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AGE-RELATED CHANGES OF HIGHER MENTAL FUNCTIONS IN 7–9-YEARS OLD CHILDREN WITH DIFFERENT TYPES OF STATE REGULATION DEFICITS

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Abstract

The topic of this paper is an analysis of the developmental changes in cognitive functions in children with poor state regulation (function of the first – energetic unit of the brain, according to A.R. Luria). The article is based on clinical and experimental psychological research. The neuropsychological battery of tests for 5-9 years old children is used as well as 2 computer-based tests: the modified variant of the test “Dots” and a computer-based version of tests for performance efficiency measurement — Schulte-Gorbov tables. One hundred seventy three primary school children from the 1st and the 3rd grades participated in the study. The results displayed the presence of two variants of state regulation deficits: children with slow processing speed and mental fatigue, and children with hyperactivity and impulsivity. On the whole, the children with a deficit in the first functional unit are characterized by difficulties when performing energy demanding tasks, the faster onset of exhaustion, a low (in the group with slower processing speed) or fluctuating (in the group with hyperactivity) speed of performance, a dependence on motivation and emotional state, a deficit in executive functions and the capacity to process kinesthetic information. The majority of children in both groups had learning disabilities. The analysis of the specific characteristics of variants shows that children with slow processing speed in the 1st and the 3rd grades perform the tasks the slower and the worse, the more energy-demanding the task is. In this group the increase in symptoms of deficits in executive functions may be linked to the intensification of anxiety. In hyperactive children with a discrete executive functions deficit, the capacity to perform tasks produces an inverted U curve on the graph, according to the tasks’ level of complexity. They perform the simplest tasks less capably than normal children because of poor motivation, and decrease the results in the most complex tasks because of high energy demands of such tasks.

Keywords: state regulation deficits, activation/arousal, hyperactivity, slow processing speed, learning disabilities, ADHD.

The role of deficits in state regulation (functions of the first brain unit, according to A.R. Luria) in the mechanism of ADHD and learning disabilities is currently increasingly discussed in the literature. Evidence of first brain unit deficits is the most frequently observed psychological problem of children who struggle in school (Pylaeva, 1998; Akhutina, Pylaeva, 2012). It appears that these symptoms are somehow inherent in most children with learning disabilities (Akhutina, Matveeva, & Romanova, 2012; Waber, 2010). The converse is also true. Among children with pronounced activation deficits, there are exceptionally large numbers of those who are unsuccessful in learning (Glozman, Ravich-Shcherbo, & Grishina, 2007). The literature shows that ADHD and learning disabilities may be linked to state regulation deficits within their brain mechanisms (Richards, Samuels, Turnure, & Ysseldyke, 1990; and others). In this regard, the question of slow processing speed among children with a variety of developmental disorders (ADHD and others) is widely discussed (Willcutt, Sonuga-Barke, Nigg, & Sergeant, 2008; Weiler, Bernstein, Bellinger, & Waber, 2000, 2002) The suggestion that ADHD and learning disabilities share a common deficit (Pennington, 2006; Shanahan et al., 2006; McGrath et al., 2011) sheds light on possible mechanisms of co-morbidity within these disorders which is now estimated at 45.1% (DuPaul, Gormley, & Laracy, 2013). In children with dyscalculia, dyslexia and dysgraphia difficulties of automation, the shift from the *controlled* extensive energy consuming performance of tasks involved in learning, to condensed *automatic* skills are demonstrated (Waber, 2010). And deficiency of such a shift increases the demands to activation processes. This may lead to their overload.

The dysfunction of the state regulation processes is seen in ADHD on the level of short-term orientation responses to stimuli (arousal), as well as on the level of stable maintenance of a required working state (activation, vigilance). This is true for children with combined dysfunction of behavior and attention (ADHD) and for children with attention deficit disorder without hyperactivity (ADD) (Brown, 2005; Sergeant, 2000, 2005; van der Meere, 2005; Nigg, 2005). Modern researchers give much attention to the symptoms of sluggish cognitive tempo, determining them either as significant symptoms for ADD diagnostics, or an indicator of a special variant of activation deficit, distinct from ADD (McBurnett, Pfiffner, & Frick, 2001; Barkley, 2014; and others). Thus, according to researchers, activation regulation deficit may be manifested differently and be one of the most essential mechanisms in the origin of ADHD, learning disabilities and co-morbid behavioral disorders. Its study is an important task for the modern child neuropsychology.

The *objective* of the current article is the study of different variants of state regulation deficit in younger schoolchildren and of the influence this deficit exerts on other cognitive functions.

Methods

The neuropsychological battery of tests for 5–9 years old children (Akhutina, Polonskaya, Pylaeva, & Maksimenko, 2008, Akhutina et al., 2012; Polonskaya, 2007) were used for the assessment of higher mental functions, as well as computerized methods of examination of functions of the first and third brain units. They are a modified version of the computer-based test “Dots” (Davidson, Amso, Anderson, & Diamond, 2006; Diamond, Barnett, Thomas, & Munro, 2007) and the computer-based version of the measurement of working efficiency and voluntary attention — the Schulte-Gorbov tables (Gorbov, 1971).

The *neuropsychological assessment* included 20 tests to examine various components of higher mental functions (HMF). The data of these tests was evaluated within 225 parameters that included productiveness of performance and the various errors committed. The parameters, that reflected the state of the studied components of HMF most specifically, after standardization procedures were summed to calculate the following indices: 1) programming and control functions of the third unit (executive functions), 2) serial organization of movements, 3) processing of kinesthetic, 4) auditory, 4) visual and 6) visuospatial information. The higher the index, the worse the state of HMS was observed.

During the assessment, as well as the traditional analysis of performance tests, the child's behavior patterns reflecting state regulation levels, were recorded. These symptoms included slow tempo, fatigability, hyperactivity, impulsivity and perseverative behavior. To assess hyperactivity and impulsivity diagnostic characteristics from DSM-IV were used. Each parameter was estimated in a 4 point scale, where 0 showed minimal degree of symptom severity, and 3 showed maximal degree. After standardization of these parameters the sum of them was counted for each child and it formed the integral index of the first brain unit. Besides, 5 listed measures underwent factor analysis (principal component analysis) with varimax rotation. In result 2 factors were extracted, which explained 71% of variance. Factor loadings after rotation are shown in the Table 1.

Factor 1 has high loadings on slow cognitive tempo, fatigability and perseveration variables, which permits it be named as a factor of slow tempo. Factor 2 has high loadings on hyperactivity and impulsivity, and it was interpreted as the general factor of hyperactivity[1]. Two independent indices were formed on the basis of these results, which

Table 1

Factor loadings matrix

	Factor 1	**Factor 2**
Slow tempo	0.825	–0.252
Fatigability	0.816	0.257
Perseverative behavior	0.747	0.224
Impulsivity	0.090	0.829
Hyperactivity	0.070	0.872

[1] The loadings of indices of hyperactivity and impulsivity on one factor coincide with the typical picture of combination of symptoms of hyperactivity/impulsivity in ADHD, which allowed us to keep the term hyperactivity for the naming of the factor and for the children covered by this factor. Their symptom-complex coincides with the clinical picture of ADHD, though ADHD was never diagnosed in them by medics. The first-graders didn't have the necessary observation of symptoms during 6 months, and it was impossible to send to the doctor the third-graders that were included in the group of hyperactive children without bringing this to the attention of other children, which would stigmatize them.

reflected the condition of the functions of energetic unit: the index of slow tempo and the index of hyperactivity. Thus, in whole for description of HMF state 9 indices were used: 3 for the first unit and 6 for the second and third units.

The computer-based test "Dots" consists of 3 subtests. In the first (congruent) subtest the stimulus (red heart) appears on the screen either left, or right (quasi-randomly); a child has to press the key on the keyboard of the PC as quick as possible with his left or right hand from the side where the stimulus appeared. In the second (non-congruent) subtest with the appearance of the stimulus (blue flower) one has to press the key on the opposite side of the keyboard. In the third (mixed) subtest congruent and non-congruent stimuli appear randomly. We evaluated the efficiency of performance (number of correct answers in each subtest) and the mean time for correct answers. The second and the third subtests allow evaluating the ability to switch and inhibit inadequate response (executive functions of the third brain unit). The third test is energy-consuming and sensitive to the state of functions of the first brain unit.

The test "Schulte tables" consists of 5 subtests. In each subtest a table appears on the screen of the tablet PC. The table consists of 20 (5 x 4) cells, in which 2 sequences of numbers from 1 to 10 are placed at random, one sequence is of black numbers and another sequence is of red numbers. Children were asked to find and touch with the finger as quickly as possible numbers in the following order: 1) black numbers in ascending order; 2) red numbers in ascending order; 3) black numbers in descending order; 4) black and red numbers in ascending order (parallel sequences); 5) red numbers in descending order. The mean time of choices in each of the 5 subtests (in ms) and total number of mistakes (omissions, perseverations, program malfunctions) were measured.

The proposed set of tasks allows the evaluation of the children's ability to master (1) the simple programs of ascending order (the 1st and the 2nd subtests), the more complicated descending (the 3rd and the 5th subtests) and the most complex parallel (the 4th subtest) programs, (2) to switch from one program to another, (3) to inhibit inadequate answers (functions of the third brain unit). Long duration of work in all the subtests, which demanded stable attention, gave the possibility to assess the processes of activation (the first brain unit). Both computerized tests enabled to trace the state of the first and third functional units. We hypothesized that within children showing deficits in first unit, the deficiencies of functions of the third brain unit may be either secondary or a combination of the secondary and the primary disorders.

The *sample* consisted of 92 first-graders (45 boys, 47 girls) and 81 third-graders (35 boys, 46 girls) from the Moscow schools. According to the expert assessment of their teachers, the analysis of the marks in the third grade and results of tracking diagnostics (analysis of behavior at school and of mistakes in exercise books) among the participants of the experiment, children with learning disabilities were found (31 and 27 people in the 1st and the 3rd grade accordingly).

On the basis of the 2 indices of functions of the first brain unit (index of slow tempo and index of hyperactivity) the sample was divided into 3 groups. Those children were assigned to the group representing the norm from the point of view of activation components of HMF, whose values in integral indices of hyperactivity and slow tempo didn't exceed the sample average by more than 0.5 of the standard deviation (further — group N, or control group, the 1st grade — 52 children, the 3rd grade — 47 children). To the group of hyperactive children those children were assigned whose index of hyperactivity exceeded average in the whole sample by more than 0.5 of the standard deviation and was higher than the index of the slow tempo (further — group H, the 1st grade — 14 children, the 3rd grade — 19 children). At last, the group with slow cognitive tempo consisted of those, whose index of slow tempo exceeded average in the whole sample by more than 0.5 of the standard deviation and was higher than the index of hyperactivity (further — group S, the 1st grade — 26 children, the 3rd grade — 15 children).

Results

According to the results of the assessment and calculation of indices which showed the state of various components of HMF (Akhutina et al., 2012), the neuropsychological profiles of hyperactive and slow schoolchildren of the 1st and the 3rd grade were built (Figures 1A and 1B).

The results of ANOVA (analysis of variance) in the 1st grade (see Figure 1A) showed that the factor GROUP has a significant influence on the state of executive functions ($F(2, 87) = 6.265$, $p = 0.003$) and on functions of the processing of kinesthetic information ($F(2, 87) = 4.871$, $p = 0.01$). Additional pairwise comparisons of groups with Tukey's Multiple Comparison test showed that the group of hyperactive children received significantly worse marks in comparison to slow children on integral index of the first brain unit ($p < 0.001$). Hyperactive children also significantly differed from the control group on the indices of executive functions ($p = 0.004$). Slow children in comparison with the children from the control group had lower marks for processing of kinesthetic information ($p = 0.014$) and had subsignificantly lower marks for executive functions ($p = 0.086$).

However, in groups H and S from the 1st grade no statistically significant differences were found in any indices of neuropsychological assessment.

The results of the similar ANOVA in the 3rd grade (see Figure 1B) showed that the factor GROUP has significant influence on the state of executive functions ($F(2, 77) = 6.588$, $p = 0.002$), functions of processing of kinesthetic ($F(2, 77) = 16.243$, $p < 0.001$) and visual ($F(2, 77) = 7.071$, $p = 0.002$) information. Additional pairwise comparisons of the groups with Tukey Multiple Comparison test showed that children of the groups H and S significantly differed from the group N on the indices of processing of kinesthetic information ($p < 0.001$ in both groups) and executive functions: slow children had significant difference ($p = 0.003$), hyperactive children had subsignificant differences ($p = 0.084$). Besides, in children of the group H significant differences were found in processing of visual information both from the control group ($p = 0.001$) and the group S ($p = 0.031$). There were no other differences between the groups.

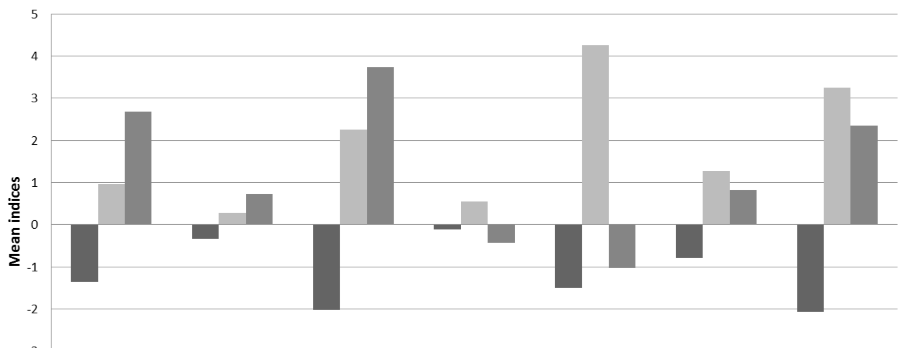
Figure 1A

Neuropsychological indices of the first-graders

	Executive functions	Serial organization of movements	Kinesthetic information processing	Auditory information processing	Visual information processing	Visuospatial information processing	Integral index of the first brain unit
N	-1.48	-0.46	-1.18	0.50	-1.18	-0.93	-2.36
H	2.90	0.91	1.30	-0.78	1.60	1.22	4.56
S	0.84	0.48	1.72	-0.52	0.87	0.72	2.26

Figure 1B

Neuropsychological indices of the third-graders



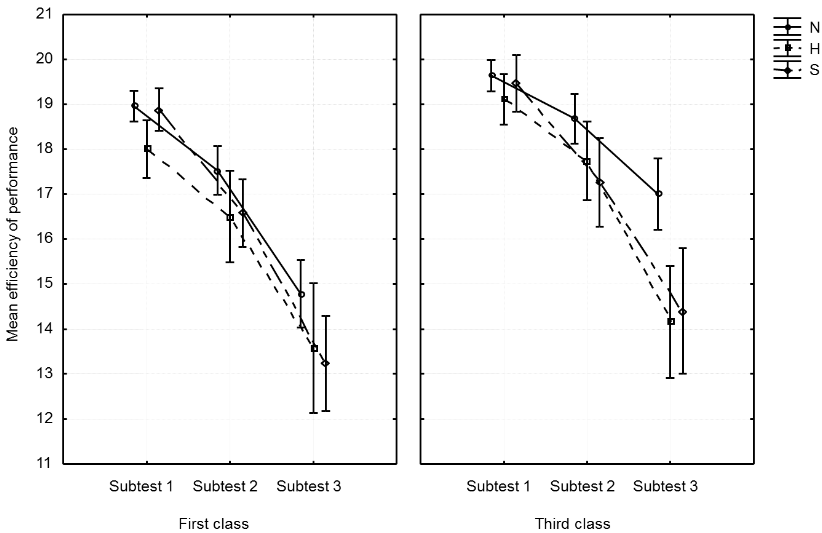
	Executive functions	Serial organization of movements	Kinesthetic information processing	Auditory information processing	Visual information processing	Visuospatial information processing	Integral index of the first brain unit
N	-1.37	-0.33	-2.03	-0.11	-1.50	-0.79	-2.06
H	0.95	0.28	2.25	0.55	4.25	1.27	3.25
S	2.68	0.73	3.74	-0.42	-1.03	0.81	2.35

The results of the test "Dots". Repeated measures ANOVA (rmANOVA) was used to evaluate the effects of the between-group factors GROUP (3 levels: N, H and S) and GRADE (2 levels: the 1st grade and the 3rd grade), as well as within-group factors in Types of Tasks (3 levels — congruent, non-congruent and mixed subtests). The dependent variables were the efficiency of performance and the mean reaction time of correct answer.

Average indices of efficiency of performance in children from various groups are shown on the Figure 2.

Figure 2

Efficiency of performance of the test "Dots"



The factor GROUP showed significant influence on efficiency of the test "Dots" performance ($F(2, 154)=16.98$, $p < 0.001$). Irrespective of the complexity of tasks children from both the 1st and 3rd grades with weaknesses in the first functional unit made significantly more mistakes during the performance of the test (results of planned comparisons: the 1st grade $F(1, 154) = 16.98$, $p < 0.001$; the 3rd grade $F(1, 154) = 17.01$, $p < 0.001$). The factor GRADE also had significant influence on efficiency ($F(2, 154) = 16.97$, $p < 0.001$): the third-graders perform the test more successfully than the first-graders. Planned comparisons demonstrated that children in the 3rd grade from the group N progressed to the maximum efficiency of performance ($F(1, 154) = 15.03$, $p < 0.001$); in children from the groups H and S the progress was less articulated, and significant differences were observed only in the group S (the group H: $F(1, 154) = 3.07$, $p = 0.08$; the group S: $F(1, 154) = 5.94$, $p = 0.02$). The factor TYPE OF TASK also influenced efficiency ($F(2, 308) = 218.94$, $p < 0.001$): with the growing difficulty of subtests efficacy of performance decreases both in the 1st and in the 3rd grade. A significant interaction GROUP×TYPE OF TASK was found ($F(4, 308) = 6.17$, $p < 0.001$). It is due to the fact that efficiency in groups with various states of functions of the first brain unit changes differently from subtest to subtest. The quality of performance of the simplest subtest is significantly lower in the hyperactive first-graders in comparison to the children from the groups N and S ($F(1, 154) = 4.62$, $p = 0.03$, the results of planned comparison, scheme H vs. N+S), but in more complex subtests effectiveness lowers already in both groups of children with deficits of functions of the first brain unit against the group N (F(1, 154) = 10.28, $p < 0.001$ and F(1, 154) = 9.32, $p = 0.002$ for the 2nd and the 3rd subtest respectively, results of planned comparison, scheme N vs. H+S) (see Figure 2). All third-graders perform equally well on the 1st simple subtest, but efficiency of the 2nd and the 3rd subtests in children with deficit of the first brain unit is significantly lower than in the group N (F(1, 154) = 6.11, $p < 0.01$ and F(1, 154) = = 17.33, $p < 0.001$ for the 2nd and the 3rd subtest respectively). All other interactions of factors are insignificant (ps > 0.4).

The mean response time in various groups of subjects are shown in the Figure 3. The rmANOVA showed absence of influence of the factor GROUP (F(2, 154) = 2.41, $p = 0.09$). However irrespective of the type of task children from the group S were slower than the successful schoolchildren from the group N (F(1, 154) = 4.54, $p = 0.03$) (see Figure 3). At the same time, significant influence of the factor GRADE on the average time to answer correctly was found: F(1, 154) = 16.06, $p < 0.001$). The most pronounced improvement of response time was found in children from the group N, in the group H it was insignificant (influence of the factor GRADE in the groups N, S and H respectively: F(1, 154) = 14.22, $p = 0.0002$; F(1, 154) = 5.21, $p = 0.02$; F(1, 154) = 2.79, $p = 0.1$). Also expected significant influence of the factor TYPE OF TASK was found (F(2, 308) = 584.16, $p < 0.001$) – with the growing difficulty of the tasks response time lengthens. Significant interactions of factors were not found (ps > 0.3).

Results of performance of the test "Schulte tables". RmANOVA was used for statistical processing of data; the factor TYPE OF TASK had 5 levels: 5 subtests of the test, and dependent

Figure 3

Response time in the test "Dots"

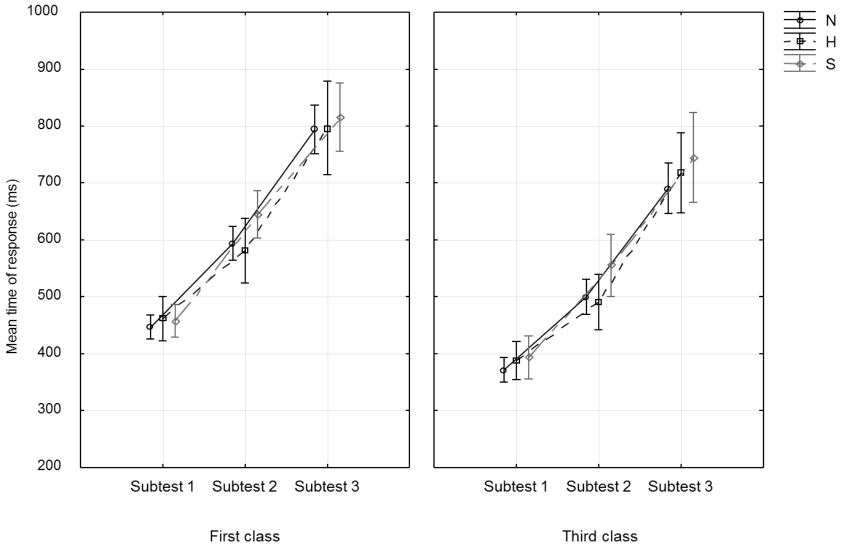
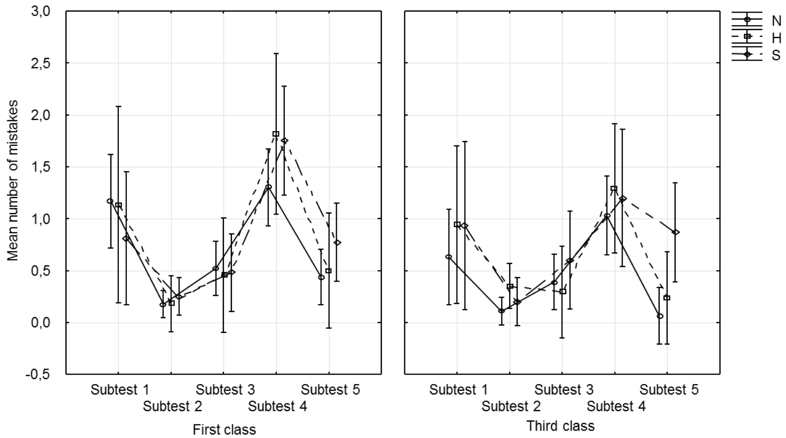


Figure 4

Rate of mistakes in "Schulte tables"



variables were mean number of mistakes in performance and mean response time.

Mean number of mistakes in the subtests shown in the Figure 4.

Statistical analysis showed that in whole irrespectively of the subtest both first-graders and third-graders with deficit of the first brain unit committed significantly more mistakes in comparison to peers from the group N (influence of the factor GROUP: $F(2, 143) = 3.36$, $p = 0.037$). Also the influence of the factor TYPE OF TASK was significant ($F(4, 143)=26.43$, $p < 0.001$). Influence of the factor GRADE and interactions of factors were insignificant (*p*s > 0.2).

A planned pairwise comparison of third-graders showed the presence of pronounced difficulties in initiating tasks in hyperactive children (differences of the groups N and H in the 1st subtest: $F(1, 143) = 4.49$, $p = 0.03$); and in slow third-graders there were observed indicators of fatigue by the end of the test (differences of the groups N and S in the last subtest: $F(1, 143) = 11.22$, $p = 0.001$). The positive dynamic of errors lessening with age was observed only in children of the group N ($F(1, 143) = 6.36$, $p = 0.01$). The conducted planned comparisons showed that significant influence of the factor GRADE in children from the group N appears because of the lessening with the age of the number of mistakes in the first subtest of the test ($F(1, 143) = 6.61$, $p = 0.01$).

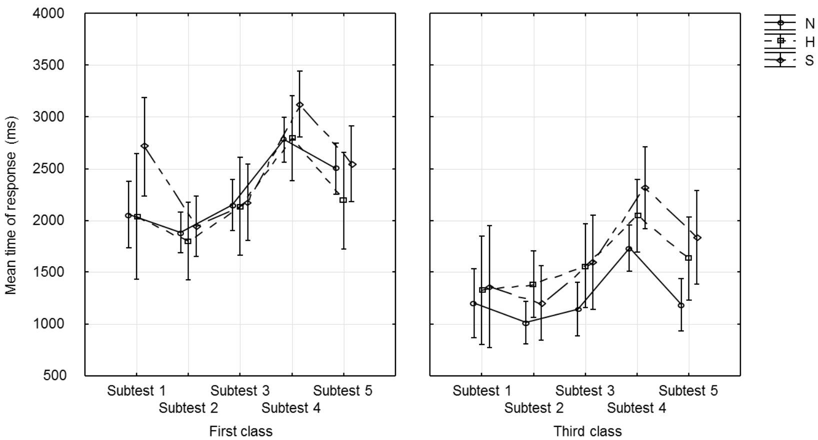
The mean response time is shown in the Figure 5.

RmANOVA showed significant influence of the factor GRADE ($F(1, 153) = 57.23$, $p < 0.001$), and the time of response decreases from the 1st to the 3rd grade. Also significant influence of the factor TYPE OF TASK was found ($F(4, 612) = 66.13$, $p < 0.001$): response time grew with the difficulty of subtests (see Figure 5). Influence of the factor GROUP and interaction of factors in this case were insignificant (*p*s > 0.11).

According to the results of the planned comparisons, slow children

Figure 5

Mean response time in the test "Schulte tables"



spent subsignificantly more time in number searches when compared to the children in Groups N and H both in the 1st and in the 3rd grades (p<0.1) (see Figure 5). However significant differences in search time in the first-graders of the group S were seen in the 4th, the most difficult subtest with parallel sequences (F(1, 153) = 5.93, p = 0.01). Among the third-graders the group S was slower both in the 4th and in the 5th, last subtest (PL: F(1, 153) = 9.24, p = 0.003; 10-1s: F(1, 153) = 6.56, p = = 0.01). In the hyperactive third-graders there also was a tendency for lengthening the search time in the two last subtests, but differences with the group N didn't achieve significance ($p < 0.07$).

Analysis of interaction of neuropsychological assessment and computerized tests results. To explore the consistency of the data from neuropsychological assessment and computerized tests we conducted a correlation analysis of the indices of performance of "Dots" and "Schulte tables" with the neuropsychological indices. In evaluation of significance of the received values of coefficients Holm correction for multiple correlations was used.

When analyzing the performance of the test "Dots" by first-graders were found significant correlations of the indices of the first brain unit (of the slow tempo (index S) and the integral index) and efficiency of performance of the 2nd (r = −0.353, p = 0.006 and r = −0.302, p = 0.018 respectively) and the 3rd subtests (r = −0.365, p = 0.006 and r = −0.347, p = 0.009 respectively). Also a subsignificant correlation of the hyperactivity index (index H) with the performance time on the 2nd subtest (r = −0.251, p = 0.096) was found, which indicates that hyperactive children are prone to work quickly in this subtest. In the 3rd grade similar situation was observed: the integral index of the functions of the first brain unit significantly negatively correlated with efficiency of performance of the 2nd subtest (r = −0.333, p = 0.012), and in the 3rd subtest there were observed significant correlations with all 3 indices of the state of the first brain unit: S, H and integral ($r = -0.335$, $p = 0.012$; $r = -0.371$, $p = 0.003$ and $r = -0.477$, $p < 0.001$ respectively).

When analyzing the data on the test “Schulte tables” in the first-graders we may note significant correlation between response time and index S in the most energy-consuming 4th subtest with parallel sequences ($r = 0.320$, $p = 0.025$): the higher the index S, the slower the group with slow tempo responded. The hyperactive children haven't got similar dependency from the index H, there can be seen opposite tendency (see discussion).

In the third-graders the consitency between the results on the test and the evaluations of the functions of the first brain unit are more pronounced. We found significant correlations between the integral index of the first brain unit and mistakes in the 1st ($r = 0.352$, $p = 0.01$) and the 2nd ($r = 0.417$, $p = 0.001$, $r = 0.443$, $p < 0.001$) subtests. Subsignificant correlations were found between mistakes and the index H in the 1st subtest ($r = 0.270$, $p = 0.063$) and the index S in the energy-consuming 4th subtest ($r = 0.248$, $p = 0.180$), which indicate difficulties of warming-up in hyperactive children and overload associated with fatigue in slow children.

Besides the correlations of the indices of the first brain unit functions, we correlated the results of the computerized tests with the indices of executive functions. The analysis of the data on the test “Dots” showed that in 1st graders there is a negative correlation between this parameter and the number of correct answers in the most difficult 3rd subtest ($r = -0.359$, p = 0.006), which was expected. When analyzing correlation with performance time a significant negative correlation with performance time on the 3rd subtest was found ($r = -0.304$, p=0.018). In the third-graders the indices of executive functions were negatively correlated with the quantity of correct answers in the difficult 3rd subtest ($r = -0.307$, p = 0.018), which is similar to the results of the first-graders.

In the comparison of state of executive functions with number of mistakes in performance of the test “Schulte tables” by the first-graders subsignificant correlations were found for the 2nd and the 3rd subtests (rs < 0.222, ps < 0.065) and significant correlations were found for the 4th and the 5th subtests ($r = 0.333$ и $r = 0.332$ respectively, $p = 0.015$). In the third-graders significant correlations were observed between the indices of executive functions and the speed in the 3rd and the 4th subtests (ps < 0.027).

High correlations between the results of the computerized tests and the indices of performance of the first and third brain units were found, and the increase in number of significant correlations of the indices of the first brain unit from the 1st to the 3rd grade. Thus, correlation analysis shows expected consistency of the data of neuropsychological assessment and the computerized tests.

Connection between the deficits of activation components of HMF and learning disabilities (LD). In our sample, which included 173 children, 74 (42.8%) had a deficit of the first brain unit. According to the data from teachers and tracking diagnostics, 58 children from the sample (33.5%) had learning disabilities. The analysis of correspondence of weakness in the first brain unit and learning disabilities showed that in the 1st grade among children with LD 71% has deficit of the first brain unit, while among successful students there are only 20.5% of such children. 85.2% of the children with LD and 20% of successful students had weakness in the first brain unit in the 3rd grade. According to the χ^2, the connection between having LD and deficits in the first brain unit is highly significant (on the level of $p<0.001$). In our study we also found the increase in number of children with deficit in the first brain unit among children with LD from the 1st to the 3rd grade (from 71% to 85%). This data has to be checked carefully in the next studies, as this may point to a disturbing fact of maladjustment of energetic resources of children with the growing demands to them at school.

Discussion

In order to diagnose children with a deficit in functions of the first brain unit, we used for this study a neuropsychological assessment that was extended by an evaluation of behavior and the characteristics of performance of the test battery with 5 parameters: slow tempo, fatigability, hyperactivity, impulsivity and perseverative behavior. Factor analysis enabled them to be categorized into 2 factors: the first one consisted of slow tempo and fatigability and the second one included hyperactivity and impulsivity. Similar results: closeness of parameters of hyperactivity and impulsivity in children with ADHD, from the one side, and combination of slow tempo of task performance with difficulties of attention in children with ADD, from the other side, were found in other studies (Chabildas, Pennington, & Willcutt, 2001; McBurnett et al., 2001; Milich, Balentine, & Lynam, 2001; Hartman, Willcutt, Rhee, & Pennington, 2004 and others), which confirms the validity of differentiation of these two variants of state regulation deficit.

It is worth noting that the index of perseverative behavior is loaded on both factors, though it had higher loadings on the first factor (Factor S) (see Table 1). Similar data was obtained with factor analysis of the results of neuropsychological assessment of a different sample of first-graders (Agris, Akhutina, & Korneev, 2014). From the literature we know that tendency to perseverate in children may be observed both in impairment of frontal lobes and middle brain structures (Symernitskaya, 1985; Luria, 1973; Moskovichyute, 1998). The Moskovichyute's study states that the frequency of systemic perseverations (which appear in several types of psychic activity) in the group with thalamic tumors appear more often than in patients with injuries of cortex (Moskovichyute, 1998). On the basis of this fact we held that a perseverative tendency may reflect both deficits in the first and third brain units, and deficit of functions of the third brain unit may be either secondary or a combination of primary and secondary disorders. These data and practical experience show that perseveration is a less specific characteristic of the described variants, it influences the intensity of activation deficit symptoms in both groups of children with poor state regulation.

To sum up the factor analysis as a whole, we may state that it allowed us to show the heterogeneity of the sample in various parameters of activation deficit and to discriminate 2 types of deviations, on the basis of which 2 experimental groups were formed.

As far as in our study we conducted non-selective testing of the first- and the third-graders of 2 Moscow schools, data about the size of the groups may be used for evaluation of occurrence rates of these variants in the population. Children without a deficit of activation constituted 56.5% in the 1st grade and 58.0% in the 3rd grade. The groups H in the 1st and the 3rd grades included respectively 15.2% and 23.5% of children, and the groups of slow children made respectively 28.3% and 18.5%. Such a tendency to a reduction in the slow children in the 3rd grade (from 28% to 18%) is insignificant according to the χ^2 (p=0.194). The presence of symptoms of "high fatigability and slow cognitive tempo" in children with ADHD was analyzed by Machinskaya, Sugrobova, and Semenova (2014). According to their data, these symptoms were inherent for 2 of 3 groups of children with ADHD of 7–8 years of age, but they practically disappeared in children of 9–10 years of age.

Learning disabilities (LD) were found in 57% of 14 hyperactive first-graders and in 73.7% of 19 children from the 3rd grade. LD were found in 53.8% of 26 slow children from the 1st grade and in 60% of 15 children from the 3rd grade. Thus, both variants of activation deficit may lead to school problems, especially in the 3rd grade, but we didn't find significant differences between the groups H and S on the presence of LD by χ^2. This result is in accordance with studies where the interaction of LD both with hyperactivity-impulsivity and a slow tempo of information processing was found (Richards et al., 1990; Shanahan et al., 2006; McGrath et al., 2011,Compton, Fuchs, Fuchs, Lambert, & Hamlett, 2012; DuPaul, Gormley, & Laracy, 2013).

Neuropsychological assessment of the first- and the third-graders showed significant differences of HMF in 2 groups of children with various manifestations of general activation deficit. Our data shows weakness of executive functions in junior schoolchildren with deficit of activation. In the 1st grade it is particularly distinct in the group of hyperactive children, in the 3rd grade — in children with slow cognitive tempo. There is contradictory data about this in contemporary works. Some works report a more acute deficit of executive functions (EF) in children with ADHD combined type in comparison to children with ADD with slow cognitive tempo (Barkley, 1997, 2014). In other works differences in EF between ADHD and ADD are not found (Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2005). According to the data of Machinskaya et al. (2014), occurrence of sluggishness and fatigability is found both in combination with weakness in EF (ADHD with frontal thalamic insufficiency) and without it (deficit of non-specific activation).

Moreover, there is an opinion, that deficit of EF in ADHD is context-sensitive, dynamic, secondary to state regulation and motivation (Sonuga-Barke, Wiersema, van der Meere, & Roeyers, 2010; van der Meere, 2005). The findings of Machinskaya et al. (2014) oppose this last statement about indispensable secondary nature of EF failure and convincingly show heterogeneity of neurophysiological factors of cognitive difficulties in children with ADHD. But the thesis of contextual dependency of EF, their dynamic nature does not contradict empirical research and theoretical statements.

This thesis well corresponds to the principle of dynamic organization and localization of HMF by L.S. Vygotsky — A.R. Luria. It allows explaining the results of neuropsychological assessment. *Hyperactive first-graders* had quite low integral index of state of the first brain unit, which equals 4.56 (see Figure 1A), their index of executive functions was also low (2.90). A part of "executive" tasks is fairly energy-consuming for first-graders, so we may assume, that is why hyperactive children give impulsive answers and do not cope with the tasks. Slow first-graders with an integral index of the first brain unit 2.26 performed these tasks better, though slowly; their index for executive functions was 0.84.

Hyperactive third-graders in our sample had an integral index of the first brain unit 3.25 (see Figure 1B); their index of executive functions was 0.95. The severity of deficit of executive functions decreased in comparison with their peers with slow cognitive tempo. It may be connected with the sample characteristics or with other reasons. Firstly, the same tasks become less difficult and energy-consuming for the third-graders, and children cope significantly better with them. Secondly, literature states quicker development of executive functions in first-graders with initially low indices (Voronova, Korneev, & Akhutina, 2013).

Slow third-graders with an integral index of the first brain unit 2.35 cope with the tasks worse than their hyperactive peers; their index of executive functions equals 2.68. There may be several explanations, but first of all we need to note that there cannot be strict linear dependence between states of various brain units, even if some failures are secondary in nature. The state of functions and structures depends on many factors, for example, on neurotrophic factors, neuromediators, on involvement of structures in various functional systems. It is possible that in our sample part of third-graders could have primary failures of the third brain unit, and their ratio in first-graders and third-graders could be different. But apart from that factor of accidental group cast there is another factor. We suppose that anxiety could have heightened in third-graders with slow cognitive tempo, as their sluggish tempo and low efficiency could have led to systematic failures in education, which contributed to rise of anxiety. According to the literature, children with ADD with slow cognitive processing speed have high comorbidity with anxiety disorder (Pliszka, 1989; Biederman, Newcorn, & Sprich, 1991; Skirbekk, Hansen, Oerbeck, & Kristensen, 2011). Consideration of emotional states of children, i.e., consideration of context, which may change the pattern of EF in a given period or moment, is an important and promising topic for future research.

Besides the link between deficit of the first brain unit and EF, it is worth noting other characteristics of children from the deficit groups, invariant for both ages. Firstly, there is a distinct deficit of processing of kinesthetic information. In these processes children with activation deficit significantly differ from the control groups of both first- and third-graders. In the first-graders these characteristics mostly apply to children with slow tempo (similar data was received in the study of Agris et al., 2014), and in the 3rd grade they are found both in slow and in hyperactive children. The presence of regulatory and visual difficulties (in the 3rd grade) combined with deficit of the first brain unit and difficulties of kinesthetic information processing helps us to assume that complex volitional movements may suffer because of the whole constellation of deficits. Such a conclusion is confirmed by research of developmental coordination disorder which symptoms are often present in AD(H)D (Gillberg, 2003). Slowness and instability of tempo and problems in executive functions, as well as problems of processing of kinesthetic, visual and visuospatial information, are inherent both for DCD (Wilson & McKenzie, 1998; Piek, Dyck, Francis, & Conwell, 2007) and for children with deficit of the first brain unit in our study. This is an important fact for building remedial programs for children with learning disabilities and activation deficit. It is notable, that in the 1st grade teachers still pay attention to development of fine motor skills (exercises for drawing patterns, finger gymnastics), but in the 3rd grade it is considered as not any more important. Our data show that fine motor skills in children with weakness in the first brain unit need additional development.

Results of *computerized tests* show a decrease of both efficiency and speed of performance of cognitive tasks in both tests in children with deficit of the first brain unit. The most distinct differences from norm are found in the parameter of *effectiveness*. In both the computerized tests, the quality of performance in children with deficit of the first brain unit is significantly lower than in children without such problems. Thus, children with deficit of the first brain unit show difficulties in coping in complex subtest in “Dots” (especially under the conditions of required fast tempo of work). In hyperactive first-graders a decrease in efficiency in the easiest 1st subtest is seen, which may be the consequence of difficulties of task initiating, that is inherent for executive functions deficit. In “Schulte tables” test where tempo of performance is regulated by a child, such distinct differences in efficiency in the most difficult subtests are not seen in children with deficit of the state of the first brain unit in comparison with the group of norm. But in this test hyperactive children again show a decrease in efficiency in the easiest 1st subtest, though not in the 1st, but in the 3rd grade, which we have already seen in “Dots”. It is important to state that the problem of task initiating, inherent for hyperactive children, is not seen in this test in the first-graders, which is consistent with the idea of dynamic nature of deficit of executive functions in ADHD and its complex connection with the context of activity and motivation. At the same time, slow third-graders show predictable drops in effectiveness in the last subtest in “Schulte tables” (with regard to their high fatigability, seen in neuropsychological assessment).

Differences on the parameter of speed are not so evident. In “Dots” there are no significant differences between the groups, though children with low processing *speed* show slower tempo of performance. In “Schulte tables” test general decrease in tempo in these children in comparison to the group of norm becomes subsignificant only in the 4th, the most difficult subtest (both in the first-graders and the third-graders). Also in the third-graders the 5th, last subtest suffered, which corresponds to the hypothesis about high fatigability of children with slow cognitive tempo. This pattern (decrease in speed in the 4th and the 5th subtests) is present as tendency in hyperactive third-graders. But the overview of parameters of efficiency and response time separately does not allow noticing significant results. We will examine them together.

Hyperactive first-graders in the 3rd, the most difficult subtest of "Dots" come close to the norm group in response time, but make many errors. As far as these children have the lowest index of executive functions, it is their contribution that is reflected in significant negative correlation of response time in the 3rd subtest with the parameter of executive functions (the worse the executive functions, the quicker the answer). It is important to note that in performance of "Schulte tables" test by the first-graders the similar trend is seen. Hyperactive first-graders perform the subtests 1–4 with the normal speed, the 5th subtest they perform quicker than the norm, while they make more mistakes than the norm group, i.e., in the 5th subtest, when children are tired, they hurry up to "get rid of the test", which is indirectly seen in negative correlation between response time in the last test and index H, though it is not statistically significant ($r = -0.245$, $p = 0.180$). Divergent correlations between response time and indices of executive functions in the 1st and the 3rd subtests of the test "Dots" ($r = 0.320$ и $r = -0.245$ respectively) may also give evidence to a change of strategy with the difficulty of subtests. Such a strategy of avoidance of difficulties by means of change of productive response with the impulsive one is also found in neuropsychological assessment. The third-graders use this strategy of performance of the tests "Dots" and "Schulte tables" rarely, so it is not detected statistically.

Hyperactive children also differ in performance of the simplest subtests. In first-graders we found decrease in efficiency in the 1st, the easiest subtest in "Dots", in third-graders there is decrease in efficiency in the 1st subtest of test "Schulte tables". In this regard we should remind that the literature knows reversed U-shaped performance of subtests by children with ADHD depending on the complexity of tasks, particularly, depending on the speed of stimuli presentation (Sonuga-Barke et al., 2010; van der Meere, 2005): children with ADHD perform worse on the simplest (uninteresting) and the most difficult subtests, while their performance of the subtest of medium difficulty is closer to norm.

The data analysis of the *age dynamics of efficiency and speed of performance of the computerized tests* shows that the third-graders of the control group (group of norm according to the first brain unit) demonstrate faster tempo of performance and better quality of work on both tests in comparison to the first-graders. Children with deficit of functions of the first brain unit demonstrate predominant improvement of tempo of performance (though a lesser one, than the control group). Their improvement of efficiency is seen only in test "Dots" and only for the sub-group of slow children, notably significantly less pronounced, than in the group of norm.

We should note that the logic of acquisition of any skill usually supposes improvement of time indices of performance *after* increase in efficiency (optimal variant of acquisition of writing: at first children learn to write neatly and only then they gradually increase the tempo), and not vice versa, as in children with weakness in the first brain unit in our study. Children with activation deficit start working faster with age (but not much more efficiently), which is a sign of insufficiently effective strategies with the automation of skills, which may exert significantly negative influence on the acquisition of school skills and abilities (compare similar point of view, Waber, 2010).

Conclusion

In the dynamics of development of psychic processes in children with deficit of the first brain unit there are notable *general* differences from the norm on activation deficit indices and on indices of development of various components of HMF. They have inherent problems of voluntary regulation of activity and processing information of various types (especially kinesthetic and in hyperactive children — visual), associated with deficit of the first brain unit.

The analysis of specific characteristics of variants shows that the first-graders and the third-graders with *slow cognitive tempo* perform slower and worse, the more energy-consuming the subtest is. The increase in symptoms of deficit of the third brain unit (if it is not induced by the characteristics of the sample) may be related to increase in anxiety to which, according to the literature, these children are inclined.

In *hyperactive* first-graders, who have evident weakness in executive functions (both according to the literature and our data), there is a tendency to perform on the subtests with the reversed U-shaped influence of complexity of tasks: in the simplest and the most difficult tasks they perform worse in comparison to the control group. At the same time, in performance of difficult tasks there is a notable tendency for avoidance of difficulties by means of quick hasty answers. In hyperactive third-graders, the decrease of executive functions was less pronounced, and they had the same dependence on energy-consumption of the task, as other third-graders: the more difficult the task, the slower (and almost always worse) they performed. The exception is the first simple subtests: mistakes in their performance may be connected to insufficient activation before the work and with low motivation because of the simplicity of the task.

Thus, in whole difficulties of performance of energy-consuming tasks, quick fatigability, slow (in group S) and fluctuating (in group H) tempo of work, dependence of performance of motivation and emotional state are inherent for children with deficit of the first brain unit. All of this data is important to understand normative development of the processes of state regulation in children of 7–9 years, as well as disorders of this development. The research should also be taken into account when creating much needed remedial developmental programs in contemporary education for children who have problems acquiring school skills.

References

Agris, A. R., Akhutina, T. V., & Korneev, A. A. (2014). Varieties of Unit I functions deficits in children *with the risk of learning disabilities. Vestnik Moskovskogo Universiteta. Seriya 14. Psikhologiya, 3*, 34–46.

Akhutina, T. V., Matveeva, E. Yu., & Romanova, A. A. (2012). Application of the Luria's principle of the syndrome analysis in processing of neuropsychological assessment data of children with developmental disorder. *Vestnik Moskovskogo Universiteta. Seriya 14. Psikhologiya, 2*, 84–95.

Akhutina, T. V., Polonskaya, N. N., Pylaeva, N. M., & Maksimenko, M. Yu. (2008). Neiropsikhologicheskoe obsledovanie [Neuropsychological assessment]. In T. V. Akhutina & O. B. Inshakova (Eds.), *Neiropsikhologicheskaya diagnostika, obsledovanie pis'ma i chteniya mladshikh shkol'nikov* [Neuropsychological diagnostics, assessment of writing and reading in younger schoolchildren] (pp. 4–64). Moscow: Sfera; V. Sekachev.

Akhutina, T. V., & Pylaeva, N. M. (2012). *Overcoming learning disabilities: A Vygotskian-Lurian Neuropsychological Approach*. New York, NY: Cambridge University Press.

Barkley, R. A. (1997). *ADHD and the nature of self-control*. New York, NY: Guilford Press.

Barkley, R. A. (2014). Sluggish cognitive tempo (concentration deficit disorder?): current status, future directions, and a plea to change the name. *Journal of Abnormal Child Psychology, 42*(1), 117–125.

Biederman, J., Newcorn, J., & Sprich, S. (1991). Comorbidity of attention deficit hyperactivity disorder with conduct, depressive, anxiety, and other disorders. *American Journal of Psychiatry, 148*(5), 564–577.

Brown, T. E. (2005). *Attention deficit disorder: The unfocused mind in children and adults*. New Haven, CT: Yale University Press.

Chabildas, N., Pennington, B. F., & Willcutt, E. G. (2001). A comparison of the neuropsychological profiles of the DSM-IV subtypes of ADHD. *Journal of Abnormal Child Psychology, 29*(6), 529–540.

Compton, D. L., Fuchs, L. S., Fuchs, D., Lambert, W., & Hamlett, C. (2012). The cognitive and academic profiles of reading and mathematics learning disabilities. *Journal of Learning Disabilities, 45*(1), 79–95.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia, 44*(11), 2037–2078.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. Science, 318(5855), 1387–1388.

DuPaul, G. J., Gormley, M. J., & Laracy, S. D. (2013). Comorbidity of LD and ADHD: Implications of DSM-5 for Assessment and Treatment. *Journal of Learning Disabilities, 46*(1), 43–51.

Geurts, H. M., Verté, S., Oosterlaan, J., Roeyers, H., & Sergeant, J. A. (2005). ADHD subtypes: do they differ in their executive functioning profile? *Archives of Clinical Neuropsychology, 20*(4), 457–477.

Gillberg, C. (2003). Deficits in attention, motor control, and perception: a brief review. *Archives of Disease in Childhood, 88*(10), 904–910.

Glozman, Zh. M., Ravich-Shcherbo, I. V., & Grishina, T. V. (2007). Neirodinamicheskie faktory individual'nykh razlichii v uspeshnosti shkol'nogo obucheniya [Neurodynamic factors of individual differences in successful school study]. In V. A. Moskvin (Ed.), *Neiropsikhologiya i psikhofiziologiya individual'nykh razlichii* [Neuropsychology and psychophysiology of individual differences] (pp. 103–113). Belgorod: POLITERRA.

Gorbov, F. D. (1971). Determinatsiya psikhicheskikh sostoyanii [Determination of psychic states]. *Voprosy Psikhologii, 5*, 20–29.

Hartman, C. A., Willcutt, E. G., Rhee, S. H., & Pennington, B. F. (2004). The relation between sluggish cognitive tempo and DSM-IV ADHD. Journal of Abnormal Child Psychology, 32(5), 491–503.

Luria, A. R. (1973). *Osnovy neiropsikhologii* [Basic neuropsychology]. Moscow: Moscow University Press.

Machinskaya, R. I., Sugrobova, G. A., & Semenova, O. A. (in press, 2014). An interdisciplinary approach to analysis of the cerebral mechanisms of learning difficulties in children. Experience of studies of children with signs of ADHD. *Neuroscience and Behavioral Physiology.* doi:10.1007/s11055-014-0040-1

McBurnett, K., Pfiffner, L. J., & Frick, P. J. (2001). Symptom properties as a function of ADHD type: An argument for continued study of sluggish cognitive tempo. *Journal of Abnormal Child Psychology, 29*(3), 207–213.

McGrath, L. M., Pennington, B. F., Shanahan, M. A., Santerre-Lemmon, L. E., Barnard, H. D., Willcutt, E. G., ... Olson, R. K. (2011). A multiple deficit model of reading disability and attention-deficit/hyperactivity disorder: searching for shared cognitive deficits. *Journal of Child Psychology and Psychiatry, 52*(5), 547–557.

Milich, R., Balentine, A. C., & Lynam, D. R. (2001). ADHD combined type and ADHD predominantly inattentive type are distinct and unrelated disorders. *Clinical Psychology: Science and Practice, 8*(4), 463–488.

Moskovichyute, L. I. (1998). Asimmetriya polusharii mozga na urovne kory i podkorkovykh obrazovanii [Asymmetry of hemispheres on the level of cortex and subcortical systems]. In E. D. Khomskaya, T. V. Akhutina (Eds.), *I Mezhdunarodnaya konferentsiya pamyati A.R. Luriya. Sbornik dokladov* [I International Conference in Memory of A.R. Luria. Book of abstracts] (pp. 96–101). Moscow: Russian Psychological Society.

Nigg, J. T. (2005). Neuropsychologic theory and findings in attention-deficit/hyperactivity disorder: the state of the field and salient challenges for the coming decade. *Biological Psychiatry, 57*(11), 1424–1435.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101*(2), 385–413.

Piek, J. P., Dyck, M. J., Francis, M., & Conwell, A. (2007). Working memory, processing speed, and set-shifting in children with developmental coordination disorder and attention-deficit–hyperactivity disorder. *Developmental Medicine and Child Neurology, 49*(9), 678–683.

Pliszka, S. R. (1989). Effect of anxiety on cognition, behavior, and stimulant response in ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry, 28*(6), 882–887.

Polonskaya, N. N. (2007). *Neiropsikhologicheskaya diagnostika detei mladshego shkol'nogo vozrasta* [Neuropsychological diagnostics of younger schoolchildren]. Moscow: Akademiya.

Pylaeva, N. M. (1998). Neiropsikhologicheskaya podderzhka klassov korrektsionno-razvivayushchego obucheniya [Neuropsychological support of the classes of correctional developmental teaching]. In E. D. Khomskaya, T. V. Akhutina (Eds.), *I Mezhdunarodnaya konferentsiya pamyati A.R. Luriya. Sbornik dokladov* [I International Conference in Memory of A.R. Luria. Book of abstracts] (pp. 238–243). Moscow: Russian Psychological Society.

Richards, G. P., Samuels, S. J., Turnure, J. E., & Ysseldyke, J. E. (1990). Sustained and selective attention in children with learning disabilities. *Journal of Learning Disabilities, 23*(2), 129–136.

Sergeant, J. (2000). The cognitive-energetic model: an empirical approach to attention-deficit hyperactivity disorder. *Neuroscience & Biobehavioral Reviews, 24*(1), 7–12.

Sergeant, J. A. (2005). Modeling attention-deficit/hyperactivity disorder: a critical appraisal of the cognitive-energetic model. *Biological Psychiatry, 57*(11), 1248–1255.

Shanahan, M. A., Pennington, B. F., Yerys, B. E., Scott, A., Boada, R., Willcutt, E. G., ... DeFries, J. C. (2006). Processing speed deficits in attention deficit/hyperactivity disorder and reading disability. *Journal of Abnormal Child Psychology, 34*(5), 584–601.

Skirbekk, B., Hansen, B. H., Oerbeck, B., & Kristensen, H. (2011). The relationship between sluggish cognitive tempo, subtypes of attention-deficit/hyperactivity disorder, and anxiety disorders. *Journal of Abnormal Child Psychology, 39*(4), 513–525.

Sonuga-Barke, E. J., Wiersema, J. R., van der Meere, J. J., & Roeyers, H. (2010). Context-dependent dynamic processes in attention deficit/hyperactivity disorder: differentiating common and unique effects of state regulation deficits and delay aversion. *Neuropsychology Review, 20*(1), 86–102.

Symernitskaya, E. G. (1985). *Mozg cheloveka I psikhicheskiye protsessy v ontogeneze* [Human brain and psychological processes in ontogenesis]. Moscow: Moscow University Press.

Van der Meere, J. (2005). State regulation and attention deficit hyperactivity disorder. In D. Gozal & D. L. Mofese (Eds.), *Attention deficit hyperactivity disorder: from genes to patients* (pp. 413–433). Totowa, NJ: Humana Press Inc.

Voronova, M. N., Korneev, A. A., & Akhutina, T. V. (2013). Longitudinal study of the development of higher mental functions in primary school children. *Vestnik Moskovskogo Universiteta. Seriya 14. Psikhologiya, 4*, 48–64.

Waber, D. P. (2010). *Rethinking learning disabilities: Understanding children who struggle in school*. New York, NY: Guilford Press.

Weiler, M. D., Bernstein, J. H., Bellinger, D. C., & Waber, D. P. (2000). Processing speed in children with attention deficit/hyperactivity disorder, inattentive type. *Child Neuropsychology, 6*(3), 218–234.

Weiler, M. D., Bernstein, J. H., Bellinger, D., & Waber, D. P. (2002). Information processing deficits in children with attention-deficit/hyperactivity disorder, inattentive type, and children with reading disability. *Journal of Learning Disabilities, 35*(5), 449–462.

Willcutt, E. G., Sonuga-Barke, E., Nigg, J., & Sergeant, J. (2008). Recent developments in neuropsychological models of childhood psychiatric disorders. In T. Banaschewski & L. A. Rohde (Eds.), *Advances in biological psychiatry* (Vol. 24: Biological child psychiatry. Recent trends and developments, pp. 195–226). Basel: Karger.

Wilson, P. H., & McKenzie, B. E. (1998). Information processing deficits associated with developmental coordination disorder: A meta-analysis of research findings. *Journal of Child Psychology and Psychiatry, 39*(6), 829–840.

Возрастные изменения высших психических функций у детей 7–9 лет с разными типами дефицита регуляции активности

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Резюме

Цель статьи – дать анализ возрастных особенностей состояния высших психических функций у детей со слабостью процессов регуляции активности (функций I энергетического блока мозга, по А.Р. Лурии). В статье описано клинико-психологическое и экспериментальное исследование, используются стандартное нейропсихологическое обследование, по А.Р. Лурии, адаптированное для детей 5–9 лет, и два компьютерных теста: 1) модифицированный вариант методики «Dots», а также компьютерная версия известной методики оценки работоспособности — таблицы Шульте–Горбова. В исследовании приняли участие 173 ученика I и III классов. Результаты исследования позволили показать наличие двух вариантов дефицита регуляции активности: обнаружены дети с низким темпом деятельности и утомляемостью и дети с гиперактивностью и импульсивностью. В целом для детей с дефицитом I блока характерны трудности выполнения энергоемких заданий, быстрая истощаемость, низкий (у группы с замедленным темпом) или колеблющийся (у группы с гиперактивностью) темп работы, зависимость выполнения действия от мотивации и эмоционального состояния, слабость функций программирования и контроля и переработки кинестетической информации. Большинство детей из обеих групп имеют трудности обучения. Анализ специфических характеристик вариантов показывает, что и первоклассники, и третьеклассники с замедленным когнитивным темпом выполняют задания тем медленнее и тем хуже, чем более энергоемкой является проба. Наблюдающееся у них нарастание симптомов слабости III блока может быть связано с усилением тревожности. У гиперактивных школьников, имеющих выраженную слабость функций программирования и контроля, отмечается тенденция к выполнению заданий с обратным U-образным влиянием сложности заданий: они выполняют хуже детей группы нормы как самые простые (из-за слабости мотивации), так и самые сложные (энергоемкие) задания.

Ключевые слова: нарушения регуляции активности, процессы активации, гиперактивность, низкий когнитивный темп, трудности обучения, СДВГ.