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SUSTAINED ATTENTION IN CHILDREN WITH ADHD

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SUMMARY

Introduction. *The symptoms that comprise inattentive behaviour in ADHD include problems with focusing on a task and sustaining attention over a long period, even in advantageous external conditions. There is also a characteristic excessive distractibility under the influence of other, unimportant stimuli. Thus attention processes are one of the main variables which form the clinical picture of ADHD. The research published to date on this topic does not, however, lead to an unequivocal conclusion concerning the existence of sustained attention deficits (vigilance deficits). The aim of our research was to assess this aspect of attention processes in children with the combined and inattentive type of ADHD.*

Material and Methods. *The research group consisted of 132 children, age 9;06-12;02 (combined type – 64 children, inattentive type – 21 children, control group - 47 children). The level of sustained attention was defined as the capability to sustain attention over a long period (the 20-minute Stop Signal Task requires a high level of vigilance), and to perform effectively a monotonous, easy, but rather long task (the 20-minute Continuous Performance Task).*

Results. *The results obtained by the children from both clinical groups differ significantly in all parameters from the controls. This suggests that there exists an attention alertness network deficit in ADHD. No significant differences were observed between the combined and inattentive type.*

Conclusions. *Our results confirmed problems with sustained attention during long-lasting and monotonous tasks in ADHD children. The deficits of sustained attention in combined ADHD and inattention ADHD are alike, so those deficits are common for all children with ADHD.*

INTRODUCTION

Processes of attention are of great importance in our daily lives. Thus they also play a particular role in the functioning of a child in school age, because they determine cognitive development to a high degree. Attention may be described as a non-specific mental activity, because it always constitutes the background for other functions and processes, and does not occur in isolation. There is no possibility to observe a process of pure attention. In any case, conclusions about its quantity are drawn from the functioning of other mental processes: perception, learning, memory, mentation, etc. Mental activities always contain a component of attention (Sterr, 2004; Pąchalska, 2007; Jodzio, 2008).

Attention is defined by its main task, which is the selection of information (it also collaborates in the choice of reactions). The selective function of attention is always realized, irrespective of the process for which it constitutes the background. Thus selectivity is not one of the components or attributes of attention, but rather its basic function (see: Nęcka, 1994; Maruszewski, 1996; Strelau, 2000, Nęcka, Orzechowski, Szymura, 2006). The ineffective working of this mechanism may lead to confusion in information processing. This kind of problem affects children and adults with ADHD.

Secondary to selection in attention is the function of estimating the value or valence of stimuli, and using important pieces of information to build structures of knowledge and control behavior (Maruszewski, 1996). There are two mechanisms engaged in information evaluation. The first of these is the mechanism of central management of mental resources, also called attention resources allocation (Kahneman, 1973, cited by Nęcka, 1994). It is assumed that the human brain has limited attention resources, which results in the need to manage them, especially when the situation requires performing several activities at the same time. Thus, depending on stimuli importance and the requirements concerning their processing, energy resources are assigned in parcels (attention divisibility). Another attention mechanism involves sustaining permanent readiness to work steadily for certain and usually long periods of time (sustained attention) (Nęcka, 1994). Its effectiveness can be effected by fatigue, lapse of time, and automation (improvement of action due to practice).

Apart from analyzing attention in terms of its psychological structure, attempts have been made to identify its neuronal basis (Łuria, 1976; Fernandez-Duque, Posner, 2001; Mirsky 1989; Pąchalska, 2007; Pąchalska, MacQueen, 2005). In Posner's significant conception of attention (Fernandez-Duque, Posner, 2001) three neural networks connecting anatomic regions engaged in attention are distinguished:

1. a network of orientation to sensory stimulus;
2. a network for maintaining alertness;
3. the network for organizing the operations necessary to perform complex daily life tasks.

For the present purposes, the alertness network will be characterized more precisely. This is the capacity to achieve and sustain an alert state. Alertness is responsible for turning on the waking state and maintaining preparedness to react. The alertness network allows the organism to achieve tonic and phasic arousal. Tonic arousal is keeping a constant level of activation, which allows one to stay mentally active for longer periods of time. Reading a book, for instance, is made possible only by this mechanism. Phasic arousal has a more specific nature, and is evoked by a definite kind of stimulus. For example, when we are waiting in a crowd for somebody who is supposed to be wearing a brown coat, the arousal will have a particular character, because first of all it will concern activation of the regions which are involved in visual functions. These regions – due to the requirements of the situation – will be activated to work in an especially attentive way.

To assess the alertness network, two types of tasks are used: tasks requiring caution and tasks of continuous performance. The first type allows us to evaluate how fast the subject reaches a maximum level of readiness after receiving a warning signal that a reaction is needed. This way phasic arousal is assessed. The tasks of continuous performance investigate sustained attention during a situation that requires remembering to detect a stimulus of slight intensity, thus difficult to notice, or occurring rarely. Another kind of task is one that requires continuous reactions for a longer time. The participants are supposed to keep vigilance and ignore unimportant pieces of information.

Disturbances of sustained attention in children with ADHD

Attention Deficit Hyperactivity Disorder is a neurodevelopmental disorder, characterized by stable behavioral patterns in the form of motor hyperactivity, impulsiveness and inattentive behavior (Wolańczyk et al., 1999; Wolańczyk, Komender, 2004; Borkowska, 1999, 2003; Święcicka, 2003). The symptoms that comprise inattentive behavior include problems with focusing on a task and in sustaining attention over a long period, even in advantageous external conditions. There is also a characteristic excessive distractibility under the influence of other, unimportant stimuli. In short, the mechanism of attention selection works ineffectively. Thus attention processes are one of the main variables that form and determine the clinical picture of ADHD.

From among the axial symptoms, several seem to be connected with sustained attention deficits, including:

1. The child often has problems with sustained attention in tasks or entertainment activities (i.e. games).
2. The child often does not comply with commands, does not follow instructions, and does not complete schoolwork, tasks and duties, but this does not result either from a resistant attitude towards authority, or misunderstanding of commands.
3. The child does not like and often avoids occupations that require sustained intellectual effort (i.e. doing homework or reading).

In the diagnostic criteria provided by DSM-IV-TR and ICD-10, the symptoms of inattentive behavior reflect disorganized child behavior, arbitrarily attributed to attention dysfunction. However, the behaviors described as inattentive are not necessarily linked with a dysfunction of the basic process of attention, or with the neural networks responsible for attention itself. They may be related to other dysfunctions, such as impairments of inhibition and memory, or to psychological mechanisms, such as motivation disturbances (Huang-Pollock, Nigg, 2003; McDonald et al., 1999). Researchers also emphasize the role of executive dysfunctions (Barkley, 1997), excessive or inadequate arousal (Zentall, Zentall, 1983), faulty allocation of effort during motor behavior (Sergeant, Oosterlaan, van der Meere, 1999), or inappropriate responses to reinforcement (Newman, Wallace, 1993) and other disorders.

The question remains, if and how far the components of attention processes in ADHD (including sustained attention) are disturbed. So far the results of published studies have been ambiguous, although the majority of researchers (with regard to the essence of the disorder) simply assume the existence of such difficulties in ADHD ex hypothesi. Several scales and measures of alertness have been used. In the investigation by Huang-Pollock et al. (2000), while assessing reaction time of children in several blocks of trials (tonic arousal), no differences between ADHD and non-ADHD children were observed. This suggests that this component of attention works properly in ADHD. Similar results were obtained by Sergeant, Oosterlaan and van der Meere (1999). They suggest that ADHD is not characterized by dysfunction of sustained attention or vigilance. In the studies by Westerberg, Forssberg and Klinberg (2001), the quality of reactions was compared in the Continuous Performance Test, go-no/go tasks, and a visuospatial working memory test. The rate of processing was measured by reaction time and inhibition control. The results showed statistically significant differences between children with ADHD and without deficits only in visuospatial working memory test and reaction time. Neither CPT nor go-no/go tasks differentiated the groups.

Another method used to assess sustained attention was the Gordon Diagnostic System (GDS). It measures:

1) the level of reaction effectiveness (proportion of correct and incorrect responses);
2) the ability to sustain attention (number of correct responses);
3) the ability to control impulses (number of overreactions).

El-Sayed et al. (1999) used GDS in studies of Swedish children. All the respective scale results were lower in children with ADHD. According to these authors, this shows that the process of forming mature forms of attention is slower in such children. Gordon, the author of the method (from: Wada et al., 2000) stated that omission errors, average reaction time and diversity of reaction time were higher in the group of ADHD children. His studies involved children with ADHD, oppositional defiant disorders, conduct disorders, and learning disabilities. He claimed that results more than 1.5 standard deviations below the norm are characteristic for 80% of children with ADHD, and for 72% of other clinical groups.

TOVA is also a kind of continuous performance test. The research by Wada et al. (2000) revealed statistically significant differences between all measures in a test that covers omission errors, overreactions, response time and diversity of reaction time. Reaction time decreased with age in the control group, but there was no such tendency in the group of ADHD participants. Moreover, there were no differences determined by age in any of these parameters. The authors conclude that TOVA is useful in ADHD diagnosis. They also confirm that there are deficits of sustained attention in this clinical group.

In studies over the second function of alertness – the system of phasic arousal, for which there is slower mean reaction time and greater variety than in healthy children – longer reaction times were observed in children with ADHD. This shows that there is a deficit of this aspect of the alertness system (Tomporowski et al., 1994; Wood et al., 1999).

Summing up, the results of research performed to date do not allow for an unequivocal statement as to whether or not there are deficits of sustained attention (vigilance) in children with ADHD, or how extensive they are. Probably one of the reasons for such discrepancies is that the subtypes of ADHD have not been taken into consideration. This study was undertaken to fill that gap. Its aim was to assess this aspect of attention among children with two ADHD subtypes: inattentive type (predominantly symptoms included in inattentive behaviors) and combined type (with co-occurring symptoms of hyperactivity, impulsiveness and inattentive behaviors).

MATERIAL AND METHODS

Subjects

The experimental group consisted of children with a clinical diagnosis of ADHD. The diagnosis of ADHD was made according to standard procedure, using

1) a diagnostic interview with parents and the child based on DSM-IV criteria; its aim was to evaluate symptoms of hyperactivity, impulsiveness and inattention, and to determine how the symptoms influence the child's functioning at home, at school and in the peer group, and if they cause major disturbances in the child's functioning in the most important activity domains;
2) interview with parents, related to psychiatric, neurological or psychological consultations;
3) interview with parents oriented towards other neuropsychiatric disorders or somatic diseases and methods of treatment;
4) detailed developmental interview with parents;

5) written interview with a teacher (form-master) concerning the child's functioning at school, and information as to if and how far the symptoms hinder or prevent the child from achieving optimum learning results;
6) clinical observation of the child.

As a supporting method, the Scale of Psychomotor Hyperactivity – Version for Parents was used. It was assumed that the quantitative indexes for the intensity of axial symptoms will be data from the Scale of Psychomotor Hyperactivity – Version for Parents. Inclusion in the clinical group and ADHD types was based on DSM-IV criteria. Children with co-occurring language disorders were disqualified. The group with ADHD included participants who fulfilled the following conditions:

A. Diagnostic criteria of DSM-IV were fulfilled - at least six in the sphere of inattention and at least six in hyperactivity-impulsiveness or symptoms in both spheres.
B. Children who were characterized by six or more symptoms in an inattentive sphere and less than six symptoms in a sphere of hyperactivity-impulsiveness were classified in a group of hyperactive inattentive children, ADHD/N
C. Children who were characterized by six or more symptoms in the sphere of hyperactivity-impulsiveness and six or more in the inattention sphere were classified into a group of children with full-symptomatic hyperactivity syndrome, ADHD/P.
D. There was no case where at least six symptoms of hyperactivity-impulsiveness and less than six symptoms of inattention were simultaneously observed. Thus no impulsive group was distinguished.
E. Symptoms of anomalous behavior have occurred for more than a year (parents reported objectionable behavior that has lasted from the preschool period or from the beginning of primary school).
F. Both in the home environment and other domains of the child's life, the symptoms hampered or made impossible proper functioning.

Since ADHD diagnosis requires excluding sources of behavior similar to those which appear in other nosological entities or developmental disorders, the following procedure was applied. On the basis of psychological observation and the interview with a child, as well as a detailed developmental interview with parents and medical consultations (paediatrician and in several cases also the child's psychiatrist), children with symptoms of somatic diseases and mental disorders were excluded. The following problems were the causes of such exclusion: thyroid diseases, adenoids, dermatological and parasitic diseases, malnutrition, epilepsy, abuse of intoxicating substances, disturbances of affectionate relationship in childhood, battered child syndrome, posttraumatic stress disorder, nocturia, bipolar disorder, and anxiety disorders. In ambiguous cases, where other serious somatic or mental disorder was difficult to exclude, the child was disqualified from the research group. These children did not take any medicines. Neither neurological disorder nor mental impairment was diagnosed. There were also no documented skull or brain injuries.

The research group consisted of 132 children, ranging in age from 9;6 to 12;2. In the hyperactivity group of combined type (ADHD/C) there were 64 children, including 59 boys and 5 girls; the group of inattentive type (ADHD/I) consisted of 21 children (17 boys and 4 girls). The control group of participants with no disorders (CONT) composed of 47 children - 40 boys and 7 girls. The general characteristics of the study group in respect to symptom intensity, age and intellectual level is provided in table 1.

An analysis of differences between groups performed with the ANOVA Kruskal-Wallis test showed that all general parameters in the Scale of Psychomotor Hyperactivity differentiate in a statistically significant way five analyzed groups:

- OLP (H=78.80 p<0.000),
- LPN (H=68.33 p<0.000),

Table 1. Results in the primary parameters of the Scale of Attention Deficit Hyperactivity Disorder obtained by children from the three research groups

Parameter	ADHD/C N=64		ADHD/I N=21		CONTROL N=47		H (2;132)	P
	Mean	SD	Mean	SD	Mean	SD		
OLP	41.03	6.68	27.40	7.41	11.76	5.81	56.70	0.000***
LPN	21.85	3.83	19.46	3.39	7.16	4.18	49.31	0.000***
LPI	19.20	4.10	9.66	3.63	4.60	2.27	58.35	0.000***
LKN	8.03	1.34	7.20	1.26	1.40	1.97	48.43	0.000***
LKI	7.09	1.43	2.73	1.57	0.64	1.03	64.68	0.000***
Age (months)	136.14	10.86	141.33	12.17	138.51	9.66	6.53	0.056 in.
IQ gen	110.35	12.65	108.31	13.92	112.78	11.33	1.32	0.722 in.
IQ v.	110.05	15.06	110.02	15.91	112.57	12.91	1.17	0.759 in.
IQnv.	109.09	10.19	104.84	13.44	111.75	12.91	2.57	0.311 in.

OLP – overall number of points obtained in the full scale
LPN – number of points obtained in the scale of inattention
LPI – number of points obtained in the scale of hyperactivity-impulsiveness
LKN – number of accepted diagnostic categories in the scale of inattention
(behaviors assessed as occurring often and very often)
LKI - number of accepted diagnostic categories in the scale of hyperactivity-impulsiveness
(behaviours assessed as occurring often and very often)
IQ gen. – full intelligence quotient
IQ v.. – intelligence quotient in verbal scale
IQ nv. – intelligence quotient in non-verbal scale
in. – difference statistically insignificant
*** - difference significant at the level of p<0.001

- LPI (H=72.38 p<0.000),
- LKN (H=68.33 p<0.000),
- LKI (H=80.64 p<0.000).

This suggests that the selection to the clinical and control groups was correct. Age and intelligence measured with the WISC-R did not differentiate the research groups. Thus it may be assumed that these variables will not significantly influence the results of the research.

The method used to assess the children's capacity for continuous sustained attention was a computer task of continuous performance and a task of stopping to a signal.

Continuous Performance Task – CPT

The Continuous Performance Task (CPT) is a method applied to assess alertness and to investigate sustained attention and its deficits. There exist many versions of the task, which differ in the kind of modality engaged (auditory versus visual) (Ballard, 2001), as well as duration and test material (letters versus images). The essence of the task is a common feature of all methods. The participant is asked to look at the computer screen, where various stimuli occur in a certain sequence, and to execute a particular motor reaction (most often press a key) when he or she sees a so-called "critical stimulus." In other cases the person should not react at all. There may appear two kinds of errors in the method:

- omission errors, when a key is not pressed although the critical stimulus occurs
- overreaction errors, when a key is pressed although a stimulus other than the critical stimulus is seen.

Reaction time is a period of lag between the appearance of a critical signal and the motor reaction of the subject.

The results of many studies have revealed that children with ADHD make more omission and overreaction errors in CPT than their healthy peers. Some authors have found such a difference only in regard to omission errors or false alarms, but others did not observe any significant disparities (Schachar et al. 1995). It is questionable if children with ADHD are characterized by a greater – in comparison with healthy children – decline in the capacity to make correct reactions to stimuli as the test goes on.

In our research the following parameters of performance in CPT were assumed:

1. the number of correct reactions;
2. the number of incorrect reactions, where three kinds of errors were distinguished:
    - omission errors (no reaction to letter X following A)
    - overreaction errors to letter X
    - overreaction errors to another letter
3. average reaction time.

Stop-Signal Task

The SST is a main measure of the capacity to inhibit reaction, but one of the results obtained in this task may be used as a sustained attention index. The task in its first part lies in a simple motor reaction (pressing a key) when a particular stimulus occurs on the computer screen. In the second part, the participant is supposed to abstain from such motor reaction whenever the visual signal occurs simultaneously with an auditory stimulus (a simple sound). The sound is a signal to stop the reaction. Such a task, which consisted of 500 stimuli, required from the participant a high level of alertness for the whole time of the study (up to 20 minutes). In the SST, the index of the capacity to sustain attention was the number of stimuli to which a participant reacted (irrespective of their correctness).

RESULTS

The first index of CPT accomplishment was the number of correct and incorrect reactions. Fig. 1 illustrates the proportion of correct to erroneous reactions in the study groups.

The height of these columns is very diverse, because it depends on the total number of all reactions, which was a sum of correct and erroneous reactions. The maximum number of correct reactions was 48. If a child performed many more reactions (that is, he or she carried out too many incorrect reactions), the total number was higher than 48. When the task was finished before the end of the allotted time (the child was not able to complete the task because of serious deficits of sustaining attention), the total number of reactions might be less than 48 (however, such situations were relatively rare). For that reason the graphs show only the proportion of correct to incorrect reactions (without specification of error sorts). Children with hyperactivity of a combined type performed relatively the most erroneous reactions in relation to correct reactions. A slightly better result was obtained by children with

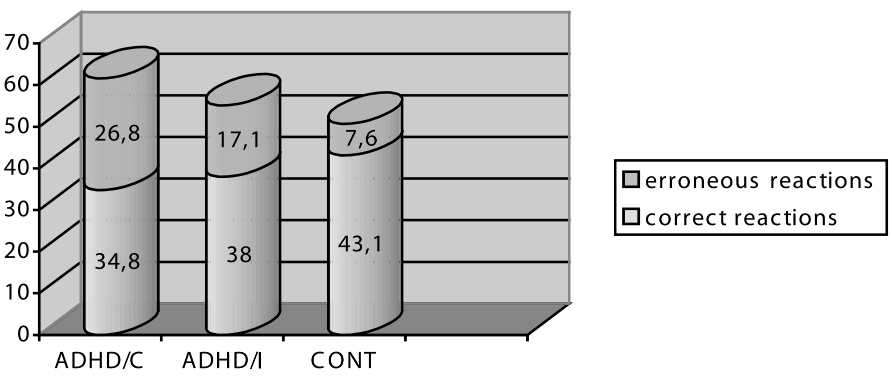

Fig. 1. Proportion of correct to erroneous reactions in the CPT in the three study groups

hyperactivity of the inattentive type, and the best outcome was reached by children without disorders.

During the task, the children made three kinds of errors:

- omission errors (no reaction to letter X following A); it was assumed that they show deficits of attention focusing for a longer period of time, that is, deficits of sustained attention;
- overreactions to letter X - showing difficulties in attention and a lack of focusing on a stimulus, in connection with working memory;
- overreactions to other letters, which is an index of impulsivity, that is, problems with inhibiting a reaction to a stimulus that should not elicit any reaction.

Thus each of these kinds of errors is an indicator of a somewhat different deficit.

A specification of error sorts is given in table 2.

An analysis of the results presented in the table indicates that the total number of errors turned out to be the highest in children with ADHD/C. A lower number was noticed in the group of inattentive children, and the best outcomes were obtained by control participants. The particular types of errors occurred proportionally to their total numbers. All the parameters significantly differentiated the study groups. For the total errors, $H = 36.64$, $p<0.001$; for omission errors, $H = 24.24$, $p<0.001$; for overreactions to X, $H = 21.89$, $p<0.001$; and for overreactions to other letters, $H = 26.29$, $p<0.001$.

An analysis of the differences between the groups is contained in table 3.

Children with ADHD of combined and inattentive type differed significantly from control children in all parameters in the CPT. First of all, they were characterized by longer average reaction time than children in the control group. This outcome may be interpreted as an index of a slower process of phasic arousal, which should appear as a result of the perception of an important stimulus. Children from both clinical groups displayed significantly fewer correct reactions and significantly more erroneous reactions. This may

Table 2. Means and analysis of differences between the groups in the aspect of total error number and their sorts in CPT (comparison made with ANOVA Kruskal-Wallis test)

	ADHD/C		ADHD/I		CONT		H (2;132)	p
	mean	SD	mean	SD	mean	SD		
Total	26.87	19.93	17.1	11.23	7.63	6.40	36.64	0.000***
Omissions	10.75	7.72	7.35	5.26	3.36	3.0	24.247	0.000***
Overreactions to X	9.82	10.77	7.20	10.02	3.33	3.23	21.892	0.000***
Overreactions to other letters	6.05	7.85	2.85	2.20	0.87	1.63	26.290	0.000***

*** - difference significant at the level of p<0,001

Table 3. An analysis of the differences between the groups in rates of average reaction time and number of correct and incorrect reactions in CPT (comparison made with Mann-Whitney U test)

	ADHD/C ADHD/I		ADHD/C CONT		ADHD/I CONT	
	z	p	z	p	z	p
Average reaction time	-0.121	n.s.	3.520	0.000***	2.110	0.034*
Number of correct reactions	-1.475	n.s.	-4.697	0.000***	-2.458	0.013*
Total number of incorrect reactions	1.847	n.s.	5.417	0.000***	3.972	0.000***
Number of omission errors	1.469	n.s.	4.784	0.000***	2.917	0.003**
Number of overreactions to X	1.038	n.s.	3.597	0.000***	2.596	0.009**
Number of overreactions to other letters	1.362	n.s.	4.693	0.000***	2.926	0.003**

* - difference significant at the level of $p<0.05$
** - difference significant at the level of $p<0.01$
*** - difference significant at the level of $p<0.001$
n.s. – difference not statistically significant

give evidence for a deficit of sustained attention in the domain of tonic arousal. In the analysis of the kinds of incorrect reaction, in terms of sustained attention deficits, omission errors seem to be the most important. These children did not react to a stimulus, because they did not "notice" it, which resulted from turning off attention. In respect to deficits of reaction inhibition, overreaction errors are the most significant. The overreactions which followed X show the children's difficulties in attention, as well as a lack of focusing on a stimulus in connection with working memory, because it means that the children did not perceive and did not remember the preceding letter. Only a reaction to X following A was proper. Other overreactions should be treated as an indicator of impulsiveness, because the children were not able to inhibit responses, although the signal was given not to initiate a reaction.

Stop-Signal Task

This task consisted of 500 stimuli, thus the maximum number of reactions amounted to 500 as well. The difficulties in the entire task performance constitute an index of problems with sustained attention. The diagram presented below illustrates the percentage of children who displayed a particular number of reactions. To show the result, three categories of stimuli were distinguished (R):

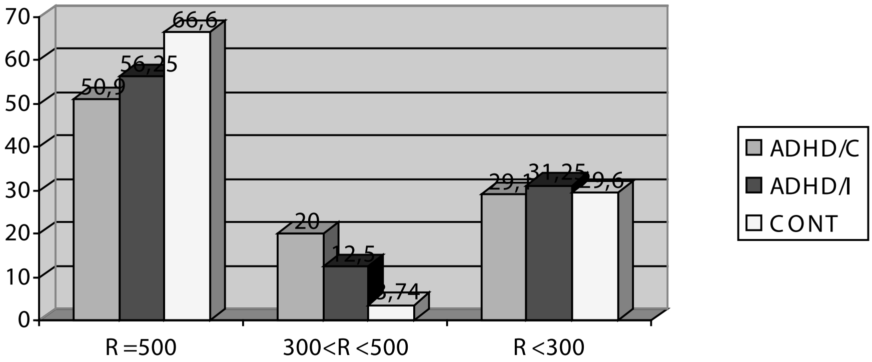

Fig. 2. Percentage of children who displayed a particular number of reactions

1) completed task, R=500;
2) reactions to 300 to 500 stimuli, 300<R<500;
3) less than 300 reactions, which means interrupting a task after a little more than half has been performed, R<300.

The data in the diagram show that in all our study groups the highest percentage of children executed the entire task. However, full performance was noticed only in 50.9% of the children with full-symptomatic ADHD. The task was completed by somewhat more participants from the inattentive group (56.25%). All reactions were displayed by an even higher proportion of children from the control group (66.66%). Statistically significant differences were only observed between the control and ADHD/C groups ($p<0.05$). Similarly, the percentage of children in the group with ADHD of the combined type, who reacted 300 to 500 times, proved to be significantly higher than in the control group ($p<0.001$).

The graph also reveals a distinct tendency showing that if a child did not complete the task, he or she interrupted the task after half had been done, so he/she reacted to less than 300 stimuli. The percentage of children who behaved this way (30%) is similar in all three study groups (the differences did not reach the level of statistical significance).

DISCUSSION

The results presented here contribute to the discussion over sustained attention deficits in ADHD children. In our research, several aspects of the alertness of the attention network were assessed. The outcomes obtained in the Stop-Signal Task show the difficulties of these children – both with combined and inattentive type – in a situation that requires long-lasting effort. From a practical point of view, this is a crucial factor in hyperactive children's daily functioning. Parents, caregivers and teachers very often stress that hyperactive children do not complete activities when they last too long and require a major intellectual effort. Then these children need a rest more often than other children, due to fatigability, and they do not finish a task despite exterior motivation. Such a result may confirm an assumption concerning a possible energy deficit in ADHD, formulated by Oosterlaan and Sergeant (1998). These authors consider three energy domains crucial for tasks performance: effort, arousal and activation. An effort is understood as the energy necessary for coping with task requirements to perform well. The cognitive complexity of a task is a variable that influences and shapes effort. This is most noticeable when the state of the organism is not sufficient to meet the challenge of a task. Arousal is a phase reaction, and the time reserved to process a stimulus. One factor that affects arousal is the quality of incoming stimuli - novelty and intensity increase arousal. Activation is identified with tonic changes of physiological activity, which constitutes preparation for motor reaction. Effort mainly influences the central processing of a stimulus, arousal affects stimulus decoding (separating a stimulus from information noise), and activation influences reaction organization. Effort also has an influence on arousal and activation. If our ADHD children did not complete a task, this may signify that their arousal state was too low to perceive and process stimuli adequately. They exhibited this as weariness, especially because the experiment involved a typical situation of homogenous stimulation of a tiresome and non-activating nature. This kind of situation, in accordance with the model's assumptions, is not conducive to increased arousal - on the contrary, it leads to reduced arousal. At the same time, the situation requires a permanent alert state and concentration (effort), due to the need to inhibit reaction when the signal STOP occurs.

Thus the energy state in the domain of effort may have influenced the task performance. The results obtained in the CPT show, among other things, that longer average reaction time occurs in children with ADHD. This suggests problems with phasic arousal in the alertness network. The appearance of a stimulus that should elicit a reaction evokes phasic arousal to an insufficient degree. A significantly higher number of omission errors in comparison to healthy children confirms the assumption that there are also deficits of tonic arousal. Thus our children with ADHD, irrespective of type, turned out to have problems with sustained attention during a long-lasting and monotonous task. The efficiency of their work was significantly worse than that of healthy children. Such results may be translated to the school functioning of these children. This means that, if a school situation requires long work (15-20 minutes), the efficiency of the ADHD child's performance may be low, owing to the fast drop-off of arousal. Parents' and teachers' awareness of such a deficit should result in the adjustment of concentration demands to individual capabilities. It is crucial not only to make intervals, but also change the kind of activity, which will automatically evoke the rise of phasic and tonic arousal.

Taking into consideration the discussion over mechanisms affecting the clinical picture in two ADHD groups, combined and inattentive type, the lack of statistically significant differences in all parameters seems to be essential. The task of continuous performance is therefore not a method that enables differential diagnosis of different ADHD clinical groups. On the other hand, the results indicate that the deficits of sustained attention in these groups are alike.

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