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PSYCHOMETRIC AND NEUROPHYSIOLOGICAL ASSESSMENT OF SCHOOL CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER-TOWARD BETTER MANAGEMENT AND TREATMENT

ПСИХОМЕТРИСКА И НЕВРОПСИХОЛОШКА ПРОЦЕНКА НА ШКОЛСКИТЕ ДЕЦА СО ДЕФИЦИТ НА ВНИМАНИЕТО И ХИПЕРАКТИВНОСТ- ЗА ПОДОБРО МЕНАЦИРАЊЕ И ТРЕТМАН

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ABSTRACT

ADHD represents a big problem in the educational process because these children are not able to be attentive, patient, to seat quietly during the class, and additionally they have learning difficulties. In the past decade researchers became more involved in defining and evaluating executive functions in children manifesting Attention Deficit Hyperactivity Disorder (ADHD). Executive functions are involving information from the working memory, inhibition of the inappropriate behavior, as well as directing and sustaining the attention, towards a goal-oriented behavior.

The aim of this article is to show our results obtained from psychometric and neuropsychological evaluation of the executive functions in a group of school children diagnosed as ADHD, as well as results for neurofeedback training we used therapeutically.

The evaluated group is composed of 50 ADHD children and 20 healthy children as a control, matched by age and gender. Neurophysiological assessment was performed with Visual Continuous Performance Test (VCPT) from which Event Related Potentials were extracted. Psychological assessment comprised the use of Stroop Color Word Task (SCWT) and Wisconsin Card Sorting Test (WCST), while mothers fulfilled Child Behavior Check List (CBCL) and ADD-H: Comprehensive Parent Rating Scale (ACTeRS).

Obtained results from psychological and neurophysiological assessment confirmed the diagnosis of ADHD as well as a presence of serious difficulties in executive system functioning trough ERP's component extracted from QEEG analysis.

As a used nonpharmacological therapeutic approach we accentuated very positive outcome of neurofeedback treatment of these children.

Key words: ADHD, children, executive functions, neuropsychological assessment

INTRODUCTION

The syndrome of restless, inattentive and impulsive behavior, known as Attention Deficit Hyperactive Disorder (ADHD) is a common neurodevelopmental problem in children and adolescents having an incidence of 3-7% worldwide. For our opinion, it is better to consider ADHD as a specific condition than as a real illness/disorder. In our county the estimated incidence is around 2% of school children (Pop-Jordanova, 2005).

It is no genetic markers in the identification of children with ADHD, although the dopamine related genes are strongly involved (especially D1 and D2) (Jaber, 1996). However, it is known that this specific state could be

present in the same family members, as well as in twins (Mick, 2008).

In order to find the neurologic basis, many imaging techniques are used. Brain imaging studies using PET scanners showed that brain metabolism in children with ADHD is lower in the areas of the brain that control attention, social judgment, and movement. In this context, EEG recording is appeared to be a simple, non-expensive and useful indicator of brain metabolic activity. Low metabolic activity in the area that generates the corresponding EEG is characterized by increase of slow activities (delta and theta waves) and decrease of beta activities.

It is supposed that the main brain system impaired in ADHD is the executive system. The executive system is characterized mainly by two parameters: generalized activation of the system (arousal =A) and the response associated with different operations such as working memory, action selection, action inhibition and action monitoring (focused activation =At).

Recently, endophenotype is becoming an important concept in the study of ADHD. Endophenotype represents simpler clue to genetic mechanism that the behavioral symptoms. It helps to define subtypes of a particular disorder and can be used as a quantitative trait in genetic analysis of probands and families. Concerning ADHD, a QEEG spectrum classification of ADHD population has been developed defining four main subtypes: I subtype (abnormal increase of delta-theta frequency range centrally or centrally-frontally); II subtype (abnormal increase of frontal midline theta rhythm), III subtype (abnormal increase of beta activity frontally) and IV subtype (excess of alpha activities at posterior, central or frontal lobes) (Kropotov, 2009).

Still, ADHD is the most underdiagnosed or misdiagnosed condition in school children. The main reason is the comorbidity with other psychiatric conditions such as: learning disorders; conduct disorder; anxiety; depression; speech problems; autism spectrum disorder or epilepsy. The high comorbidity rate created confusion regarding the definition and diagnosis of true ADHD. From a neuropsychological perspective comorbidity is considered part of the same brain and cognitive mechanisms that produces attentional and behavioral difficulties (Barkley, 2009).

ADHD represents a big problem in the educational process because these children are not able to be attentive, patient, to seat quietly during the class, and additionally they have learning difficulties. So, the diagnosis must be done precisely in order to find the real way for the management and personalized treatment. In the diagnostic procedure not only history, clinical signs and psychometric evaluation are enough. The exact diagnosis must include as least QEEG recording and additional use of others neuroimaging evaluation if needed.

AIM OF THE STUDY

The aim of this article is to show our results obtained from psychometric and neuropsychological evaluation of executive functions in a selected group of school children diagnosed as ADHD, as well as results for neurofeedback training we used therapeutically. All children were diagnosed and treated as outpatients in the University Children's Hospital, Skopje Macedonia, directed for evaluation of the main problems related to school discipline and achievement.

SAMPLE AND METHODOLOGY

A randomly selected group of 50 children (from more than 300 treated), both genders, boys aged 7,33±1,01 years, and girls aged 8,46±1,53 years, all in primary school, were evaluated for possible ADHD. Main symptoms were attention deficit, hyperactivity, distractibility, poor peer interrelations, behavior problems and average school achievement. The clinical diagnosis is made according criteria in ICD-10 Manuel. All children were tested with Kohs Block Design Test, the Stroop Color Word Task (SCWT), and Wisconsin Card Sorting Test (WCST) and recorded with QEEG. Mothers fulfilled Child Behavior Checklist (CBCL) and ADD-H: Comprehensive Parent Rating Scale (ACTeRS). Control group is consisted of 20 healthy children matched in age and gender.

The Kohs Block Design Test (Zavod za produktivnost dela, 1967) is performance test standardized to measure intelligence for mental ages 3-19. Easy-to-give and understand instructions, test was designed to be performed without many verbal explanations. In this context, it is especially valuable for testing those with language and hearing handicaps. Block design test possess a high degree of correlation and reliability with Bennet-Simon IQ test and WISC. The test consists of 16 colored cubes and 17 cards with colored designs which the subject is invited to duplicate. Kohs cubes are used for assessment of the intellectual capacities e. g. analytical, synthetic and logical thinking.

The SCWT (Stroop, 1935) was designed to differentiate between individuals who are non-brain damaged and individuals with brain damage. This test remains a standard measure in neuropsychological assessment. It assesses cognitive processing and provides valuable diagnostic information on brain dysfunction, cognition, and psychopathology. The SCWT is based on the observation that individuals can read words much faster than they can identify and name colors. Whether the test is used as a screener or as part of a general battery, its quick and easy administration, validity, and reliability make it a highly useful instrument.

The WCST (Anderson, 1991) is a neuropsychological test for evaluation of the mental flexibility ("set-shifting") when the stimulus is changed, the attention, the working memory and visual processing.

The CBCL (Achenbach, 1983) is designed to obtain the parent's/teacher's descriptions of the child behavior in a standardized format. 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 have several forms adjusted on the child's age and gender. Two broadband grouping are focused: internalized and externalized. They reflect a distinction between fearful, inhibited, over controlled behavior and aggressive, antisocial, under controlled behavior. The profile can contribute to a formal diagnosis by showing the degree of child's deviance in behaviors that parents are more likely to observe than clinicians, as well as help to structure effective training.

ACTeRS (Ullmann R, 1985) is a simple, standardized form of test composed of 24 items that objectively measures four separate factors: attention, hyperactivity, social skills, and oppositional behavior. This instrument was developed by researchers at the University of Illinois Institute for Child Behavior and Development. ACTeRS can be used by teachers and physicians to help determine which children are likely candidates for therapeutic intervention. It can also be used to monitor the effects of treatment. There are versions for teachers and parents, but also as a self-report form for adolescents and adults. With the paper/pencil version, raw scores are quickly obtained from the Rating Form and transferred to the Profile Form, where norm comparisons are read. Reliabilities average. 87 using various methods, including internal consistency, test-retest, and inter judge calculations. We used it as more quick but equally valuable as Connor's tests.

The psychometric evaluation of every child was in a duration of two hours. WCST and SCWT were conducted with Computer Assisted Neuropsychological Diagnostics and Therapy [CANDIT], software developed by Institute for neuropsychology, Zurrish, Switzerland.

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 (we used Mizar technology with 10/20 electrode positions). The QEEG includes spectral and wavelet analysis of the EEG signals.

During the QEEG recording, the testing of executive functions 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 tree 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.

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. 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.

RESULTS AND DISCUSSION

Results obtained for Kohs Block Design Test showed that evaluated ADHD children have intellectual capacities in the norm (IQ = 96 ± 13, 15).

Mean school notes were as follows: mathematics 3 (range 1 - 5); language 4.5; nature and society 3.

At the profile of ACTeRS results showed abnormal scores in the scales for attention, social adaptation and oppositional behavior (between 10 and 23 percentile). Similar results are obtained for boys and girls, still boys being more hyperactive than girls (Fig.1).

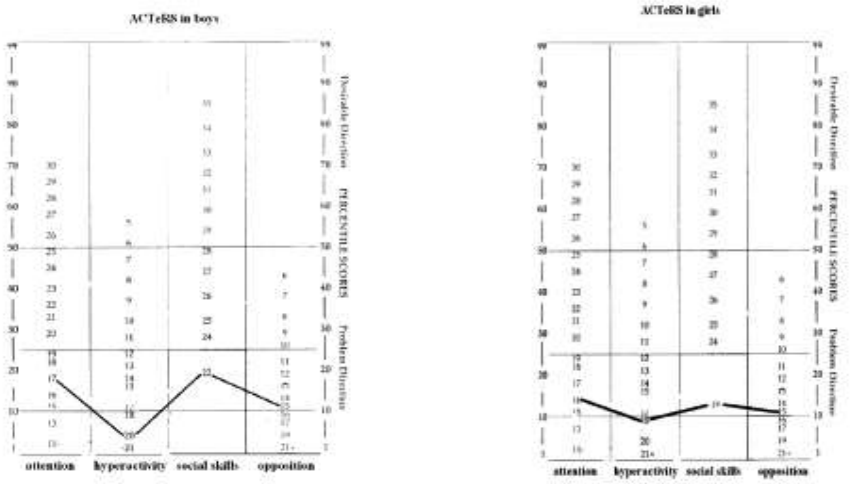
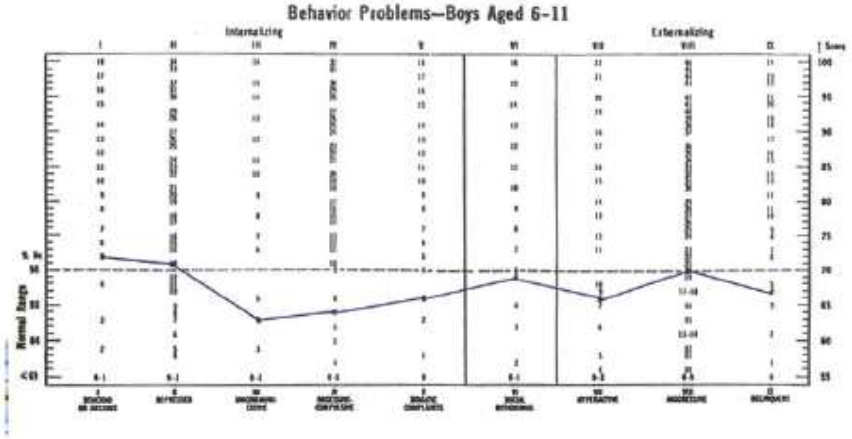


Fig. 1 Profiles obtained for ACTeRS

CBCL fulfilled by mothers showed for boy's accentuated anxiety, depression, social withdrawals and aggressive behavior. Girls are also with social withdrawals, hyperactive and manifest delinquent behavior

(Fig 2).



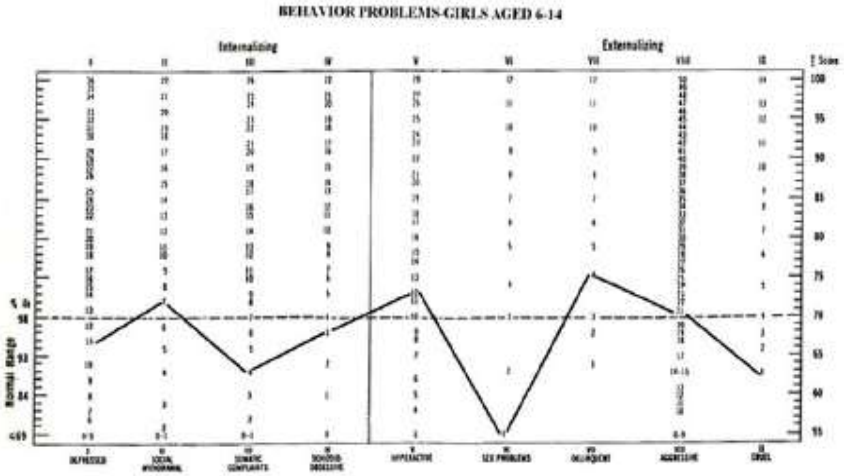


Fig. 2 CBCL profiles for boys and girls

Results for WCST and SCWT confirmed that hyperactive children made significantly more perseverative and non-perseverative mistakes, used more cards for all categories and have more difficulties in the mental flexibility that healthy children (Tables 1 and 2).

Table 1. T scores and statistical significance for WCST in ADHD and control

WCST	T score ADHD	test signi-ficance	T score Control	test signi-ficance	p value
N categories	42	Low average	55	average	0,32
N perseverations	31	Below average	51	average	0, 00001*
N mistakes	32	Below average	50	average	0, 00000*
Carts total	30	Below average	52	average	0, 00001*
M categories	31	Below average	51	average	0, 00001*

Table 2. T scores and statistical significance for SCWT in ADHD and control

SCWT	T score ADHD	test signi-ficance	T score Control	test signi-ficance	p value
Mistakes (St)II	50	average	55	average	0,1
Mistakes III	29	Very low	50	average	0,00001*
Mistakes III/II	29	Very low	53	average	0,00000*
St III-St II	50	average	53	average	0,02

* means significant

ANOVA for WCST results showed significant difference between ADHD children and control (F 13.11; p< 0,001), as well as for SCWT between the two groups (F 15, 66; p < 0.001).

The QEEG assessment generally showed: dominant theta activity (4-8 Hz) and deficit of beta activity (16-20 Hz). The detail analysis of all QEEG records among Macedonian ADHD children (over 300) showed very slow alpha excess (subtype 4) in 25% of children, and high theta/beta ratio in frontal-central cortex (subtype 1) in another 25%. The majority of 48% belong to the combined 1 and 2 subtypes. Very rarely (under 2%) we found subtype III were overactive cortex is typical finding (Pop-Jordanova et al. 2005; Zorcec et al. 2007). Fig. 5 shows schematically components of ERP's included in the executive function of the brain. All components are diminished in ADHD children.

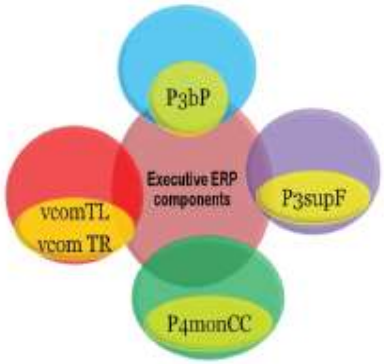


Fig. 5 Executive ERP components

VCPT, as a part of QEEG analysis, showed that hyperactive children performed significantly much omission errors and commission errors, longer reaction time (RT) and high variation of the reaction time (var RT) compared with test norms (table 3).

Table 3. VCPT in ADHD children compared with test norms

VCPT	ADHD	norm	t-test	p value
Omission errors (Go)	32.25	4	15.65	0, 00001*
Commission errors (NoGo)	4.75	1	7.58	0, 00000*
RT(ms) Go	456. 89	486	-9.17	0, 0001*
var RT	18.97	11.7	8.78	0, 0000*

In the analysis of P3Go component (activation processes) we did not find significant differences concerning the latency and amplitude, while for P3NoGo component (inhibition processes) the latency is not disturbed but the amplitude is statistically lower (Table 4).

Table 4. P3Go and P3NoGo in children with ADHD

ERP's	ADHD	norm	t-test	p-value
P3Go (ms)	327.15	327.89	-0.12	0,9
P3Go (mV)	9.73	8.55	0.77	0.44
P3NoGo (ms)	402.05	415.78	-0.69	0.49
P3NoGo (mV)	4.67	6.23	-2.89	0,006*

Generally, psychometric and psychophysiological evaluation of the examinees with ADHD syndrome showed accentuated hyperactivity, average intellectual capacities, significant number of perseverative and non-perseverative mistakes, and use of more cards for all categories of tasks, as a result of significant difficulties in mental flexibility. Achievement for VCPT showed significantly higher number of mistakes related to inattention (omission errors), wrong answers (commission errors), shorter reaction time (RT) and higher variation in reaction time (var RT) compared with test norms. Values of P3Go component in latency and amplitude are different from the norm, while P3NoGo component showed significant difference in the amplitude.

In the treatment of our clients we used behavior therapy, and biofeedback. No medication is used in our country. For ADHD children personalized biofeedback protocols are used related to the QEEG subtype. Generally, we started with 3-5 sessions of electro dermal biofeedback for diminishing anxiety, and in the follow the neurofeedback is used, two time per week in duration of 50 minute. Common protocol comprised diminishing theta activity and optimizing beta brain activity in specific skull points depending of QEEG subtype (Pop-Jordanova, 1999). Table 5 shows results before and after biofeedback application. It is clear that with this kind of therapy we achieved diminishing of theta, higher power of beta brain waves, changes of theta/beta ratio, as well as change of brain rate parameter. Theta/beta ratio is a parameter used for assessment of ADHD in many studies (Lubar, 1997; Monastra, 2001; Reader, 1994). The brain rate parameter is indicator introduced by Pop-Jordanova N, Pop-Jordanov J. (2005) for the evaluation of general mental arousal. The values of this parameter is approved in other studies performed in our country (Markovska-Simoska, 2011; Demerdzieva, 2011)

From the Table 5 it can be concluded that brain-rate parameter is more realistic and corresponds to clinical improvement more than theta/beta ratio.

Results obtained in this study correspond to results in many other studies concerned ADHD children (Brown, 2006; Doyle, 2006; Zorcec, 2010).

We confirmed through the obtained results of SCWT and WCST that the main problem in this condition is a deficit in the executive system. These results correspond with the results of Reader et al. (1994). In a meta-analysis of Pennington and Ozonoff, (1996), for 18 studies concerned to ADHD children, in 15 is confirmed the deficit of executive system. In the article of Sergeant et al. (2002), in which the analysis is done in studies performed over 20 years, ten of them confirmed problems in mental flexibilities. In all studies it is confirmed that SCWT and WSCT are very sensitive tests in the differentiation of problems in executive functions.

However, the ADHD is a complex syndrome and the diagnosis must include neuropsychological assessment to evaluate the executive system, because the symptoms could be different from child to child. In this context, the analysis of ERP's is a modern approach in the diagnosis of ADHD showing the difference in amplitude or latencies. Van der Meere, (1996), proposed that the smaller amplitude of P3 component is the result of smaller ability for the engagement of the child in the task performance. Keage et al. 2006, obtained shorter latencies of P3 component in ADHD patients. The executive system is changeable through the developmental process, which suggest that ADHD could be the result of slower developmental of some neurological parts of the brain.

Table 5.

Parameter	Before NF (μV)	After NF (μV)	t-test	Significance
Beta brain waves	4.86 ± 1.6	8.0 ± 1.38	5.23	p< 0.01
Theta brain waves	20.95 ± 1.38	15.29 ±1.38	8.47	p< 0.01
Theta/beta	4.7 ± 1.38	2.0 ± 1.6	4.5	p< 0.01
Brain-rate	7.86 ± 0.56	8.22 ± 0.63	6.6	p< 0.01

CONCLUSIONS

The study confirmed the need of psychometric and neurophysiologic assessment of all school children with ADHD symptoms.

The obtained results in our study confirmed serious impairment of executive system.

Psychometric assessment of executive functions through WCST and SCWT showed more perseverative and non-perseverative mistakes, uses of more cards and difficulties in mental flexibility.

Neurophysiologic assessment of the executive system through VCPT (P3NoGo and P3Go) ERP's components in children with ADHD symptomatology confirmed significantly more mistakes, omission and commission errors as well as the higher variation of the reaction time, and reduced amplitude of P3NoGo, but not specific disturbance in P3Go component.

Neurofeedback showed positive outcome as a nonpharmacological treatment. In this context a brain-rate parameter appeared to be more realistic in the follow up of the obtained results. In the future, we propose to include brain-rate based neurofeedback training.

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ПСИХОМЕТРИСКА И НЕВРОПСИХОЛОШКА ПРОЦЕНКА НА ШКОЛСКИТЕ ДЕЦА СО ДЕФИЦИТ НА ВНИМАНИЕТО И ХИПЕРАКТИВНОСТ- ЗА ПОДОБРО МЕНАЦИРАЊЕ И ТРЕТМАН

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АБСТРАКТ

АДХД претставува голем проблем во едукативниот процес бидејќи овие деца не се способни да бидат внимателни, трпеливи, да седат мирно за време на часовите и дополнително имаат проблем со учењето. Во последните децении истражувачите станаа повеќе инволвирани во дефинирањето и истражувањето на егзекутивните функции кај децата кои манифестираат АДХД. Егзекутивните функции се инволвирани во информации добиени преку работната меморија, инхибицијата на несоодветното поведение, како и во насочувањето и одржување на вниманието, преку целно-насочено однесување.

Цел на овој труд е да ги покажеме нашите резултати добиени со психометриското и невропсихолошкото испитување на егзекутивните функции кај група на школски деца дијагностицирани како АДХД, како и резултатите од неурофидбек тренингот кој го користевме тераписки.

Испитуваната група ја сочинуваат 50 деца со дијагноза АДХД како и 20 здрави деца на слична возраст и пол, како контролна група.

Невропсихолошката проценка е направена со Визуелен Континуиран Тест на Перформација (VCPT) од кој се извлечени Потенцијалите предизвикани со настан (ERP). Психолошката проценка подразбира користење на Строп тест на обоени зборови (SCWT) како и Висконсин тест на сортирање на карти (WCST), додека мајките пополнуваа Тест за проценка на однесувањето (CBCL) и тест ADD-H (ACTeRS). Добиените резултати од психолошкото и невропсихолошкото тестирање ја потврдија дијагнозата на АДХД како и присуството на потешкотии во функционирањето на егзекутивниот систем преку компонентите на ЕРП извлечени од QEEG анализата.

Користењето на нефармаколошкиот тераписки приод (неурофидбек) покажа многу позитивни резултати кај овие деца.

Клучни зборови: АДХД, егзекутивни функции, деца, невропсихолошка проценка