

Manifestations of Social Cognition Deficit in Children with Mental Retardation

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The article presents a study of the mental model deficit in preschoolers with mental retardation. The aim of this study using eye tracking is to identify markers that can predict the difficulties of social cognition associated with a deficit in the mental model in children with mental retardation. A comparative study of 64 typically developing preschoolers and preschoolers with mental retardation was carried out. To study the formation of a mental model, the paradigm of understanding false beliefs and experimental situations were used, which actualize in children the idea of the possible success of using and recognizing deception. Additionally, in the experimental situation, the method of registration of eye movement was applied to identify the level of the mental model. It is shown that with a deficiency of the mental model (from the point of view of understanding and applying false beliefs), there is a concreteness of perception, difficulties in using sign-symbolic means of social interaction, inability to suppress impulsive action and act from the position of a social partner. Children with mental retardation often turn not to sign-symbolic means, but to specific external signs of the situation: behavioral manifestations, actions, experience difficulties in distancing themselves from their own beliefs in order to rely in behavior on ideas about the knowledge of an adult. According to the results of an eye tracking study on heat maps of preschoolers with mental retardation, there is a deficiency of a gaze direction detector, which is necessary for understanding the intentions and predicting the actions of an adult. Eye movement analysis confirms that children with mental retardation often do not track the behavior of an adult and his reactions in situations of recognition and application of false actions.

Keywords: mental model, social cognition, joint attention, preschool age, mental retardation, eye tracker.

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Проявления дефицита социального познания у детей с задержкой психического развития

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В статье представлено исследование дефицита модели психического у дошкольников с задержкой психического развития. Цель исследования методом слежения за движением глаз выявить маркеры, которые могут предсказать трудности социального познания, связанные с дефицитом модели психического у детей с задержкой психического развития. Проведено сравнительное исследование 64 типично развивающихся дошкольников и дошкольников с задержкой психического развития. Для исследования становления модели психического были использованы парадигма понимания ложных убеждений и экспериментальные ситуации, актуализирующие у детей представления о возможной успешности применения и распознавания обмана. Дополнительно в экспериментальной ситуации на выявление уровня модели психического был применен метод регистрации движения глаз. Показано, что при дефиците модели психического (с точки зрения понимания и применения ложных убеждений) наблюдаются конкретность восприятия, трудности применения знаково-символических средств социального взаимодействия, неспособность подавить импульсивное действие и действовать из позиции социального партнера. Дети с задержкой психического развития чаще обращаются не к знаково-символическим средствам, а к конкретным внешним признакам ситуации: поведенческим проявлениям действия, испытывают трудности дистанцирования от собственных убеждений, чтобы опираться в поведении на представления о знаниях взрослого. По результатам айтрекинг-исследования на тепловых картах дошкольников с задержкой психического развития наблюдается дефицит детектора направления взгляда, необходимого для понимания намерений и прогнозирования действий взрослого. Анализ движения глаз подтверждает, что дети с задержкой психического развития часто не отслеживают поведение взрослого и его реакции и в ситуации распознавания и применения ложных действий.

Ключевые слова: модель психического, социальное познание, совместное внимание, дошкольный возраст, задержка психического развития, айтрекер.

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Introduction

Today, in science, special attention in the study of child development is paid to the ability with which the child is able to interpret and predict the behavior of other people, based on their own beliefs and intentions [5; 12; 25].

In this regard, the approach of the “mental model” (the theory of mind, ToM) is actively developing in the study of the processes of social cognition [2; 7; eleven; 24]. The mental model is understood as a system of conceptualization of knowledge from one’s own mentality and the mentality of other people, which allows one to explain and predict their behavior, a certain phenomenon of “reading” the mental state (mindreading) of other people [1; 2]. With the help of the mental model, we are able to infer mental states (opinions, desires, intentions, ideas, emotions, etc.) that cause the actions of other people. The mental model allows revealing the cognitive mechanisms of understanding in interpersonal interaction, since the communication process is based on constant monitoring and comparison of understanding of mental states and events [3, p. 120].

Such coordination is possible only at the level of symbolic communication; therefore, the deficiency of the mental model can be associated with impaired thinking and

perception, the complexity of contextual representations, and the distortion of cognitive schemes. Without a certain critical level of symbolic thinking (with a symbolic deficit), the ability to decode social signals is reduced, therefore, to understand and adequately respond to them. Cognitive mechanisms are not being formed that make it possible to define hidden variables in a fundamentally different way (for example, intentions, mental states), which makes it difficult to fill gaps in direct perception [8; 9; 13; 23].

Important in the development of the child is the ability to use “signs” as pointers and social signals in relation to other people, the formation of a system of collective signs that generate a symbolic function as a means of expressing thinking [1].

The question of the origin of disorders of the mental model remains relevant, whether they arise as a result of a cognitive deficit or are an independent disorder. In the study of the mental model, no matter how scientists try to control their influence on verbal learning, memory [13] and thinking [11; 12; 19; 21] and language [13] contribute to group differences in the performance of tasks on the mental model.

At the same time, the limitations of previous results are related to the fact that most studies involved children with autism who were mentally retarded, and some

of their symptoms are due to this lag [22]. Therefore, it is impossible to fully explain the difficulties that were recorded in social interaction due to the combined diagnosis [3].

We can talk about the threshold value of the level of intelligence necessary for the formation of a mental model, however, the question remains whether it can be considered that the level of development of psychometric intelligence, assessed on the basis of tests, indicates the necessary role of cognitive development for the formation of a mental model [5, p. 7; 14]. To resolve this issue, it is necessary to test the specificity of the manifestation of joint attention deficit in a sample of children with cognitive impairments.

From the point of view of experimental design, the main methodological procedure in the “model of the mental” direction is tasks for incorrect opinions or understanding of false beliefs [5; 6; 12].

The ability to understand deception testifies to the cognitive development of the child and reflects the formation of a “mental model” as a system of representations of one’s own mental phenomena and the mentality of other people, since it involves ideas about the knowledge of another person and ways to change it [3; 10]. To recognize deception, children need to understand not only the manifested mental phenomena, but also carefully hidden ones, i.e. perform double decoding (recognize deception), based on additional knowledge and ideas. When an individual knows what the other wants (desires) and what he thinks (beliefs) about how to achieve this, the individual can predict his behavior (intention) [11]. Differences in the ability to apply and recognize deceptive actions will fix the level of development of the mental model.

However, some studies have shown that autistic people do well on tests of false expectations, when in fact they do not have the ability to represent internal representations. For example, D.M. Bowler, C.D. Frith, F. Happ believe that, most likely, these subjects find some kind of solution strategy that is justified specifically for these tasks, which gives them the opportunity to “hack” these imperfect tests, but cannot be used in real life (unlike true representation of internal representations) [17]. In this regard, the topical issue is the application of the situation of real interaction between a child and an adult [18]. Therefore, in our opinion, it is necessary to use the natural conditions of interaction between an adult and a child, where one can trace the response to a naturalistic flow of events that a child can easily encounter in real life, and we strive to characterize the natural variability of gaze movement patterns in episodes of joint attention [18; 20; 27].

From the point of view of research opportunities, the use of eye tracking in children as a potential diagnostic tool in the study of the mental model is currently gaining popularity [7; 12; 15; 16; 23; 24; 26; 27].

The task is a comparative analysis of the model of the mental as a cognitive ability to understand mental states and ways of their changes in the form of a deceptive action in typically developing preschoolers and preschoolers with mental retardation.

The main goal is to use eye tracking to identify patterns that can reflect learning difficulties associated with a deficit in the mental model in children with mental retardation.

Method

Empirical study sample

The empirical sample of the study was formed in a randomized way on the basis of preschool institutions in Barnaul (Russia): 64 preschool children aged 5 to 6 years (mean age 6 years 4 months). Of them:

- 32 preschool children with mental retardation (class F80–F89 according to ICD-10).
- The contrast sample consisted of 32 typically developing preschoolers.

When the diagnosis was made the level of intelligence development was assessed by the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). Children with mental retardation are below average (<85 points). According to the results of diagnostics by a kindergarten psychologist, children with normative age development had an average level of intelligence development (>100 points).

Research methods

To study used experimental situations that make it possible to trace not only the detection of deceit, but also the ability and strategies to change the mental state of the communicative partner.

Methodology for direct opposition and deception (Sadian and Frith 1992)

This task consisted of two series. In the first series, the child was given instructions to directly counter the deception: “There is a thief coming, what are you going to do?” – the child needed to close the box, thereby hiding the toy from an imaginary thief, and in the second, “a friend is approaching, what will be your actions?” – on the contrary, the child needed to open the box, which indicated that the preschooler was ready to share the item. The task of the preschooler was to apply false beliefs to the adult experimenter, recognizing his intentions depending on the signal of the thief or friend now in front of him.

The task of applying false beliefs in the situation of the game “Find the toy in the box”

The child was asked to hide the toy in one of three small boxes so that the experimenter did not know exactly where it was. It was allowed to hide the item in any

box and rearrange them in the chosen order. The experimenter was asked what kind of box the toy was in. The children had to “deceive” the experimenter by pointing to an empty box, while using false beliefs.

**Game on the use of false beliefs
 “Guess which hand the coin is in”**

The child was asked to hide the toy in one of three small boxes so that the experimenter did not know exactly where it was. It was allowed to hide an item in any box and rearrange them randomly. The children had to “deceive” the experimenter by pointing to an empty box, while using false beliefs.

Game on the use of false beliefs “Guess which hand the coin is in”.

The child had to hide the object in the fist of the left or right hand, while not showing the experimenter in which hand he was hiding the coin. When the experimenter asked the question: “In which fist is your coin?”, the children had to falsely point to the hand where nothing was.

All series of experiments were repeated 5 times. Successfully completed attempts were recorded from 0 to 5.

Eye Movement Recording Method

In the experimental situation of the game on the application of false beliefs “Guess which hand the coin is in”, the method of registering eye movement was used.

The main method is the method of eye movement registration using a portable tracker Pupil Headset-PLabs – an eye tracker in the form factor of glasses, binocular version. Camera delay 4.5 ms. Processing latency depending on the CPU > 3 ms.

Heatmaps were built – a graphical display of areas of interest in which the respondent most often looked, where the focus of attention was and what elements were ignored in visual attention. To analyze the data, the results in the form of color spots are superimposed on the eye movement graph. The color corresponds to the duration of viewing different zones: blue – no fixation of the gaze, red – predominant fixations. The following areas of interest were

marked with special markers for fixing data: the face of an adult experimenter, the target object (toys), and the non-target object. Data processing was carried out using the SPSS V.23.0 statistical information processing program.

Results

To find the differences between the contrast groups in the mental model in all series of the experiment, analysis of variance was applied (Lvin’s criterion ≥ 0.05) (table 1).

Comparisons were made between two game series of the experiment, where the child needed to recognize and counter deceit in the first case, and in the second, on the contrary, apply false beliefs. In both situations, the child had to refrain from cheating or hindering the friend’s actions. It was revealed that children with mental retardation either cannot understand and accept deceit, or do it much less often in a game in a series of tasks for direct opposition to deception and the use of false beliefs (Fig. 1).

The difference between the compared situations was that deceit (lying or incorrectly pointing to an empty box) affects the expectations of the "competitor", while direct opposition (locking the box in which the candy was located) only affected his behavior.

Preschoolers with mental retardation could not cope with direct opposition and could hardly deceive at all.

The conditions and rules of the game were presented in the form of symbolic symbols ("a thief is coming" and "a friend is approaching" as symbolic signs – signals for a certain symbolic action). It is significant for us that in a game with a deceptive action, the child was required to use signs to anticipate events that made it known about the nascent action of an adult, or the child himself had to use signs to change the behavior of an adult. The difficulties of children with mental retardation can be viewed as a low level of formation of symbolic-modeling means of social interaction in general, based on the mental model.

Next, a series of experiments was compared, where the preschooler had to hide the toy in one of three small

Table 1

**Descriptive statistics in tasks on direct opposition to deception and the use of false beliefs
 [Please, align the figures accordingly: put a dot, not a comma – 11.34, not 11,34]**

		M	Standard error	F	Significance
Task for direct counteraction to deception	typically developing preschoolers	5	0	1705	0,0001
	preschoolers with mental retardation	0,416	0,148		
False Belief Challenge	typically developing preschoolers	5	0	6242,7	0,0001
	preschoolers with mental retardation	0,083	0,0833		
Hidden Toy in a Box Challenge	typically developing preschoolers	4,6	0,40	131,89	0,000
	preschoolers with mental retardation	0,523	0,145		
Hidden Toy in a Box Challenge	typically developing preschoolers	1	0	11,34	0,001

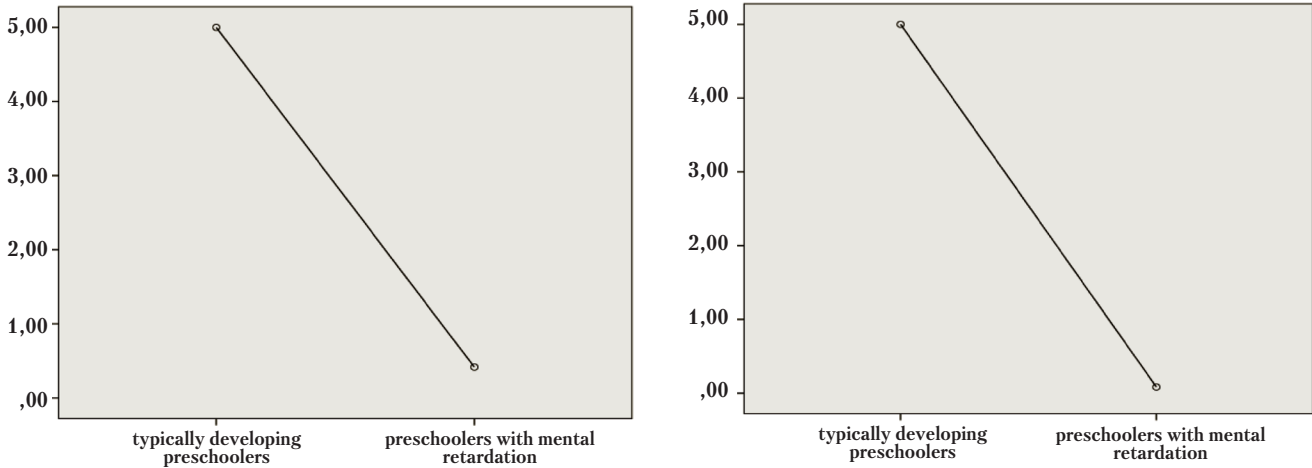


Fig. 1. The difference between contrasting groups in the task of directly counteracting deception and the use of false beliefs

boxes so that the experimenter did not know where exactly it was and confuse the experimenter by pointing to an empty box, while using false beliefs. Children with mental retardation, as well as in the previous series of the experiment, were less likely to use the game condition for the use of false beliefs (Fig. 2).

Next, a series of experiments was compared, where the preschooler had to hide the toy in one of three small boxes and confuse the experimenter by pointing to an empty box, while using false beliefs (Table 1). Children with mental retardation, as well as in the previous series of the experiment, were less likely to use the game condition for the use of false beliefs (Fig. 2).

Children with mental retardation had difficulty understanding the principle "to know is to see": instead of moving the toy into another box, they rearranged the boxes or hid the box with the toy under other boxes or under the table. The principle of actions of children with mental retardation can be described as: "if the box where the toy is hidden is not visible, then the experimenter will not know that the toy is in it." This also confirms the

specificity of perception and the difficulties of the sign-modeling use of social signals.

A comparison was made of contrasting groups for the use of false beliefs "Guess which hand the coin is in", where the child had to hide the coin in his fist and falsely point to the hand where nothing was (Fig. 3).

A child with a mental retardation could not commit a "fraudulent act", they did not accept the rules of the game and each time they pointed to the hand where the hidden object lay. Compliance with the game rules is considered as one of the criteria for the development of arbitrary control of the child. Therefore, the difficulties are associated not with the inability to represent internal ideas, but with the child's inability to suppress his own action directed at the object, based on the position of the social partner.

In the experimental situation of the game "Guess which hand the coin is in", the eye movement registration method was used and the results of the eye tracker study were analyzed. For visualization, heat maps were built (Fig. 4).

Children with mental retardation are characterized by: incorrect correction of the gaze movement route with ini-

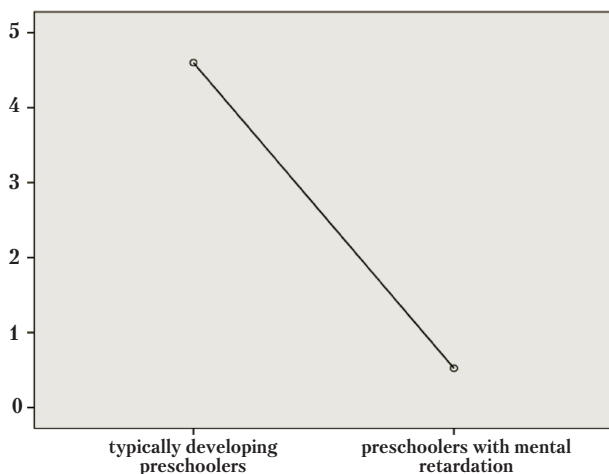


Fig. 2. Differences in contrasting groups in the task with a hidden toy in a box

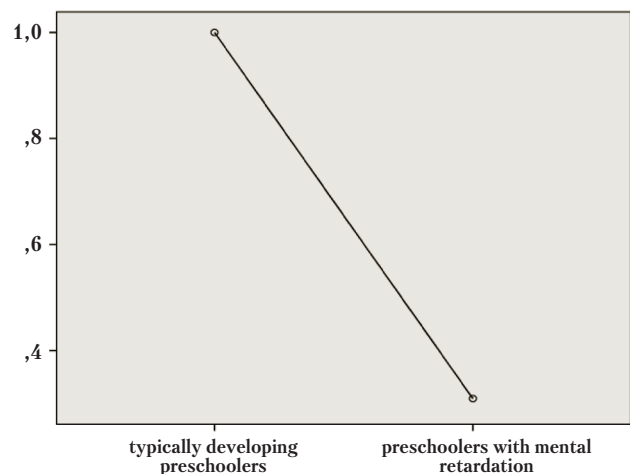


Fig. 3. Differences of contrasting groups in the task with a hidden coin in hand

tially correct tracking of the adult's gaze movement trajectory as a target prompt, difficulties in cross-eyed, synchronous gaze, dispersal of the child's areas of interest, preference for non-social signals, neutral or non-target objects.

These symptoms indicate a violation of the mechanism of joint attention necessary to establish a triadic relationship between an adult-child-object, understanding the intentions and predicting the actions of an adult, a high mental load, and the cognitive complexity of recognizing social signals. An analysis of eye movement confirms that children with mental retardation have a reduced motivation for social participation: they do not track whether an adult sees a hidden coin, which hand he looks at, how he chooses, which hand the adult showed.

Eye tracker study data were subjected to quantitative analysis by Student's T-test for independent groups.

Comparison data of contrast groups confirm the features of establishing joint attention in children with mental retardation:

- The time of fixations to social cues decreases (for example, in the eyes and face of an adult) and the time of fixations to non-target or neutral stimuli increases. It is these features that can lead to the difficulty of identifying relevant features for the formation of a target representation of social signals.

- The time of the total duration of fixations increases, which is necessary for the stabilization of visual attention and the selection of information features.

- The total number of fixations is increasing. It is difficult for children with mental retardation to predict where the adult's gaze will be in the next moment; in order to have time to synchronize, the child needs to follow the actions of the adult more often, so more fixations are needed.

It can be assumed that it is the change in the duration of fixations that is decisive for the emergence of a synchronous gaze, which is necessary for monitoring the focus of attention and combining the focus of attention of a child with an adult.

Discussion

These studies reflect the relationship between the cognitive level of development and the level of the mental model in the process of forming the basis of social cognition. It can be assumed that the formation and development of the mental model proceeds in parallel with the development of the child's symbolic thinking.

In all our the series of experiments, the tasks were involved in the application and recognition of false beliefs. Recognition and false beliefs are closely related to the general "mentalization", understanding the mental state (mind reading), the ability to participate in the perception of other people's intentions. Both skills involve social cues that indicate interest in objects or events, but the first emphasizes processing information about other people's behavioral cues, while the second emphasizes

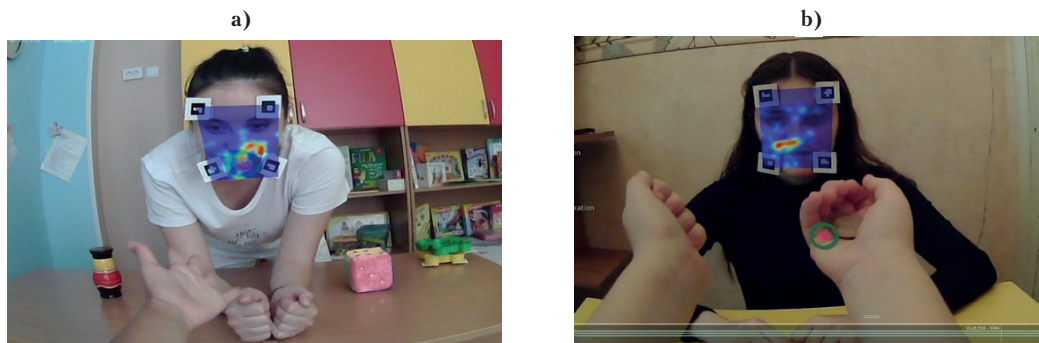


Fig. 4. Heat map of a preschooler, typically developing preschoolers (a) and mental retardation (b), in an experimental situation of recognizing and applying false beliefs

Table 2

Group statistics based on the results of eye movement fixation
[Please, align the figures accordingly: put a dot, not a comma – 11.34, not 11,34]

		M ± standard erro	Significance	Levine's test for equality of variances	
				F	Significance
Duration of fixations to non-target stimuli	typically developing preschoolers	0,59 ±0,04	0,003	3,86	0,150
	preschool children with mental retardation	0,69±0,06			
Total duration of fixations	typically developing preschoolers	36,35±1,58	0,0001	3,90	0,632
	preschoolers with mental retardation	47,99±2,94			
Ttotal number of commits	typically developing preschoolers	51,11±1,86	0,0001	9,82	0,203
	preschoolers with mental retardation	75,52±4,19			

own modeling these cues for other people to change their state of awareness. The results of our study reflect the difficulties of children with mental retardation in both skills.

The deficit of the mental model is associated with “realism”, the concreteness of perception and thinking in a game with a deceptive action. This concreteness of thinking will be observed in the recognition of social signals, which is manifested in the fact that the child confuses the symbolic rules of the game with real physical rules. It can be assumed that this is due to the low level of the mental model in children with mental retardation and a deficit of symbolic thinking.

Based on the results of the eye tracking study, it can be assumed that children with mental retardation are insensitive to social signals, do not perceive the direction of the gaze of the interlocutor as informative, significant clues for combining joint attention. A huge role is played by the lack of joint attention necessary for the formation of cognitive components responsible for understanding social signals. These results complement the data of S. Baron-Cohen that the violation of the representation of internal representations can be a secondary manifestation of an earlier violation of the construction of the “triadic representation”.

With a delay in mental development, disorders are primarily expressed in the difficulties of comprehending

and restructuring one’s own mental interpretations that are inadequate to the communicative context, and the weakness of the reflective component.

Conclusion

A comparative analysis of contrasting samples allows us to conclude that the state of delayed or incomplete mental development, which is characterized primarily by a decrease in skills that determine the general level of intelligence, is directly related to the functioning of the mental model.

As a result of the study on contrasting samples, the specificity of the lack of means of social interaction based on the model of mental development is shown: a group of preschoolers with mental retardation has difficulty in using the direction of an adult’s gaze as a social signal for detecting intentions, that is, they recognize it as an information sign, but not always can use. It is analyzed that in a game with a deceptive action, the child is required to use signs to anticipate events that let you know about the nascent action of another person. At the same time, children with mental retardation in the game with deceptive action showed a situational mode of action without taking into account the model of the mental partner in interaction.

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