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**EXECUTIVE FUNCTIONS AND THEORY OF MIND IN SENIOR
PRESCHOOL AGE**

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Abstract

The goal of our study is to specify the role of executive functions in cognitive and social development in preschool age. This research examined the relation between individual differences in all three components of executive functioning (working memory, cognitive flexibility and inhibition) and theory of mind performance in senior preschool-age children.

The study involved 267 children aged 5-6 years (143 boys and 124 girls), pupils of the older kindergarten groups in Moscow.

The study used NEPSY-II diagnostic complex subtests aimed at diagnosing the level of executive functions and social development («Theory of mind» is one of them). We also used the Raven's progressive matrix test, the DCCS method and the Test of Emotion Comprehension.

The obtained result's analysis showed the significant connection between all three components of executive functions and theory of mind. Three types of development of regulatory functions in preschool children were identified. Children belonging to different types shown differences in the successfulness of the theory of mind's tasks performing.

Our results provide important details about understanding the relation between executive functioning and theory of mind development in the senior preschool age and practical implications for child's future academic success, which requires high level of regulation and socio-emotional competence.

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1. Introduction

One of the most actively developing areas of modern research in developmental psychology aims to study theory of mind and its connection with other psychological characteristics of child development (Apperly et al, 2011; Bock et al, 2015; Frye et al, 1995; Hughes, 1998; Miller, 2009; Miller, 2012; Wellman, & Peterson, 2013; White et al, 2009). This cognitive ability underlies children's social skills that along with executive function development provide for a child's successful adaptation to school education (Willoughby et al, 2012).

1.1. Theory of Mind

The term "theory of mind" denotes a cognitive ability to understand one's own mental states such as thoughts, desires, beliefs and emotions, as well as other people's mental states (Perner, Lang, & Kloof, 2002). This line of research is based on J. Piaget's idea of egocentrism as being a specific feature of the pre-operational thinking stage which implies that a child constantly discovers its relative inability to take the position of another person, i.e., to treat one's own point of view only as one of many possible others and coordinate it with the latter (Flavell, 1963).

This implies the child's inability to understand another person's point of view, to assess critically its own reasoning, which was shown in a number of experiments by Piaget himself and his followers. The most well-known experiment that reflects this peculiar feature of children's thinking consisted in simulating a situation where a child was to look at a certain scene from one point and simultaneously imagine what it looked like when viewed from another angle. As shown in this experiment, the child at his early age gives an answer that corresponds to the way it views the situation through its own eyes, which speaks of its egocentrism. But as Piaget noted, in the process of social interaction with other people, especially when engaged in disputes and disagreements, there occur gradual decentration and transition to the stage of concrete operations.

Modern research confirms that theory of mind develops rapidly in early childhood (Frye et al, 1995; Hughes, 1998; Wellman, & Liu, 2004) and continues to improve throughout the preschool and primary school years (Apperly et al, 2011; Bock et al, 2015; Happé, 1994; Miller, 2009; Miller, 2012; White et al, 2009). Significant changes in theory of mind development occur at an older preschool age: at the age of 5-6 there is a transition to the level, when one's own mental model can not only be separated from the model of the mental Other, but there arises a possibility to mentally influence it, the model becomes situationally independent (Wimmer, & Perner, 1983). This qualitative leap in theory of mind development provides a capability to understand and predict other people's behavior. Studies show that in the older preschool age, children also develop abilities to discern and understand such subtleties in conversation and social interaction as deception, irony, sarcasm, and figures of speech (Devine & Hughes, 2014; Filippova & Astington, 2008; Happé, 1994). It is important to note that development of various components of the theory of mind is simultaneous rather than consecutive. Thus, the period most fascinating for studying the development of this ability is the preschool age which sees significant changes in theory of mind.

According to the studies carried out with different versions of false representation tasks, regardless of cultural differences there is a shift in understanding the difference between one's own belief and that of another being during years 3 and 5, (Callaghan et al, 2005; Wellman & Peterson, 2013). However, there are many other factors that impact theory of mind development. For example, a study found that children of preschool age (5.5-6 year old) who lacked maternal support had a lower level of self-control and a decreased degree of theory of mind formation, they also displayed a high level of aggression when interacting with their peers (Zelazo, 2006). There is also much evidence of the relationship between theory of mind and the executive functions development in children at the time of its onset at an early age and during its subsequent development (Cantin et al, 2016; Carlson et al, 2002; Carlson et al, 2015; Frye et al, 1995; Hughes & Ensor, 2007; Oh & Lewis, 2008; Premack & Woodruff, 1978).

1.2. Executive functions

Before discussing in more detail the relationship between theory of mind and executive functions, it is important to explain what we mean by the term "executive functions". One of the most widely used approaches to understanding executive functions in childhood is the model developed by A. Miyake and his colleagues (Almazova et al, 2016; Diamond et al, 2002; Lehto et al, 2003; Miller, 2012). According to this model, the neuropsychological basis for mastering one's behavior involves a group of cognitive skills that provide targeted problem solving and adaptive behavior in new situations - they are united under the general name of regulatory or executive functions. They are divided into the following three main components: 1) working memory; 2) attention flexibility or switching; 3) inhibition. These components are related to one another, but they can also be viewed as being separate, independent from each other, so this model came to be called "unity-with-diversity".

2. Problem Statement

2.1. The connection between theory of mind and executive functions

There are several viewpoints on what underlies the relationship between the level of executive functions development and the successful performance of theory of mind tasks. There are data according to which the concept of the mental model and executive functions is served by the single front lobe zone (Olson et al, 2011). Some authors assert in their works that general cognitive abilities are behind the executive functions and theory of mind development (Willoughby et al, 2012). For example, the Dimensional Change Card Sorting Task (Almazova et al, 2016; Olson et al, 2011) and theory of Mind tasks have a common logical structure. In the same way as the above false belief task, sorting tasks involve switching from one rule to another. According to P.D. Zelazo & D. Frye, 1997, three-year-olds cannot imagine a higher order rule that unites two disparate pairs of rules, and cannot apply it for the corresponding action.

Quite a different viewpoint is held by researchers D. Kloo and J. Perner, 2003. Their work has suggested that tasks aimed at studying the theory of mind and executive functions are determined by the same process - constraining control. The authors examine the classical experiment by H. Wimmer and J. Perner, 1983 and argue that to do this task it requires the following abilities to be actualized: a) holding in

mind two possibilities, c) suppressing the dominant response and c) initiating a non-dominant response (Perner et al, 2002). The experimental study showed that working with children in order to help them to overcome difficulties in solving the card sorting task improves their performance in doing tasks that are related to the study of theory of mind (Kloo & Perner, 2003). Their findings are borne out by a number of other studies that showed a stable relationship between the performance of false belief tasks and that of the conflict-type tasks aimed to study constraining control (Carlson et al, 2002; Muller et al, 2012).

Thus, most researchers believe that the links between executive functions and theory of mind are due to the fact that understanding mental states requires certain regulatory skills: retaining different points of view or potential realities in the mind, flexible switching between them, as well as constraining one's own position in order to understand other people's viewpoints, including their false beliefs. Meanwhile recent foreign studies have shown that such components of executive functions as constraining control and flexibility are significant predictors of further theory of mind development (Bock et al, 2015; Cantin et al, 2016; Carlson et al, 2002; Muller et al, 2012; Yeniad et al, 2013).

3. Research Questions

Despite the fact that there has been active research into these issues in foreign psychology over the past 30 years, similar experimental studies are relatively rare in Russia with but very few of them being devoted to preschool age (Sobkin et al, 2016). It can be assumed that this situation stems from, among other things, the lack of well-developed diagnostic tools aimed to study theory of mind..

4. Purpose of the Study

In connection with this, the objective of our research was to study the connection between theory of mind development and executive functions development by using foreign methods we have adapted to diagnose these abilities

We sought to analyze the connection between the theory of mind and each component of executive functions separately. Also to reveal the basic patterns of development of executive functions in preschool age and to consider their connection with the development of the theory of mind.

5. Research Methods

Most of the methods used in the study are NEPSY-II neuropsychological diagnostic complex subtests (Korkman, 1999; Korkman et al, 2007), aimed at assessing the mental development of children aged 3-16 years. The diagnostic complex also included the Raven colored progressive matrices technique (Raven et al, 1998) to control the development level of preschool children's intelligence.

5.1. To diagnose theory of mind development, we used two techniques.

The former, Theory of Mind (ToM), is a NEPSY-II subtest and directly aims to diagnose the development of various components of the mental model: the ability to understand other people's turns of

phrase, intentions, thoughts, feelings, the ability to distinguish between the real and imaginary planes of reality, as well as the understanding of false beliefs.

The latter, "Test of Emotion Comprehension" (TEC) (Pons & Harris, 2000) aims to study children's ability to understand other people's emotions in different situations.

▪ **To diagnose the development level of such components of executive functions as cognitive flexibility and inhibition, the following two methods were used:**

- the Inhibition subtest, consisting of two tests - naming and inhibition which registered the number of errors made by a child and the amount of time it took the child to cope with it (Almazova et al, 2016);
- the "Dimensional Change Card Sort" (DCCS) technique (Zelazo, 2006). The above methods increase gradually the task complexity to make the child activate different components of executive functions. Comparison of the successful performance of individual tasks helps to identify which of the subject's executive function components are underdeveloped (Almazova et al, 2016);
- To study working memory, two NEPSY-II subtests were used: "Memory for Designs" for measuring the development level of the child's visual memory and visual-spatial orientation; and "Sentences Repetition" for measuring the development level of a child's verbal memory (Korkman, Kirk & Kemp, 2007).

6. Findings

6.1. Sample

Our study sample included 267 children aged 5-6 years (M = 5.6 years) attending a senior group in a Moscow kindergarten. Out of these 143 were boys and 124 were girls. This study was conducted in the 2015-2016 school year. All the tasks were carried out individually, in a quiet room.

6.2. The results of executive functions and theory of mind tasks performance

The Raven Progressive matrices method was used by us to determine the intellectual development level in preschool children. All children showed results well within their age norm, which indicates the validity of further research on this sample.

Let us first consider the results of diagnostics of executive functions and theory of mind in the children (Table 1).

Table 01. Executive Functions and Theory of Mind task's scores

Methods	Mean	Standart deviation	Max score
Memory for Designs	79,99	23,82	120
Sentence Repetition	19,64	4,33	32
DCCS, PreSwitch	5,94	0,34	6
DCCS, PostSwitch	5,50	1,19	6

DCCS, Border	7,46	2,93	12
DCCS, Total score	18,89	3,50	24
Naming, uncorrected errors	0,94	1,86	40
Naming, corrected errors	0,96	1,28	40
Naming, time	43,58	10,94	180
Inhibition, uncorrected errors	3,12	5,27	40
Inhibition, corrected errors	1,93	1,75	40
Inhibition, time	60,92	14,96	240
Theory of mind	14,97	3,46	28
Test of Emotional Comprehension	16,09	2,31	19

The results of working memory evaluation show that the children coped well with both Sentence Repetition and Memory Designs tasks. Thus, the development level of visual and auditory memory in all the subjects was found to be normal.

Let us consider the results of assignments aimed to diagnose theory of mind. The performance results of the Theory of Mind method testify to the fact that the children coped with about half of the tasks (14.97 points out of the maximum possible 28 points). The children are better at doing the test for understanding emotions, as evidenced by the average score (16.09 of 24 points), and a smaller spread of data compared with the previous method (2.31 and 3.46 points, respectively).

Consider the results of children using the DCCS method: according to the data (Table 1), children at this age already cope well with the first two tasks, i.e., they can switch from one task to another (from sorting by color to sorting by shape). However, the results of the third task show that most of the children fail to cope with an even more complicated task (the task is considered to be performed correctly if a child has scored 9 points or more). The ability to switch between two conflicting rules in a flexible manner at a given age was formed in as few as 39.3% (105 children). In further analysis, it will be advisable to use only the final score for this technique since it fully reflects the development degree of cognitive flexibility.

Now let's turn to the results of the children's performance in the Inhibition method. Children are much better at doing the naming test than the inhibition one: they make fewer mistakes (both corrected and uncorrected) and spend less time doing it (Table 1). The results obtained show that the executive function of the constraining control is also just being formed at this age.

Thus, children significantly differ in the development level of individual executive functions.

6.3. Analysis of the relationship between methods aimed at diagnosing the development level of theory of mind and executive functions

Let us consider the correlation between children's results in performing the techniques used to diagnose executive functions and theory of mind (Table 2).

Table 02. Connections of the results of children's performance of executive functions and the theory of mind methods (Spirmen coef., level of significance)

Executive Functions	ToM	TEC
Memory for Designs	r=0,126, p=0,045	r=0,200, p=0,002
Sentence Repetition	r=0,236, p=0,000	r=0,217, p=0,001
DCCS, Total score	r=0,215, p=0,001	
Naming, uncorrected errors		
Naming, corrected errors		
Naming, time		
Inhibition, uncorrected errors		r=-0,157, p=0,016
Inhibition, corrected errors		
Inhibition, time		

First, the results of both methods (ToM and TEC) are significantly correlated ($r = 0.335$, $p = 0.000$) - this suggests that they are based on the same ability. Secondly, a relationship was found to exist between the results of children performing tasks for visual and auditory working memory and both methods determining the development level of theory of mind in children (Table 2). Thirdly, the results of the correlation analysis showed the presence of significant links between the results of performing tasks on voluntariness and theory of mind: successful performance of ToM tasks is significantly related to that of DCCS tasks. We can also see from the data obtained that children who more successfully coped with the TEC tasks made fewer mistakes when performing the inhibition test ($r = -0.157$, $p = 0.016$), indicating a link between the ability to understand the feelings of others and executive functions in the senior preschool age.

However, the final score according to the "Theory of Mind" technique does not give an idea of the theory of mind development level and precisely which of its aspects are related to executive functions. In this regard, we conducted an additional analysis of the successful performance of the individual tasks of this methodology that had different levels of executive functions development.

As a result of the cluster analysis (using the K-means method) of children's performance of the DCCS and "Inhibition" methods, three groups of children were singled out, differing from one another in the type of executive functions development (Table 3). Several children were removed from consideration due to the result of their performance in the Inhibition method: three children failed to complete the task and made many mistakes in the inhibition test (more than 30 uncorrected errors), and another three took too much time to do both tests of this technique (on average, 91.3 seconds to do the naming test, 118.3 seconds to do the inhibition test).

Table 03. Result of the cluster analysis of children with different level of executive functions development

Methods	Mean	Standart deviation	Max score
DCCS	19	19	19
Inhibition, название, неисправленные ошибки	0,9	0,7	1,0
Inhibition, название, исправленные	1,1	0,8	1,0

ошибки			
Inhibition, название, время	54,2	44,0	37,7
Inhibition, торможение, неисправленные ошибки	2,6	2,6	3,1
Inhibition, торможение, исправленные ошибки	2,3	1,9	1,9
Inhibition, торможение, время	82,3	62,4	48,3
Кол-во человек	47	106	108

The above groups of children differ significantly from each other in the amount of time they spend doing both tasks according to the Inhibition method (Mann-Whitney criterion, $p \leq 0,000$). Another important indicator of executive functions development is the number of mistakes made by children and their ratio (between those corrected and uncorrected by the child). Since on average the children cope equally well with doing the figure naming test, the most revealing results are those based on the performance of the second test – that of inhibition. However, there were no significant differences identified in the number of mistakes. In this regard, it is impossible to draw a conclusion about the level of executive functions development based only on time indicators so we shall speak about three types (and not levels) of executive functions development in older preschool children. Let's analyze the specific features of each type in accordance with the most important indicators.

Children with the first type of executive functions development (47 kids) spend much more time on both tests of the Inhibition method and make more mistakes in the inhibition test - this is expressed in the number of self-corrections (for comparison, this and the other two groups on average registered 2, 3 and 1.9 mistakes respectively). Their results indicate that Type 1 is characterized by a low level of development of the processes of switching and inhibition.

Children with the second type of executive functions development (106 kids) spend significantly less time on both tasks and make fewer mistakes, which is expressed in the number of self-corrections.

Children belonging to the third type of executive functions development spend the least amount of time compared to the children from the other groups, but it is important to note that this group of children has more uncorrected mistakes than those corrected. It can be surmised that this group of children was focused more on the speed of task performance rather than on its quality, which is more characteristic of children with the second type of executive functions development.

Let us now consider the differences in the successful performance of individual theory of mind tasks in children with different types of executive functions development. As a result of the statistical analysis, several tasks were identified with which children of the first development type, i.e., with the lowest level of cognitive control, coped significantly worse. For a better understanding of the results obtained, it is important to say more about these tasks. Task 6 put two identical boxes with images of cubes on the lid before children. First, the experimenter and a child examined the first box, which did contain cubes, and then they went on to discuss the second box, which contained pencils. After that the child was asked the question: "If your friend comes into the room now, what will he think is in this box?" As a result of the statistical analysis, it was found that children belonging to Type 1, i.e., those with a lower level of executive functions development, were significantly less likely to cope with Task 6 than children with the second type of executive functions development (respectively, 57.5% and 74.5% of the

correct answers, $\chi = 3.873$, $p = 0.049$). This task aims to find out a child's understanding of false beliefs, which implies that children with a lower level of cognitive regulation have a lower level of development of this component of the mental model.

It is important to note that our methods had another similar false belief task with which, regardless of their type of executive functions development, most of the children coped (69% of the entire sample). In Task 1, a child was told the following story: "When Andrew opened a box of biscuits, he found out that Mom had put pasta in it. He was upset and put the box back in its place. Andrei's brother came in and saw the box of biscuits. What did Brother Andrew think was in the box? "

The other false belief task again revealed differences. In Task 8 the child was told the following story: "Polina and Anya wanted to ride on the Ferris wheel. Kostya and Maxim did not want to take a ride on it, instead they went to the flying horses. When the girls approached the Ferris Wheel, there was a huge queue to get in. So the girls decided to go to the fun house. When Kostya and Maxim finish riding on the flying horses where will they look for Anya and Pauline - on the Ferris wheel or in the fun house?" Let us consider how children with different types of executive functions development coped with the task (see Table 4).

Children with Type 1 of executive functions development are much less likely to perform Task 8 compared to children with Types 2 and 3 of cognitive regulation (respectively, 27.5%, 48.0% and 55.1% of correct answers, $\chi = 9.597$, $p = 0.048$). Thus, the data obtained on the successful fulfillment by the children of false belief tasks show that there is a link between the level of executive functions development and this ToM component.

As far as the ToM method was concerned the overall result was also significantly different in children belonging to Type 1 of executive functions development from the other two groups (see Table 5). It is important to note that there were no significant differences in the successful fulfillment of the TEC methods in children with different levels of cognitive regulation. Neither is there any difference between Types 2 and 3 of executive functions development.

Significant differences between children of Types 2 and 3 could be found in one of the tasks in which the children were to define the girl's emotion in the situation shown: a child was shown a picture reflecting the story of what happened to a girl called Julia; Next to each picture were 4 photos of Julia's face. The experimenter asked the child to carefully look at the picture and show the photo of Julia which most accurately depicted what she was feeling in this story. In the test illustration, which explained to the children how to perform such tasks, there was a situation in which Julia fell off her bicycle and an adult bandaged her grazed knee. Children belonging to Type 2 of executive functions development did much better than Type 3 children (71.7% and 56.8% of correct answers, respectively, $\chi = 4.511$, $p = 0.034$). This task was chosen so that it was easy for children to understand a situation depicted, the main task being to get them to understand the instruction. In connection with this, the result obtained can be explained by the hasty choice of an answer by Type 3 children, which reflects the specific features of their executive functions development.

Thus, we obtained significant differences in the children's successful performance of tasks aimed at diagnosing their ability to understand false beliefs and other people's mental states, children with a lower (type 1) and higher (type 2 and 3) levels of executive functions development.

7. Conclusion

As a result of the statistical analysis, relationships were found to exist between methods aiming to diagnose theory of mind and various components of executive functions. First, the analysis revealed a relationship between the development level of working memory (visual and auditory) and theory of mind. This result disagrees with some of the earlier studies (Carlson et al, 2002; Carlson et al, 2015; Muller et al, 2012), but it can be explained by the specific features of the methods used to diagnose theory of mind: when performing them a child must needs keep the voluminous verbal instructions in its memory and go by the pictures offered as illustrations to the tasks.

As a result of the cluster analysis, we have identified three types of executive functions development: Type 1 is characterized by a low development level of inhibition and switching processes. Children with this type of executive functions development showed poorer results in performing ToM tasks. Types 2 and 3 are characterized by a higher level of executive functions development but qualitative differences have been found to exist between them: Type 2 is characterized by a higher level of self-control when doing the tasks, these children are more concerned with accuracy and quality, therefore they tend to correct their mistakes more often whereas Type 3 is focused, first of all, on the speedy fulfillment of tasks, these children are less likely to correct their mistakes.

In general, the results of the correlation and cluster analysis indicate that there is a relationship between the level of a child's understanding of false beliefs and such components of cognitive control as inhibition and switching, which is in good agreement with the previous studies (Bock et al, 2015; Cantin et al, 2016; Carlson et al, 2015; Muller et al, 2012; Perner et al, 2002; Yeniad et al, 2013). Most authors hold the view that this relationship stems from the participation of executive functions in performing false belief tasks: a child should be flexible enough to switch between its belief and another person's vision of the situation, and also to suppress its own knowledge about the situation. According to LS. Vygotsky's concept, this relationship between executive functions and theory of mind development may be explained by the restructuring of mental functions that occurs in the preschool age: a child gradually masters its cognitive processes that begin to acquire such a higher mental function property as voluntariness.

It is important to note that according to our data, children are better able to cope with false belief tasks that are more understandable and closer to their life experience. So it is not only the level of executive functions development, but also the ability to present the situation described in the mental plane based on one's past experiences that influences the successful fulfillment of ToM tasks. This also confirms Piaget's idea that egocentrism is overcome through social interaction with other people, it is in real life situations that a child learns how to compare its viewpoint with that of its parents, siblings and peers.

Unfortunately, the data obtained do not make it possible to reveal cause-effect relations between executive functions development and ToM formation. To answer this question, it is necessary to conduct a longitudinal study that will allow us to study the development of the mental model and executive functions throughout the preschool and primary school years. That is what we are planning to do in our further research.

Thus, our study has shown the presence of significant links between all the three components of executive functions (working memory, cognitive flexibility and constraining control) and theory of mind.

The data we have obtained are only the first step in studying the links between components of executive functions and theory of mind in the preschool and subsequent ages.

Further investigation of cognitive abilities in preschool children will help to better understand and study the logic of development of such significant social skills as emotional regulation, building up of positive relationships with peers and successful behavior in the classroom. It can also serve as a basis for elaboration of developing programs to improve cognitive regulation and social interaction skills.

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