

## ADHD AS AN EXECUTIVE DYSFUNCTION

**Zorcec T., Pop-Jordanova N.**

*University Children's Hospital, Skopje, R. Macedonia*

**Abstract:** Attention-deficit/hyperactivity disorder [ADHD] is a neuropsychiatric disorder characterized by inattention, hyperactivity and impulsivity that affects from 3–5% of school-aged children. In some cases it may persist into adulthood. Prominent theories about ADHD suggest that inattention, hyperactivity and impulsivity may be due to underlying deficits of the components of attention, including alerting, orienting and executive control. The aim of this study was to investigate neuropsychological characteristics of ADHD children, especially their executive functions [EFs]. The sample is comprised of 30 ADHD children from 6 to 14 years old [10,  $45 \pm 22$ , 2], only boys, diagnosed at the department of psychophysiology, University Children's Hospital. The diagnosis was established according to ICD-10 criteria. All children had an IQ over 90 and were medication free. Psychological assessment of the children was performed with the Wechsler Intelligence Scale for Children [WISC-IV] and ADD-H Comprehensive Parent Rating Scale [ASTeRS]. Neuropsychological assessment was performed with the Stroop test and the Wisconsin Card Sorting Test [WCST]. Results showed an average IQ, manifested symptoms of hyperactivity and executive dysfunction, confirmed by the Stroop test and WCST.

**Key words:** ADHD, executive functions, children.

### *Introduction*

Attention-deficit/hyperactivity disorder [ADHD] is a neuropsychiatric disorder characterized by inattention, hyperactivity and impulsivity that affects from 3–5% of school-aged children and in some cases may persist into adulthood. ADHD is commonly treated with behavioural therapy and pharmacotherapy such as psychostimulants [1].

Prominent theories about ADHD suggest that inattention, hyperactivity and impulsivity may be due to underlying deficits of the components of attention, including alerting, orienting and executive control [2, 3].

The study of the mechanisms and nature of attention has a long history, particularly within the field of psychology. At the turn of the 20th century, William James wrote, "Everyone knows what attention is. It is the taking possession by the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought [4]."

In the more recent past, Posner and Raichle developed a comprehensive, multi-component theory of attention, called the *neuroanatomic network theory of attention*, which has become one of the leading models used by investigators to examine component processes of attention. In their research, Posner and Raichle identified three attention networks – *the networks of alerting, orienting, and executing or executive control*:

1. the *alerting process* refers to the readiness of an individual to respond to any type of stimulus [e.g., visual, auditory, originating from any position in space]. For an individual to achieve an alert state, it is assumed there must be a decrease in neural noise, which increases the signal-to-noise ratio when a stimulus occurs;

2. the *orienting process* refers to how and to what degree an individual is prepared for a specific stimulus [e.g., visual versus auditory]. On a neuropsychological test, orienting can be measured by presenting a cue that provides information about where the stimulus may occur on a computer screen [e.g., on the right side rather than the left]. Individuals can become prepared for something specific without even moving their eyes via the process of covert orienting of attention;

3. the *executive control* refers to the process of resolving conflict when two responses are simultaneously called for by stimuli. In the laboratory, the Stroop task is an example. The conflicting combination of a word like *red* written in green ink creates conflict when the task is to say the colour of the ink [green], due to the over learned reading response that automatically elicits the response based on the meaning of the word [red]. Executive control allows for the inhibition of the over learned response and the execution of a response that is more appropriate given the context [5].

In this study we will assess the executive control in ADHD children. ADHD needs to be redefined to include a wide range of "executive dysfunction" as a dysfunction from an inability to inhibit present behaviour so that demands for the future could be met.

Human beings are able to modulate their behaviour. No single part of the human brain is entirely in charge of this modulation. However, it appears

that our frontal and pre-frontal lobes' function is our "higher commander". Organizing language and memory functions from other parts of the brain, these frontal centres consider where we came from, where we want to go and how to control ourselves in order to get there.

Most importantly, *the ability to inhibit* is central to effective executive functions. Successful execution of a plan largely involves putting brakes on distracting activities. These brakes, courtesy of our pre-frontal inhibitory centres, allow us the luxury of time during which we can consider our options before reacting. This lack of inhibition is a double problem for people with ADHD. First, without these brakes, they will be viewed as unable to adequately inhibit distractions, inhibit impulsive reactions or inhibit physically acting upon these stimuli [hyperactivity]. Second, patients with ADHD do not inhibit their behaviour long enough for the other executive functions below to develop adequately either. Executive functions include:

- ♦ *self-talk*: refers to the ability to talk to ourselves – a mechanism by which we work through our choices using words. Toddlers can be heard using self-talk out loud. Eventually, this ability becomes internalized and automatic. However, ADHD children have not inhibited their reactions long enough for this skill to fully develop;

- ♦ *working memory*: refers to those ideas that we can keep active in our minds at a given moment. For example, in order to learn from mistakes, you have to be able to juggle not just the present situation, but also keep in mind past times when certain strategies did or did not work. Working memory hopefully also includes keeping future goals in mind. Without the ability to inhibit, people with ADHD never get to develop good functioning of their working memory;

- ♦ *predicting and planning for the future* will be deficient when inadequate working memory teams up with a poor ability to inhibit the present distractions. Children with ADHD cannot keep the future in mind. They are prisoners of the present; the future catches them off guard. In fact, surprisingly poor foresight is perhaps the greatest difficulty in their lives;

- ♦ *sense of time* is an executive function that is usually extremely poor in ADHD;

- ♦ *shifting from agenda to agenda* is a difficult task requiring good executive functioning. Pulling yourself out of one activity and switching to another, transitioning, is innately difficult and requires effort and control;

- ♦ *separating emotion from fact* requires time to reflect. Each event has an objective reality, and an additional "emotional tag" which we attach to it. For example, a traffic jam may occur, causing us to be late for work. That is the objective fact. How we react, though, is up to the emotional tag of significance

that we place on it. Do we stay calm and make plans to finish up a little later or do our emotions cause us to see the traffic as a personal, unfair attack, causing us to seethe and curse. Without the gift of time, we never get to separate emotion from fact. This leads to poor ability to judge the significance of what is happening to us.

In short, then, the ability to modulate behaviour comes largely from our pre-frontal lobes, whose function primarily is inhibitory. Without the luxury of inhibitory brakes, ADHD children do not get to fully utilize any of their frontal lobe "executive functions".

Redefining ADHD as inadequate inhibition explains a wide spectrum of difficulties experienced by people with the syndrome. This expanded spectrum of symptoms can create an environment of chaos.

ADHD is typically defined as a triad of inattention, impulsivity and hyperactivity. If we do not address the following resulting executive function issues, we are only dealing with a small part of the problem. Other symptoms may include:

- ♦ *lack of foresight or ability to predict the results of our behaviour* which is a major adaptive ability of humans;

- ♦ *trouble learning from mistakes or inability to inhibit the present*, ADHD children cannot stop to consider lessons from the past;

- ♦ *living at the "mercy of the moment" or inability to see the future and learn from the past*;

- ♦ *trouble returning to task*;

- ♦ *poor sense of self-awareness*;

- ♦ *poor internalization and generalization of rules*;

- ♦ *poor reading of social clues*;

- ♦ *inconsistent work and behaviour*;

- ♦ *trouble with transitions*;

- ♦ *poor frustration tolerance, often overwhelmed and getting angry frequently and quickly*;

- ♦ *pushing away those whose help they need the most*;

- ♦ *hyper-responsiveness or excessive emotions*;

- ♦ *inflexible/explosive reactions*;

- ♦ *feeling calm only when in motion*;

- ♦ *thrill-seeking behavior*;

- ♦ *trouble paying attention to others*;

- ♦ *sense of failure to achieve*;

♦ *lying, cursing, stealing, and blaming others* become frequent components of ADHD, especially as the child gets older [6].

As we can see, these are not just "incidental" symptoms. They are hard to live with. A key to understanding ADHD may be the notion that it is actually a disorder of performance rather than skill, of how one's intelligence is applied in everyday effective adaptive functioning rather than intelligence itself, of doing what you know rather than knowing what to do and of when rather than how in the performance of behaviour generally [7].

#### *Aim of the study*

The aim of this study was to investigate neuropsychological characteristics of ADHD children, especially their executive functions.

#### *Subjects and Methods*

##### *Subjects*

The subject sample is comprised of 30 ADHD children from 6 to 14 years old [ $10,45 \pm 22,2$ ], all of them boys and all diagnosed at the University Children's Hospital, Department of Psychophysiology. The diagnosis was established according to ICD-10 criteria. All children had an IQ over 90 and were medication free.

##### *Methods*

Psychological assessment of the children was performed with:

– Wechsler Intelligence Scale for Children [WISC-IV], an intelligence test for children between the ages of 6 and 16 inclusive that can be completed without reading or writing and generates an IQ score [8];

– ADD-H Comprehensive Parent Rating Scale [ASTeRS], composed of 24 items that cover four factors: attention, hyperactivity, social skills and oppositional behaviour [9].

Neuropsychological assessment of the ADHD children was performed with:

– *the Stroop test* is used in neuropsychological evaluations to measure mental vitality and flexibility, since performing well requires strong attention and self-regulation capability. This test is considered to measure selective attention, cognitive flexibility and processing speed, and it is used as a tool in the evaluation of executive functions. When the name of a colour [e.g., "blue,"

"green," or "red"] is printed in a colour not denoted by the name [e.g., the word "red" printed in blue ink instead of red ink], naming the color of the word takes longer and is more prone to errors than when the colour of the ink matches the name of the colour [10];

– *the Wisconsin Card Sorting Test* [WCST] is a neuropsychological test of "set-shifting", i. e. the ability to display flexibility in the face of changing schedules of reinforcement. The WCST assess the following "frontal" lobe functions: strategic planning, organized searching, utilizing environmental feedback to shift cognitive sets, directing behaviour toward achieving a goal and modulating impulsive responding. A number of stimulus cards are presented to the participant. The shapes on the cards are different in colour, quantity, and design. The person administering the test decides whether the cards are to be matched by colour, design or quantity. The participant is then given a stack of additional cards and asked to match each one to one of the stimulus cards, thereby forming separate piles of cards for each. The participant is not told how to match the cards; however, he or she is told whether a particular match is right or wrong. During the course of the test the matching rules are changed and the time taken for the participant to learn the new rules and the mistakes made during this learning process are analysed to arrive at a score [11].

### Results

Results for WISC-IV have shown that all the ADHD children from our study had normal IQ scores [Table 1].

Table 1 – Табела 1

*Values obtained for IQ on WISC-IV*  
*IQ вредносїти добиени на WISC-IV*

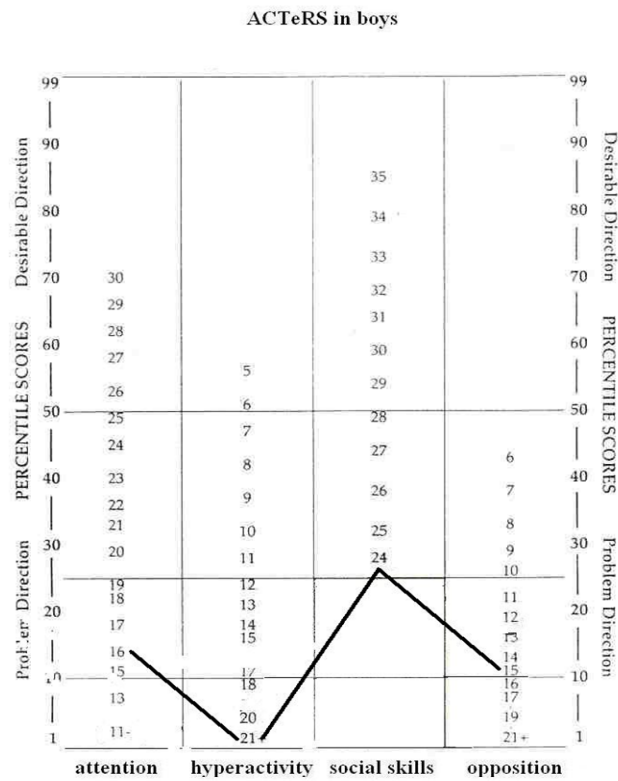
	<b>N</b>	<b>Mean IQ</b>	<b>Sd</b>
<i>ADHD</i>	30	96	13.15

On ACTeRS, the parents of ADHD boys reported moderate problems concerning attention, social skills and opposition behaviour [from 10<sup>th</sup> to 30<sup>th</sup> percentile] and severe problems concerning hyperactivity [below 10<sup>th</sup> percentile] of their children [Table 2, Figure 1].

Table 2 – Табела 2

*Raw values for ACTeRS in ADHD children*  
*Сирови скорови добиени на ACTeRS кај децата со ADHD*

	<b>N</b>	<b>Mean</b>	<b>Sd</b>
<i>attention</i>	30	16.73	14.01
<i>hyperactivity</i>	30	21.53	2.59
<i>social skills</i>	30	24.5	3.22
<i>opposition</i>	30	15.1	5.77



*Figure 1 – Values for ACTeRS in ADHD children*  
*Слика 1 – Вредности на ACTeRS кај групата на деца со ADHD*

The Stroop test and WCST showed that the ADHD children from our group do have frontal dysfunction, i. e. their achieved scores are below average for the appropriate age [Table 3&4].

Table 3 – Табела 3

*Values for Stroop test in ADHD children*  
*Вредносџи на Stroop ињесџиоџ кај деџаџа со ADHD*

<b>Stroop test categories</b>	<b>M</b>	<b>meaning</b>
<i>St II mistakes</i>	0.33	normal
<i>mistakes III</i>	<b>1.42</b>	<b>frontal pathology</b>
<i>mistakes III/ II</i>	<b>1.62</b>	<b>frontal pathology</b>
<i>mistakes St III/St II</i>	1.08	normal

Table 4 – Табела 4

*Values for WCST in ADHD children*  
*Вредносџи на WCST ињесџиоџ кај деџаџа со ADHD*

<b>WCST categories</b>	<b>M</b>	<b>meaning</b>
<i>N categories</i>	<b>3.94</b>	<b>frontal pathology</b>
<i>N perseveration 2</i>	<b>20.23</b>	<b>frontal pathology</b>
<i>N errors</i>	8.58	normal
<i>cards total</i>	<b>108.17</b>	<b>frontal pathology</b>

### *Discussion*

The new understanding of ADHD as developmentally impaired executive functions is gaining more and more support from researchers. On the other hand, the experience of a wide variety of clinicians is leading them to recognize this syndrome as an executive dysfunction too. Our clinical experience confirms this understanding as well [12, 13].

ADHD is a complex syndrome and diagnosing it in children requires neuropsychological testing. This syndrome can also be effectively diagnosed with clinical interviews, self-reporting and rating scales and screening for possible comorbid psychiatric disorders. In ADHD assessing, clinicians need to bear in mind that symptoms of this disorder are very situationally variable. Affected individuals can have a few domains in which they may be able to manage quite well despite the chronic impairments in their ability to exercise executive functions in a variety of situations. Clinicians who familiarize themselves with this syndrome can provide a treatment for their patients that is usually quite effective and, for most of them, very helpful.

People who do not have ADHD can usually pay attention to tasks, even to tasks that are boring but that they have to do. People with ADHD find it much more difficult to pay attention, unless the task is one that has immediate value to them. The core of their problem is a developmental impairment in



being able to manage their mind to focus on tasks they need to do, even when those tasks are not immediately interesting. The situational variability of ADHD symptoms illustrates that ADHD is essentially a disorder of impaired executive functions. Unfortunately, most children do not outgrow ADHD. In fact, "up to 67% of children, diagnosed with ADHD, will continue to experience symptoms of ADHD in adulthood" [14].

Since the brain anatomy of ADHD patients is different, that fact will not change as they mature and grow older. Because ADHD patients use different parts of their brains to process information into memory, the resulting problems with memory may also persist as ADHD children grow up. In addition, executive dysfunction is not something that is outgrown easily. Thus, ADHD children, as well as the adolescents and adults who will continue to experience problems related to ADHD as they mature, must compensate for the differences in their brain anatomy, brain development level, brain use areas and genetic predisposition to ADHD and the dysfunction in memory and executive function that result.

### *Conclusion*

– Prominent theories about ADHD suggest that inattention, hyperactivity and impulsivity may be due to underlying deficits of the components of attention, including alerting, orienting and executive control.

– WISC-IV results have shown that all the ADHD children from our study had normal IQ scores.

– On ACTeRS, the parents of the ADHD boys reported moderate problems concerning attention, social skills and opposition behavior and severe problems concerning hyperactivity of their children.

– The Stroop test and WCST showed that the ADHD children from our group do have frontal dysfunction.

– Most of the children, diagnosed with ADHD, may continue to experience symptoms of ADHD in adulthood.

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## Резиме

**ADHD КАКО ДИСФУНКЦИЈА НА ЕГЗЕКУТИВНИОТ СИСТЕМ****Зорчец Т., Поп-Јорданова Н.***Клиника за дејски болести, Скопје, Р. Македонија*

**Апстракт:** Дефицит на вниманието со или без хиперактивност или ADHD е невропсихолошко растројство кое се карактеризира со невнимание, хиперактивност и импулсивност, засега од 3 до 5% од децата на училишна возраст и во некои случаи може да перзистира и во адултното доба. Денес повеќе истакнати студии сугерираат дека невниманието, хиперактивноста и импулсивноста кај ADHD се должи на дефицитот на одредени компоненти на вниманието, како будност, ориентираност и егzekутивна контрола. Цел на студијата е да се анализираат невропсихолошките карактеристики на децата со ADHD, особено на нивните егzekутивни функции. Примерокот е сочинет од 30 деца со ADHD на возраст од 6 до 14 години [10, 45 ± 22, 2], сите од машки пол и сите дијагностицирани на Одделот за психофизиологија при Клиниката за детски болести. Дијагнозата беше воспоставена според ICD-10 класификацијата. Сите деца имаа интелектуални капацитети над 90 и ни едно не прима медикаментозна терапија. Психолошката процена се спроведе со Wechsler Intelligence Scale for Children [WISC-IV] и ADD-H Comprehensive Parent Rating Scale [ASTeRS]. Невропсихолошката проценка се спроведе со Stroop test и Wisconsin Card Sorting Test [WCST]. Резултатите покажаа дека сите деца имаат просечни интелектуални капацитети, манифестни симптоми на хиперактивност и дисфункција на егzekутивниот систем потврдени преку Stroop test и WCST.

**Клучни зборови:** ADHD, егzekутивни функции, деца.

**Corresponding Author:**

**Tatjana Zorcec, MSc**  
**Specialist on clinical psychology**  
**University Children's Hospital**  
**Vodnjanska 17**  
**1000 Skopje**  
**R. Macedonia**  
**Tel: + 389 70 620 226**  
**Fax: + 389 2 3164 860**

**E-mail: hospital@sonet.com.mk**