Cuadernos de Neuropsicología / Panamerican Journal of Neuropsychology
2023, Vol. 17 Nº 2 Special Issue 116 - 124

ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

Application of principles of cultural-historical neuropsychology to the study of typical development in preschoolers

Aplicación de principios de neuropsicología histórico-cultural al estudio del desarrollo típico en niños preescolares

Aplicação de princípios de neuropsicologia histórico-cultural ao estudo do desenvolvimento típico em crianças pré-escolares

RECIBIDO: *30 julio 2023* ***ACEPTADO:*** *22 octubre 2023*

Marina N. Zakharova[a] ***Regina I. Machinskaya***[b]

[a] Institute of Developmental Physiology, Moscow, Russia
[b] Multidiscipline psychological center "Territoriya Schast'ya", Moscow, Russia

Palabras Clave: funciones ejecutivas, idade pre-escolar, neuropsicologia histórico-cultural.

Keywords: executive functions, preschool age, cultural-historical neuropsychology.

Palavras-chave: funções executivas, idade pré-escolar, neuropsicologia histórico-cultural.

ABSTRACT

It is well known that the development of programming, selective voluntary regulation, and control of goal-directed behavior (executive functions - EF) is a necessary condition for successful school learning. However, methods for assessing EF in preschoolers are rather limited. The article presents neuropsychological instruments for the EF assessment in typically developing children aged 4-7 years, which can be used in individual examinations or in small groups of children. The tests are implemented both in the form of interview and in the form of computer tasks with automatic registration of the child's reactions. The proposed methods are based on the principle of qualitative syndrome analysis proposed by A.R. Luria, as well as on the data of previous study in the field of child cultural-historical neuropsychology (Glozman, Akhutina, Solovieva, among others). The results of the study indicate the geterohronous development of various EF components in the period from 4 to 7 years and the significant progressive changes in most EF components at the age of 6-7 years.

Correspondencia: Marina Zakharova e-mail: zmn@idnps.ru

Cuadernos de Neuropsicología / Panamerican Journal of Neuropsychology
2023, Vol. 17 Nº 2 Special Issue 116 - 124
ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

R E S U M E N

Es sabido que el desarrollo de la programación, la regulación voluntaria seletiva y el control del comportamiento direccionado a objetivos (funciones ejecutivas - EF) la condición necesaria para el suceso de la aprendizaje escolar. No entanto, los métodos para avaliar a FE me pre-escolares son bastante limitados. O artigo apresenta instrumentos neuropsicológicos para avaliação de la FE me crianzas como desarrollo típico de 4 a 7 años, que podemos ser utilizados en examas individuales o me pequenos grupos de crianzas. Os testes son implementados tanto en forma de entrevista como en forma de tarefas informáticas como registo automático de las reações de la crianza. Los métodos propuestos se basan en no principio de análisis cualitativo del síndrome propuesta por A.R. Luria, bien como nos dados de estudos anteriores en la área de la neuropsicología histórico-cultural infantil (Glozman, Akhutina, Solovieva, entre outros). Los resultados del estudio indican el desarrollo heterogéneo de varios componentes de la FE en período de 4 a 7 años y las mudanzas progresivas significativas en la mayoría dos componentes de la FE en edades de 6 a 7 años.

R E S U M O

É sabido que o desenvolvimento da programação, da regulação voluntária seletiva e do controle do comportamento direcionado a objetivos (funções executivas - EF) é condição necessária para o sucesso da aprendizagem escolar. No entanto, os métodos para avaliar a FE em pré-escolares são bastante limitados. O artigo apresenta instrumentos neuropsicológicos para avaliação da FE em crianças com desenvolvimento típico de 4 a 7 anos, que podem ser utilizados em exames individuais ou em pequenos grupos de crianças. Os testes são implementados tanto em forma de entrevista como em forma de tarefas informáticas com registo automático das reações da criança. Os métodos propostos baseiam-se no princípio da análise qualitativa da síndrome proposta por A.R. Luria, bem como nos dados de estudos anteriores na área da neuropsicologia histórico-cultural infantil (Glozman, Akhutina, Solovieva, entre outros). Os resultados do estudo indicam o desenvolvimento heterogêneo de vários componentes da FE no período de 4 a 7 anos e as mudanças progressivas significativas na maioria dos componentes da FE na idade de 6 a 7 anos.

The ability to plan and control goal-directed activities and behavior arises in ontogenesis in stages. In cognitive psychology these functions are combined by the term «executive functions» (EF) (Miyake et al., 2000; Diamond, 2013). The development of EF is determined both by the state of a complex of brain systems, which is the neurophysiological basis of EF, and by social experience, which should provide opportunities for the assimilation of various methods of self-regulation and their consolidation. The level of development of the brain mechanisms of EF (primarily the frontal lobes) in children is constantly changing as a result of this experience. This means that development will be highly dependent on the conditions in which it takes place (Akhutina & Pylaeva, 2015).

The neuropsychological approach to the problem of the development of EF allows to consider both components - brain mechanisms and socio-psychological factors. A neuropsychologist analyzes any complex skill based on the Vygotsky-Luria theory of the brain organization of higher mental functions (Luria, 1965). In this approach, the possibility of voluntary regulation of activity (from a psychological point of view) will be associated not only with the experience gained, but also with the state of other mental processes.

In different age periods, there is a different intensity of development of the functions of planning and control and their brain mechanisms (Machinskaya, 2015). Preschool age is characterized by the intensive development of many components of executive functions, so it is important to carefully study these components and their impact on both cognitive functions and behaviors, as well as learning success. But for the assessment of EF at this age, the tools have not yet been developed enough. At the moment, there are various types of methods: one part is focused on senior preschool age (Akhutina, 2016), the other part allows to study preschoolers from 3 to 6 years old (Glozman et al., 2008). According to G.M. Glozman, a neuropsychologist should control a set of parameters that are important for a valid diagnosis in preschool age. The main parameters are the duration of the examination procedure, the quality of the stimulus material, the specifics of tasks (Glozman, 2021). The results of all neuropsychological tests should be evaluate by syndromic analysis: the data of one task cannot be interpreted in isolation, it must be correlated with the performance of other tasks (Luria*,* 1973; Glozman, 2021; Akhutina, 2016; Solovieva & Rojas, 2017).

In our research, we used a battery of tests, consisting of two parts: 1) tests that allow for qualitative-quantitative analysis. 2) computerized tests that allow to unify the task presentation procedure and facilitate quantitative data calculation and statistical processing (Akhutina et al*.,* 2019). The study demonstrates the usefulness of neuropsychological approach to assessing executive functions in young preschoolers and presents data on EF age-related changes in preschool age.

ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

METHODS

Children aged 4-5 (average age – 4.5±0.3 yrs., n=70, boys=35, girls=35), 5-6 (average age – 5.6±0.4 yrs., n=154, boys=77, girls=77) and 6-7 (average age – 6.8±0.2 yrs., n=199, boys=100, girls=99) and participated in the current study. All age groups didn't include children diagnosed with any neurological or mental disorders. All the children attended kindergarten groups in Moscow.

To assess the development of EF, group and individual studies were used. The group study included the following tests:

- *Reciprocal Motor programmer Tes*t is designed to assess the abilities of following the speech instructions, immediate habitual reactions suppression, and switching stimuli. The test consists of two parts. The 1st part requires a child to respond with 2 knocks to a single one; and 2 knocks is to be responded with 1 knock. 16 stimuli are given. All of them follow the same scheme: stereotype -> its breaking -> new stereotype -> its breking. The next stage is even more complicated as it relies on self-control ability. 1 knock is to be responded with 2 knocks; and 2 knocks are not to be responded. The point is that it often provokes impulsive behaviour in children. The program provision is the same as in the previous subtest. The probe is also appliable for groups. If that is the case, children are to put a dash in a blank in response to 1 knock; and put a dot in response to 2 knocks. As for the second subtest, there is a dot for 1 knock and a dash for 2 knocks.
- *Graphomotor Sequences Task* is designed to assess the abilities of mastering a motor program that further separately focuses on a visual sample seamless replication, program elements swapping, and motor series automatization.
- *Spot the Difference Task* is designed to assess selective visual attention, its distribution and transition from one object to another. Children are given 2 images for comparison. Both images differ in details, which can be omitted and/or depicted differently.
- *Cancellation Test* enables evaluation of attention retention ability necessary for monotonous tasks and switching from one rule to another. Children are given 10 lines comprised of 8 randomly sequenced stimuli. The task is to underline one of the stimuli, to cross out another one, and to leave the rest.
- *"The Zoo Task"* enables evaluation of visual-spatial working memory. Children have to memorize and then correctly reproduce the location of the objects in the table.
- *The Maze-tracing Task* is devised to analyze the abilities of strategy planning and direct reactions suppression. Children have to find a way out of the labyrinths of increasing complicity.
- *Digit Symbol Coding Task* enables effectiveness evaluation of voluntary attention, including its selectivity, switching ability and long-term task retention. Children are to encrypt three similar objects by attributing a certain number of dots or dot patterns. Children 5-7 years old are offered to encode 3 different objects with a certain number of points. Children 4-5 years old complete the task with 2 objects.
- *Three-dimensional Drawing Task*: enables to evaluation of planning strategy and copying on basis on analytical and holistic components of perception. Children are offered to draw a tree, a fence, and a 3D house.

Some of the tests have been developed specifically for this study, while others have been adapted from procedures used in group neuropsychological diagnostics (Akhutina et al., 2016) and traditional children neuropsychological testing (Akhutina, 2016). Group diagnostics has been carried out by a single neuropsychologist in a group of 5-12 people (5 children aged 4-5; 6-10 children aged 5-6; 10-12 children aged 6-7) with the participation of 2-3 assistants who helped children with difficulties in understanding instructions. Also, assistants noted different behavioral manifestations in the form of impulsivity or emotional reactions that proved to be inadequate to the testing situation.

An individual study included 3 computerized methods from the "Praktika-MSU" congregation of tests (Akhutina et al., 2019) presented on the touch screen of a tablet:

- *Cancellation test* is aimed at assessing the ability to keep attention on a monotonous task (series 1) and switch from one instruction to another (series 2). In each series, the child is presented with a 16x12 table, the elements of which are six different geometric shapes. In series 1, the child is asked to find and mark all the figures of one type – circles, in series 2 – figures of two types –circles and stars.
- *Corsi Block-tapping Test*: the technique is aimed at assessing the visuospatial WM. In different places of the screen, images of cubes (from 2 to 9) are highlighted in turn in a certain sequence. The task of the child is to remember and then reproduce this sequence (if the answer is correct, the length of the reference sequence in the next sample increases).

ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

- *Hearts and Flowers Test* is a modified method of *The Dots Task (*Davidson, 2006; Diamond, 2013), consisting of three subtests, each of which presented 20 stimuli. Subtest 1 (task to press the response button on the same side where the image appears) assesses the ability to follow the instructions and reaction speed, subtest 2 (task to press the button on the opposite side from the image) - the ability to suppress direct response. In subtest 3, the participant needs to switch between two competing programs (combining the first two subtests).

The individual characteristics (presence/absence of implementation difficulties) of different components of EF were obtained in neuropsychological tests. Further, their analysis was carried out according to the Luria's approach (syndromic analysis) using the scheme proposed by O.A. Semenova (2015). Four integral indicators were created from the evaluations of these elements (see Table 1):

– deficit of programming functions (average indicators of difficulties in understanding instructions or algorithms and creating a strategy of an activity),

– deficit of selective regulation (average of scores that depicts difficulties in overcoming immediate (impulsive) reactions, switching from one action to another, switching between programs, difficulties in difficulties of sustained program execution),

– deficit of voluntary control of one's own activities, as well as

– general index of EF deficit (average of the deficits of programming, selective regulation and control).

Table 1

Neuropsychological indexes of the executive funtios' deficiency

EF components	Deficiency manifestations
1. Programming own actiones 1.1. Understanding instructions or algorithms 1.2. Creation of algorithms	Individual features of understanding instructions or algorithms (from the first presentation, after repeated presentation, after joint execution, lack of understanding) of the different tasks: Cancellation test, Spot the Difference task, Reciprocal Motor Programmer Test, Graphomotor Sequences Test, Maze-tracing Task, Digit Symbol Coding Task, "The Zoo Task". Forming an activity strategy in Maze-tracing Task, Three-dimensional Drawing Task
2. Selective regulation 2.1. Overcoming immediate reactions 2.2. Switching from one action to another 2.3. Switching from one mode of action to another, from program to program 2.4. Sustained maintenance of the acquired program.	2.1. Presence of impulsive reactions under Spot the Difference Task, Cancellation Test, Reciprocal Motor Programmer Test, "The Zoo Task"), Graphomotor Sequences Test, The Maze-tracing Task, Digit Symbol Coding Task, Three-dimensional Drawing Task 2.2. Interruptions under Graphomotor Sequences, echoic reactions under choice Go/no-go task, perseveration under Digit Symbol Coding Task, Three-dimensional Drawing Task 2.3. Difficulties with switching between probes in various tasks, difficulties with switching between stimuli under Reciprocal Motor Programmer Test and Digit Symbol Coding Task, Three-dimensional Drawing Task 2.4. Program following mistakes (incl. stimuli omission) under cancellation test, Graphomotor Sequences, The Maze-tracing Task, Digit Symbol Coding Task; programs loss under Spot the Difference task and Reciprocal Motor Programmer Test
3. Control of execution of own actions	A total amount of corrected and uncorrected errors found in all the tasks

Cuadernos de Neuropsicología / Panamerican Journal of Neuropsychology
2023, Vol. 17 Nº 2 Special Issue 116 - 124
ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

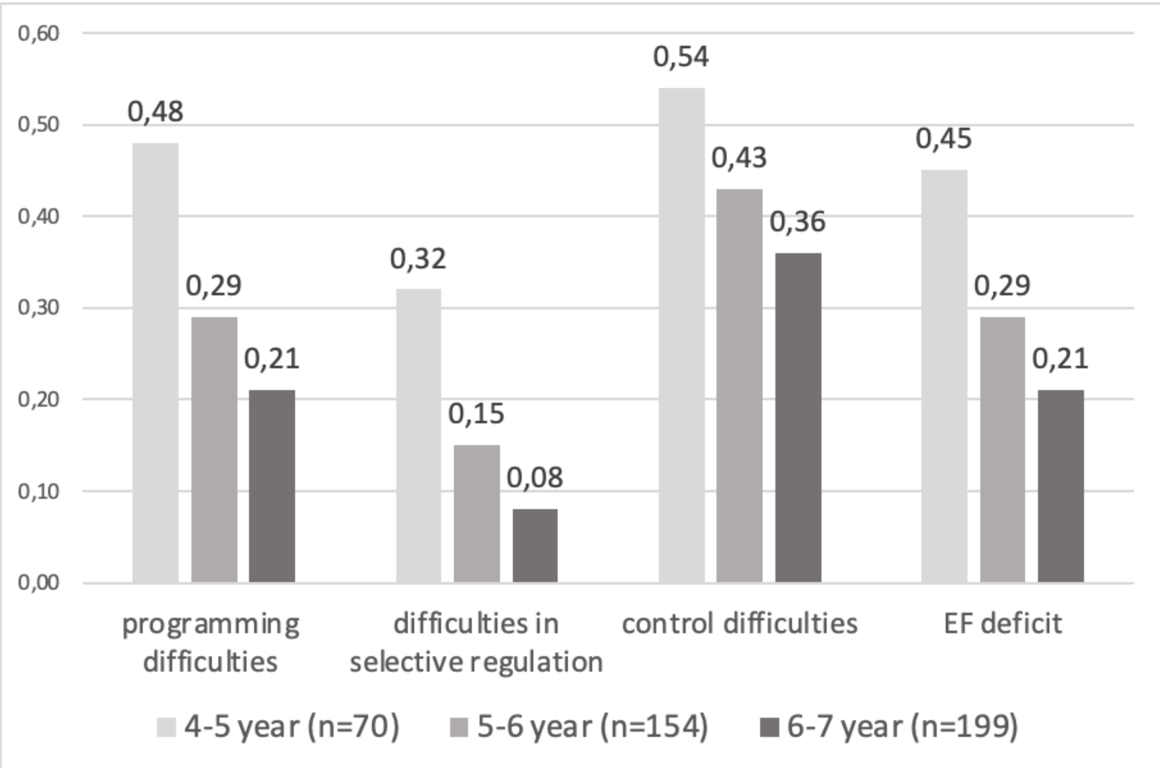
All task evaluation parameters included in the integral indicators of the immatureness of certain components represent a system of penalty points: the minimum score corresponds to the best performance, and the maximum score corresponds to the worst performance. The statistical software package SPSS 28.0 was applied for data processing. Non-parametric Kruskal-Wallis (H) and Mann-Whitney (U) criteria were used for assessing the significance of group and subgroup differences in the analyzed neuropsychological parameters.

RESULTS

Functions of programming, selective regulation and control

The comparison of three preschooler groups (see figure 1) revealed lower level of EF development in children aged 4-5 compared to other aged groups. An intergroup comparison in terms of the overall EF state index revealed significant differences in all three groups (H=80.762, p<0.001). Compared groups showed significant differences in almost all neuropsychological indices: programming deficit (H=70.336, p<0.001); selective regulation deficit (H=91.593, p<0.001); and by control deficit (H=22.229, p<0.001).

Figure 1.
Integral neuropsychological indexes of EF components deficiency (higher numbers stand for lower development level)



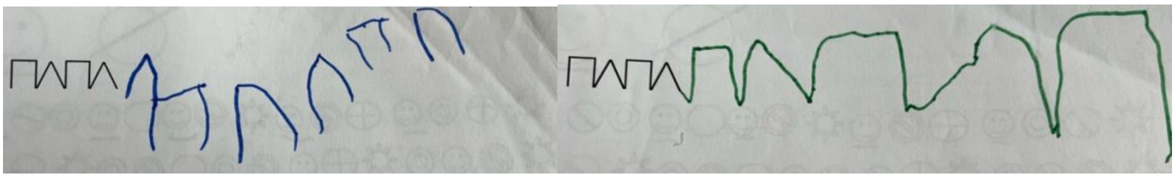
A separate consideration of the components of programming shows that when moving from younger group to elder one, there is an increase in the development of the ability to understand verbal and graphic instructions (U=2697.5, p<0.001 - children aged 4-5 vs children aged 5-6 years; U=9731.500, p<0.0001 - children aged 5-6 vs children aged 6-7 years). Significant differences in the possibilities of creating an activity strategy are found only when comparing children 4-5 years old and 6-7 years old (U=9247.000, p<0.0001). When analyzing the component of the regulation of one's activity, difficulties were noted in inhibition of direct reactions at the age of 4-5 and 5-6 years (U=9295.000, p=0.003). These manifestations are characteristic of all preschool children because the ability to resist impulsive reactions does not develop fully at preschool age: for children aged 5-6 it is more difficult than for children aged 6-7 (U=9232.500, p=0.041). Children aged 4-5 have difficulties in switching from one activity to another (U=1356.000, p<0.001). This significantly affects the graphomotor skills of the child. Difficulties are observed in the ability to switch from one mode of action to another, from one program to

ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

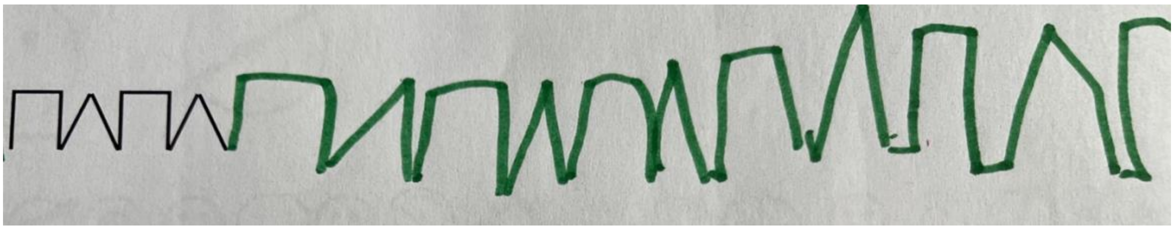
another (H=64.936, p<0.001), as well as in the stable maintenance of the learned program (H=39.742, p<0.001). On average, in terms of the parameters of selective regulation, we see an improvement by 1.5-2 times in the transition from each age to the next, which suggests the intensive development of these functions at this age stage.

Figure 2.

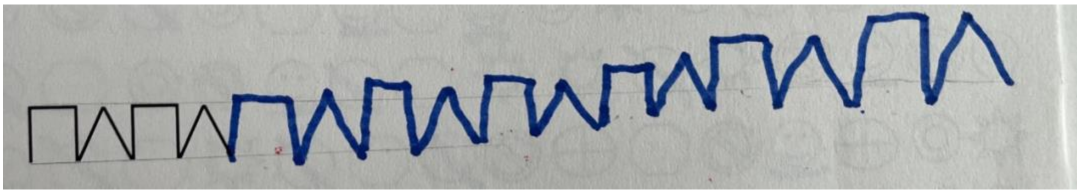
Examples of Graphomotor Sequences Task performance by children of different age groups



4 - 5 years old



5 – 6 years old



6 - 7 years old

Separately, it is necessary to analyze the features of the *Graphomotor Sequences Task* (see figure 2). Children of 4-5 years old experienced difficulties in mastering the instructions, they did not understand how to repeat a series of two elements. These children needed additional help in the form of a demonstration of drawing elements. After assimilation of the program, only 14.5% of the children kept the program on their own, 27.4% of the children needed to be reminded of the instructions (in this case, the graphic sample was in front of the child all the time). At the age of 5-7 years, there were no difficulties in mastering the program, difficulties in maintaining the program were noted in 11.4% of children aged 5-6 years.

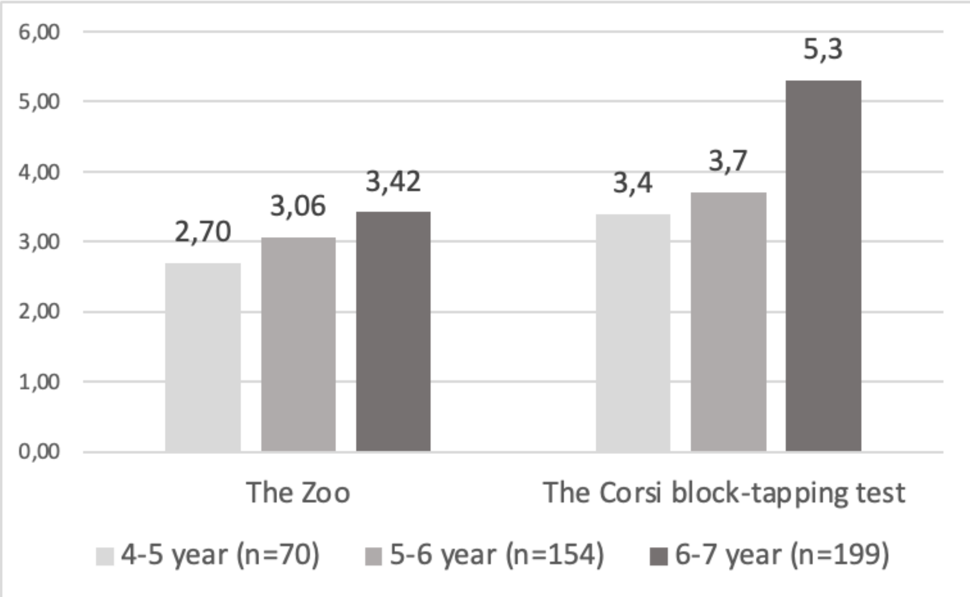
<u>*Working memory*</u>

The effectiveness of WM was assessed using two tasks – *the Zoo* and *the Corsi Block-tapping Test* (see figure 3). Children memorized from 2.7 (4-5 years old) to 3.4 (6-7 years old) elements in*"The Zoo Task"*. The ability to memorize a sequence of symbols in *the Corsi Block-tapping Test* was higher: 3.4-3.7 symbols at the age of 4-5 years and 5.3 symbols at the age of 6-7 years. Results show improvement in working memory capacity by age 6-7 (H=115.964; p≤0.000).

ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

Figure 3.

Working memory span in preschoolers



Inhibitory control and cognitive flexibility

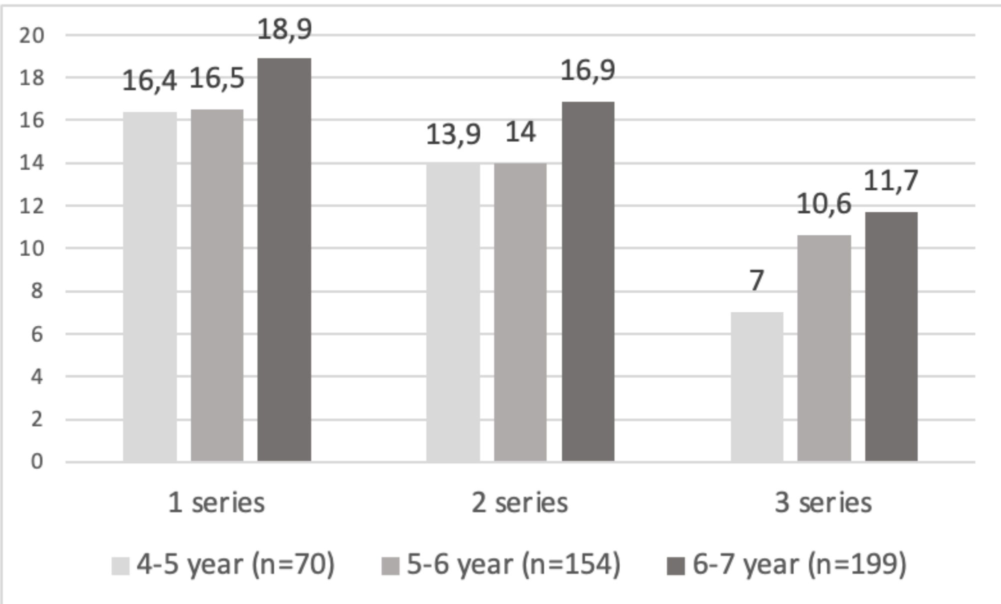
Hearts and Flowers (The Dots task) *Test* (see figure 4) evaluates the ability to understand and retain programs of varying complexity, to suppress habitual actions (inhibitory control) and to switch from one action to another (cognitive flexibility).

Productivity significantly increased in children aged 6-7 years compared with children aged 4-6 years in the first H=11.294; p<0.0001)and in the second (H=11.294; p<0.0001) series. The first series was the most simple one, which assesses the ability to follow the instructions and reaction speed. Children aged 4-6 did well with this task (average productivity – 16,5 stimuli out of 20). The second series allows to evaluate the ability to suppress direct response. This task was more difficult for children 4-6 years old (average productivity – 14 stimuli out of 20).

In the third, most difficult series, requiring the retention of two programs at once, no differences were found between the age groups of children 5-6 and 6-7 years old. The third series was not available to most children 4-5 years old, which might indicate the lack of opportunities to switch from program to program at the age of 4-5 years.

Figure 4.

The productivity of «Hearts and Flowers" conflict test in preschoolers



 ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

Sustained attention in monotonous activities

Age-related changes were revealed in the *Cancellation Test.* Differences in the number of correct answers were found in the ability to sustain a simple (cross out one type of stimulus: U=1152.000, p<0.0001) and more complex (cross out two types of stimuli: U=1335.500, p=0.001) programs during monotonous activity between groups of 5-6 and 6-7 year old. Children 4-5 years old quickly got tired when performing this task, did not complete it to the end. It is usually used in developing and corrective tasks.

DISCUSSION

Preschool age is one of the critical periods of human development. During this period, intense morpho-functional maturation of the brain is combined with significant changes in social conditions, including a transition to school learning with its' increased demands on executive functions (EF) [Diamond et al., 2007]. Summarizing the results obtained, it can be concluded that during preschool age, various components of the EF and their effectiveness in general increase significantly in general. Noticeable changes were found in the ability to assimilate instructions and activity algorithms, especially in graphomotor skills, in which there were also difficulties in switching from one movement to another at the age of 4-5 years. Both in individual and frontal examination methods, younger preschoolers often had to repeat the instruction, demonstrate it (in the case of a graphomotor program), or even include a training stage before the actual execution of the task. Attracting attention to the goal at the stage of preparation for the task contributed to the increase in the efficiency of the activities of children 4-5 years old. This technique can be used as a corrective or developmental procedure when performing various tasks at this age (Akhutina, 2015; Glozman, 2021).

The ability to create strategies for the activity at the preschool age remains significantly immature. The development of this component becomes noticeable only at the age of 6-7 years. The functions of selective regulation also showed a significant development of individual components that make it possible to retain the programs by the child. At the age of 4-5 years, there are low possibilities for inhibiting immediate reactions, difficulties in regulating impulsivity even with the help of an adult, difficulties in switching from one element of the program to another (especially in graphomotor activity), inertia when changing the algorithm of activity, and difficulties in sustaining the algorithm. This is agreed with the data on the age-related immaturity of the switching components and the ability to control the performance of one's own actions is observed in children aged 5–7 years (Semenova et.al., 2007). The ability to detect a mistake and correct it is also immature throughout the preschool age, and according to some data, throughout the entire primary school age (Luna et al., 2010). All this makes it possible to substantiate the need to work in the zone of proximal development (Vygotskij, 1991) and the formation of separate components of executive functions, which can be relied upon in the formation of reading and writing skills.

The efficiency of working memory increases significantly in the transition from 5-6 to 6-7 years. In other studies, increase in the efficiency and volume of WM observed between the ages of 5–6 and 9–10 years (Alloway et al., 2009). The absence of differences in comparison of groups of 4–5 and 5–6 years old is rather due to a specially organized procedure for examining middle preschoolers (presence of a training series, organization of attention through additional instructions) and depends on the ability to maintain attention to the task. At the same time, attention tests have revealed that the ability to concentrate and distribute attention improves significantly with age.

CONCLUSION

The study of various components of executive functions is important for understanding how the development of these processes affects each other in ontogeny and for more efficient work with the problems of programming, regulation, and control of activity. The goal of the treatment of EF deficit is currently one of the most frequently encountered in the neuropsychological practice with preschoolares. In our study preschool children demonstrate significant individual differences in the functional state of the brain regulatory systems and the effectiveness of cognitive control. The data obtained make it possible to substantiate the importance of certain methodological techniques (for example, organizing a child's goal-directed attention to a goal to improve the efficiency of completing a task, working in the zone of proximal development to develop expropriate components of the EF), as well as the absence of the need for an early start in targeted training in mastering writing and reading skills.

ISSN: 0718-4123
DOI: 10.7714/CNPS/17.2.208

REFERENCES

Akhutina T.V., Kamardina I.O., & Pylaeva N.M. (2016). *Neiropsikholog v shkole* [Neuropsychologist at school]. V. Sekachev Publ.

Akhutina T.V., Pylaeva N.M. (2015). *Preodolenie trudnostei ucheniya: neiropsikhologicheskii podkhod* [Overcoming learning disabilities: A neuropsychological approach]. Akademia Publ.

Akhutina, T. V., Korneev, A. A., Matveeva, E. Y., Gusev, A. N., & Kremlev, A. E. (2019). The Development of Integral Indices for a Computerized Neuropsychological Test Battery for Children. *The Russian Journal of Cognitive Science*, *6* (2), 4-19. https://elibrary.ru/item.asp?id=43034231

Akhutina, T.V. (ed) (2016). Metody neiropsikhologicheskogo obsledovaniia detei 6-9 let [Methods of neuropsychological examination of children 6-9 years old], V. Sekachev.

Alloway T.P., Alloway R.G. (2010). Investigating the predictive roles of working memory and IQ in academic attainment. *Journal of Experimental Child Psychology*, 106 (1), 20-29. https://doi.org/10.1016/j.jecp.2009.11.003

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), pp. 2037-2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

Diamond A. (2013). Executive functions. *Annual review of psychology*, 64, 135-168. https://doi.org/10.1146/annurev-psych-113011-143750

Diamond A., Barnett W.S., Thomas J., Munro S. (2007). Preschool program improves cognitive control. *Science*, 318 (5855), 1387–1388. https://doi.org/10.1126/science.1151148

Glozman J. M. (2021) Child neuropsychology. Urite.

Glozman J. M., Sobolev E. A., Titova Yu. O. (2008). Neuropsychological diagnosis of preschool children. Piter.

Luria, A.R. (1965). L.S. Vygotsky and the problem of localization of functions. *Neuropsychologia,* 3(4), 387-392. https://doi.org/10.1016/0028-3932(65)90012-6)

Luna B., Padmanabhan A., O'Hearn K. (2010). What has fMRI told us about the development of cognitive control through adolescence? *Brain Cogn.,* 72 (1), p. 101-113. https://doi.org/

Luria, A.R. (1973). Osnovy neiropsikhologii [Fundamentals of Neuropsychology], Moscow: Mosk. Gos. Univ.

Machinskaya R.I. (2015). Upravlyayushchie sistemy mozga [The brain executive systems]. *Zhurnal vysshei nervnoi deyatel'nosti im. I.P. Pavlova* [*I.P. Pavlov Journal of Higher Nervous Activity*], 65 (1), pp. 33—60. https://doi.org/10.7868/S0044467715010086. (In Russ.)

Miyake A., Friedman N.P., Emerson M.J., Witzki A.H., Howerter A., Wager T.D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, 41 (1), p. 49–100. https://doi.org/10.1006/cogp.1999.0734

*Semenova, O.A. and Machinskaya, R.I. (*2015) The influence of the functional state of brain regulatory systems on the efficiency of voluntary regulation of cognitive activity in children: II. neuropsychological and EEG analysis of brain regulatory functions in 10–12-year-old children with learning difficulties. *Hum. Physiol.*, 41 (5), p. 478. https://doi.org/10.1134/S0362119715050126

Semenova O.A., Koshel'kov D.A., Machinskaya R.I. (2007). Vozrastnye izmeneniya proizvol'noi regulyatsii deyatel'nosti v starshem doshkol'nom i mladshem shkol'nom vozraste [Age-specific changes of activity self-regulation in preschool-age and early school-age children]. *Kul'turno-istoricheskaya psikhologiya = Cultural-Historical Psychology*, 3 (4), pp. 39—49. https://doi.org/10.17759/chp.2007030405.

Solovieva Yu., Rojas L.Q. (2017). Syndromic analysis in child neuropsychology: A case study. *Psychology in Russia: State of the Art,* 10 (4), 172-184. https://doi.org/10.11621/PIR.2017.0415)