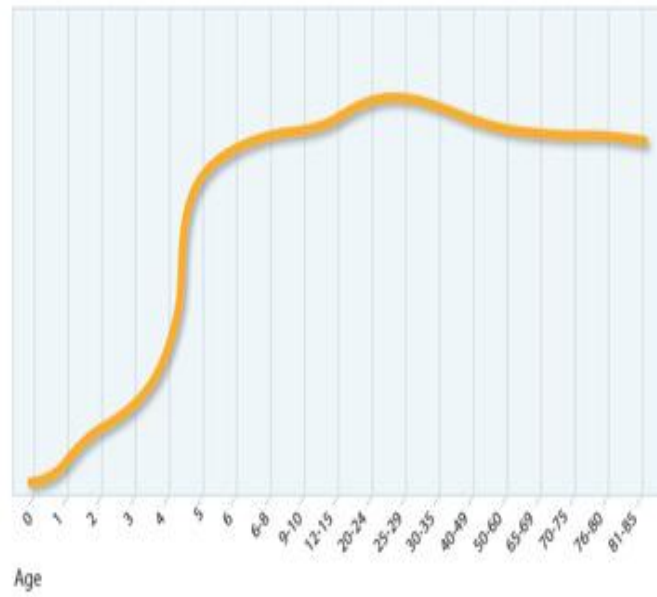


Fig. 1. Development of executive functions during life cycle

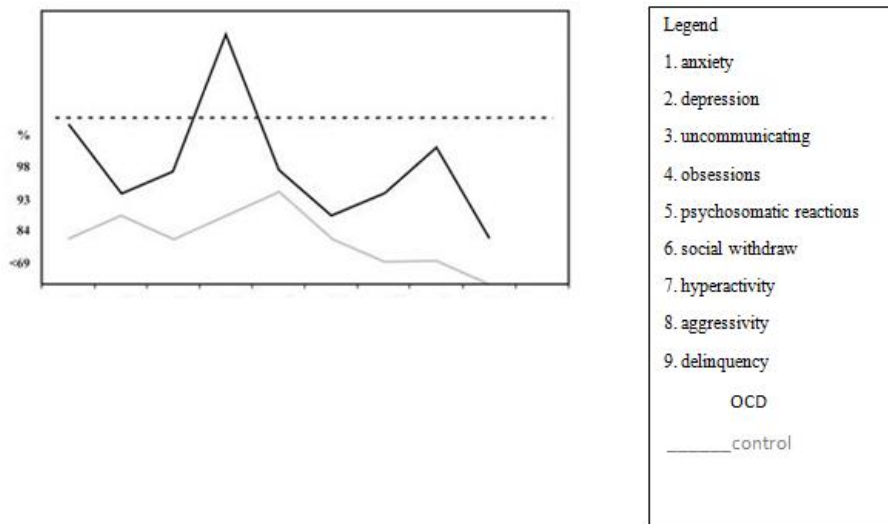


Fig. 2. CBCL profile for OCD boys and control

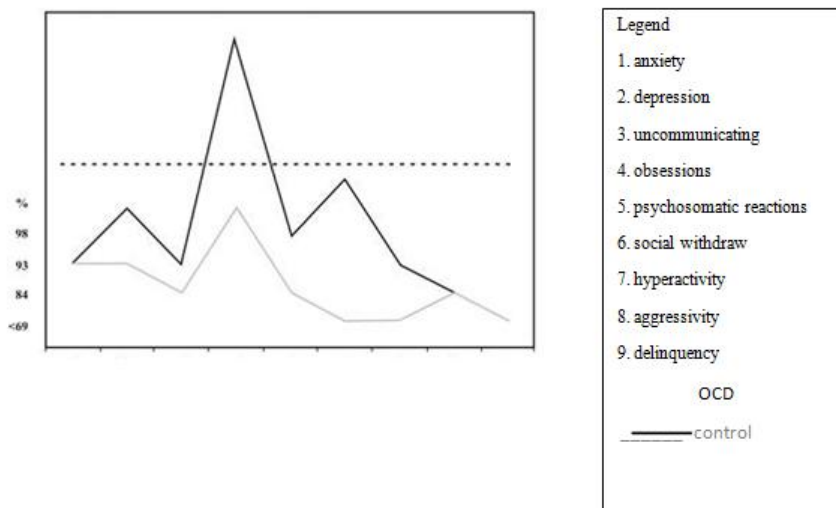


Fig. 3. CBCL for girls with OCD compared with control

The results are considered to be statistically significant at a significance level of 0,05. The data from the neuropsychological assessment that was performed via VCPT, was transferred to numerical values with the help of a PC. Those values were transformed with Fourier analysis and compared with a normative database comprised of 1000 healthy subjects, grouped by their age. The data was processed with the statistical program STATISTICA 10.0. The obtained results are presented in tables and pictures.

Tables 2 and 3

RESULTS

Results obtained for the CBCL scale for girls and boys have confirmed that there is a significant presence of obsessions (Figure 2 and 3). The results obtained with Kohs cubes for evaluation of the intellectual capacity have shown that this group of children is having superior intelligence (IQ =112±11,5). The BDI results are showing that among this group of children with OCD there are no signs of clinical depression (BDI=7). The K-SADS shows clear presence of compulsions and obsessions in all subjects (Tables 1). In the table we are showing only significant results. Table 1. The WCST and Stroop Test are showing presence of perseverative errors and mild difficulties in the mental flexibility (Tables 2 and 3).

EEG was recorded with Quantitative EEG equipment (Mitsar, Ltd.) amplifier from 19 electrodes, referenced to linked ears (on the International 10-20 system) with 250 Hz sampling rate in 0.3 – 70 Hz frequency range in the following conditions: eyes opened (EO) –5 minutes, and eyes closed (EC) –5 minutes. The ground electrode was placed between Fpz and Fz. The impedance levels for all electrodes were set to 5 KΩ. Two stimulus GO/NOGO task developed specifically for HBI (Human Brain Institute) database were used. Subjects were instructed to press a button with index finger of their right hand for GO condition and not to press a button for NOGO condition.

Fig. 4 shows QEEG spectra for a boy with OCD. It can be seen low/negative alpha band and significant high beta band especially in frontal regions. This spectra confirm high anxiety. On the ERP component P3Go (activation) there are not significant deviation according to the latency and amplitude, while the P3NoGo component (inhibition) is showing diversity for the latency values compared to the norm (Table 5). Generally, psychometric scales are showing a clear presence of obsessions and compulsions, superior intelligence, no depressive symptoms and presence of perseverative errors and mild difficulties in the mental flexibility. QEEG showed deficit of alpha brain waves and high beta in frontal regions related to anxiety.

Table 1. K-SADS results for compulsions and obsessions among OCD subjects

	parent (PE) M	parent (FE) M	patient (PE) M	patient (FE) M	conclusion (PE) M	conclusion (FE) M
compulsions						
touching	3	1	3	1	3	1
washing	2	1	3	1	2,5	1
checking	2	1	3	1	2,5	1
repeating	2,9	1	3	1	3	1
obsessions						
fear of germs	3	1	3	1	3	1
nihilistic thoughts	3	1	3	1	3	1

PE-present episode; FE-former episode; M-mean; 0=no data; 1=not present;2=no clinical value; 3= compulsions/obsessions

Table 2. T-value and statistical significance for WCST among children with OCD and the control group

WCST categories	T-values OCD	Test significance	T-values control	Test significance	p
N categories	45	low average	55	average	0,32
N perseverations	31	bellow average	51	average	0,000001
N errors	42	low average	50	average	0,55
cards total	43	low average	52	average	0,16
M categories	40	low average	51	average	0,6

*bold means statistical significance

Table 3. T-value and statistical significance of the Stroop Test in OCD and control group

Stroop Test categories	T-values OCD	Test significance	T-values control	Test significance	p
errors (St) II	52	average	55	average	0,1
errors III	25	very low	50	average	0,00001
errors III/II	44	low average	53	average	0,33
St III-St II	25	very low	53	average	0,00000

*bold means statistical significance

Table 4. VCPT performance for OCD children

	OCD	norm	t-test	p
omission errors (Go)	15,4	4	15,38	0,00001
commission errors (NoGo)	2,66	1	3,22	0,0016
RT (ms) Go	450,26	486	-2,56	0,00001
var RT	18,48	11,7	4,4	0,00002

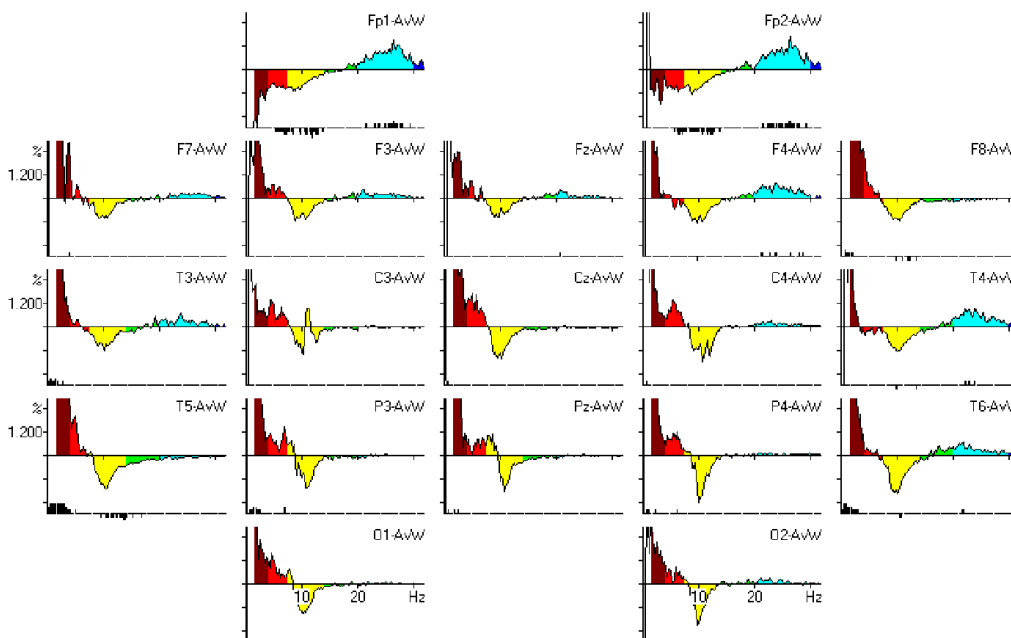


Fig. 4. QEEG spectra for boy with OCD

Table 6. P3Go and P3NoGo component values for the children with OCD compared with the normal

	OCD	norm	t-test	p
P3Go (ms)	300,26	328,53	-1,94	0,061
P3Go (mv)	9,67	8,4	1,09	0,28
P3NoGo (ms)	374,66	412	-4,56	0,00009
P3NoGo (mv)	5,4	6,22	-1,08	0,28

*bold indicates statistical significance

Behavior performance on the VCPT is showing more omission and commission errors, shorter reaction time and higher variation in the reaction time. The P3Go does not differ from the norm, while the P3NoGo is showing diversity in the latency values.

DISCUSSION

Within the last decade, evidence has accumulated that frontal lobe dysfunctions play a crucial role in the genesis of the obsessive-compulsive disorder (OCD) (Purcell, Maruff, Kyrios, & Pantelis, 1998)10. For OCD patients, a rather contradictory picture emerges regarding executive functioning. Different investigations have revealed mixed findings for various executive tasks. Whereas previous research showed that OCD is associated with frontal impairments, in a more recent review it was speculated that co morbid psychotic and depressive symptoms may have induced neuropsychological deficits, which were misattributed to OCD psychopathology. This hypothesis has been confirmed in a recent study:

It was found that OCD patients exhibiting elevated depressive scores revealed cognitive deficits, whereas OCD patients with low depressive scores could not be distinguished from controls regarding executive functioning(Moritz *et al.*,2000)11. In our study the WCST and Stroop Test have shown that there are difficulties in some aspects of the EF but not in all measured variables. Difficulties are found in the measurement of perseverative errors, inhibition processes and mental flexibility. However, difficulties in those areas are not only characteristic for children with OCD, but also for many healthy children of that age.

The reason for this is probably an incomplete process of maturation, especially of the prefrontal cortex, which is leading to lower level of developed EF. The findings in our study are in the same directions like the most findings in the literature which are stating that children with OCD especially in the early phase of the disorder do not have significant difficulties in the cognitive functioning or if they do, it is corresponding to their age.

Ornstein *et al.*,¹² in their newest study reported that children with OCD in comparison to healthy children do not have difficulties in working memory, attention, speed of information processing and response inhibition. Roth *et al.*,¹³ revealed that the group with onset of the OCD in their late childhood obtained poorer scores on the measures of executive function, compared to the group that has onset of the disease in their earlier childhood. On the other hand, there are studies which are stating that there are serious cognitive difficulties especially in the EFs, only when the depressive mood appears as co-morbid situation¹⁴⁻¹⁶. In our group of subjects there was no manifestation of depression verified on the BDI scale.

OCD is not a neuro-structure disorder, like autism for example, so the difficulties in the EF are more subtle, especially in the beginning of the disorder, when there are no depressive symptoms and the children are medication free. This arises the question of the validity of the psychometric instruments for children that should be developing further, so they will become more sensitive to those subtle changes. Larger precision of the EF evaluation instruments for the young children would be of a great importance for the basic science and clinical practice. From the ERP components, significant deviation was found for the P3NoGo component which is reflecting inhibitory processes but only on the component's latency. This could be a result of the subject's obsession which is pushing his/her stimulation to the maximum level, while he/she is performing tasks in order to maintain control. On the other hand, this is increasing the anxiety level, which is provoking the compulsions and the child with OCD is falling in a circle without end. High anxiety level in our group of subjects is confirmed on a qEEG spectra which corresponds with poor VCPT behavior performance where we have found a large amount of omission and commission errors, shorter reaction time and higher variation in the reaction time. So, the results of our study cannot be understood in the context of executive dysfunction but as a disturbance in the normal functioning caused by the high anxiety level. There is no significant clinical manifestation of the cognitive dysfunction among children with OCD in the early stage of the disorder. However this could be expected in the later stages.

Conclusions

Our clinical experience confirms that OCD is becoming a common disorder in the childhood; Evaluation of frontal lobe functioning showed that all subjects in this group had high cognitive abilities; Obsessions and compulsions are verified not only clinically but also through the CBCL and the K-SADS psychometric instruments; The Stroop Test and WCST are showing difficulties in some aspects of the EF which is within the current OCD theories; The ERP results of our study cannot be understood in the context of executive dysfunction but in the sense of disturbed normal functioning caused by the high anxiety level.

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