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Sensitivity to the Focusing Significance of the Gaze Direction of the Partner at Mentally Retarded Preschoolers

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Abstract

Introduction. The relevance of the study of communication between the mechanism of joint attention and the subsequent normal and abnormal development of the child has been substantiated. It has been shown that a child's ability to initiate and react to a joint attention of an ontogenetically precedes emergence of social and cognitive abilities. It has been determined a role of the joint attention in the child's ability o integrate information on himself, on other person and ability to unite his own intentions and other person's intentions. The problem of need for solution to a question of how the cognitive development pf the child interferes with development of social experience of the child has been raised.

Methods. Sample group was made by 514 children of preschool age, including the children with developmental disorders which characteristic of different forms of mental retardation. In the section there are descriptions of some techniques: 1. "Wrong opinion test", "Sally-Ann"; the task "What does Charlie want?", etc. for assessment of children's understanding of intentions, desires, the interests of others according to behavioural manifestations. 2. The developed task for assessment of ability of using the gaze direction of the character on the picture for the purpose of determination of its intentions. 3. Neuropsychological tests for a research of the block of reception and processing of information.

Results. Potential mechanisms of integration disorder of the joint attention, decrease in recognition of the focusing value of the gaze are revealed. The variability of formation and age changes of joint attention skills, to be exact, existence of differences in recognition, synthesis and interpretation of the focusing social information proceeding from eye contact is shown. It is revealed that children with a developmental delay have a low level of the "descending" joint attention. The parallelism of early deficiency of joint attention and difficulties of processing of information is revealed.

Discussion. The data display synchronism of cognitive development and formation of the mechanism of the joint attention. The conclusion is drawn that difficulties of integrative function of processing of social information can be combined with difficulties of synthesis of separate information signs in a Gestalt, complex information fusion, subject and symbolical orientation in space.

Keywords

theory of mind, attention, joint attention, social cognition, orienting basis of an action, developmental age, preschool age, theory of reason, autism, developmental delay

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Highlights

► Symptom expression of joint attention disturbances through determination of intentions in the gaze direction is connected with standard age formation of the child and it is moderated by cognitive functioning.
► Difficulty in social information processing can be connected with prevalence of the "ascending" joint attention at children with a developmental delay which is based on information on concrete perceptual characteristics of incentives and decrease in the "descending" joint attention connected with a semantic context of the triadic relations.
► Difficulties of processing of social information can be combined with difficulties of processing and complex information fusion.

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Introduction

At the present stage we refer such disorders of theory of mind as deficiency of the joint attention mechanism to disorders of early social interaction (Bruner, 1985). The empirical data are gained which show that children with an atypical development experience difficulties in regulation of other person's attention and ability to trace the directions of focus of attention; they do not use protodeclarative indicatory gesture to share the interest with other person. It is shown that people with deficiency of theory of mind can perceive information relating to people's behavior (the direction of a gaze, the movement of a body, facial expression), but they did not create the mechanism which will allow them to interpret and understand further sense of this information (Baron-Cohen, 1989). It is possible to state two aspects of disorder of development of orientation in social signals: a possibility to initiate and react to attraction of joint attention as well as interpretation of the focusing social signals as aspect of the formed theory of mind (Perner, 1989; Baron-Cohen, Leslie, & Frith, 1985; Flavell, 2000; Sergienko, Lebedeva, & Prusakova, 2009; Wellman, Cross, & Watson, 2001; Russell & Sharma, 2003; Tomasello, Carpenter, Call, Behne, & Moll, 2005). According to the author, this deficiency is caused by inability to fast refocusing followed by destroying the corresponding experience and the basis which is necessary for normal development of representation (Perner, 1989).

But practically all the theories perceive theory of mind as the isolated line of development, but not within the general standard developmental age (Hobson, 2005; Gopnik, Capps, & Meltzoff, 2000; Perner, Frith, Leslie, & Leekam, 1989). In our opinion, previous research works still were conducted, generally on children of an infantile and early age, and assessment of their skills of joint attention during the different periods of their developmental age remains poorly studied. Research of the later stages of development of preschool children will be the key for understanding of orientation of influence between joint attention and social and cognitive development.

In a number of research works the analysis of connection of intellectual level of development and development of theory of mind on children with autism spectrum disorders and children with

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reduced intelligence is carried out. At the same time an unresolved, in our opinion, problem is the fact that there remains a little systematized data in the sample of children with the diagnosis of a developmental delay.

The research work by G. E. Sukhareva, V. V. Kovalyov, K. S. Lebedinskaya, T. A. Vlasova, V. I. Lubovskaya, N. A. Tsypina, V. V. Lebedinsky and F. M. Gayduk show that the developmental delay has various manifestations in its causation, in pathogenesis and clinical findings as well as specific dynamics of a easy condition of intellectual incapacity which are intermediate between intellectual norm and mild mental deficiency (Yemelina & Makarov, 2018; Zlokazova, 2004; Lebedinskaya, 2005; Skvortsov, Apeksimova, & Petrakova, 2002; Shumskaya, 2013). In turn, the severity of a developmental delay characterizes extent of decline in cognitive capabilities, discontinuity of structure of intellect. At the same time, the developmental delay is included into the group of psychosocial associated disorders (Shumskaya, 2013). In this regard it becomes possible to track an intelligence role in development of preschoolers' understanding of theory of mend in the group of children with a developmental delay.

In our opinion, understanding of mechanisms of formation of a mental sphere delay both due to emotional-volitional maturation delay and due to the neurodynamic disorders which are slowing down development of cognitive activity (Yemelina & Makarov, 2018; Lebedinskaya, 2005), it also opens a possibility of a simultaneous research of continuity of development between joint attention and social and cognitive abilities in the early childhood.

The hypothesis that the deficiency which is the cornerstone of disorders of joint attention happens because of an excessive delay in development needs check (Frith, 1988). The research of decrease in orientation to social signals (first of all, by sight for establishment of episodes of joint attention) at children with a developmental delay will display a specific disorder of both social and cognitive phenomenon and will disclose not only aspect of cognitive development (what many researches on this selection are devoted to), but also aspect of the communicative disorders interfering standard developmental age.

Development deficiency theory for theory of mind

At a typical developmental age, the joint attention arises after the increasing ability of the child to integrate information on itself, on other person and on association of the intentions and other person's intentions in relation to an external object or ability to focus the attention against each other (the triadic relations) (Hobson, 2005; Charwarska, Klin, & Volkmar, 2003). Besides, the individual has to realize the fact that focus is divided among themselves and other person (Hobson, 2005; Chen, Castellanos, Yu, & Houston, 2019).

Experimental data by S. Baron-Cohen show that the deficiency of visual joint attention is a consequence of deeper disorder of the general attention mechanism at autism and it involves disorders in development of theory of mind: triad representations cannot be constructed (Self – Another – the Object) (Baron-Cohen, 1995; Baron-Cohen, Leslie, & Frith, 1985; Bora & Pantelis, 2013; Mundy, Sullivan, & Mastergeorge, 2009; Hobson, 2005). The main fundamental manifestations of the joint attention which can be broken are selected: actually, maintenance of visual contact and shift of a gaze between the gaze direction of the social partner and any object (Broz, Lehmann, Nehaniv, & Dautenhahn, 2013; Dejan, 2006). The main disturbance is shown in the child's difficulty to orientate oneself to the same general direction (in the eye span) both on other person and on the shared object of interaction (Dawson & Burner, 2011; Dawson & Levy, 1989). Children also cease

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to fixate on the first interesting (noticeable) object which they are faced with (Dawson & Burner, 2011; Dawson, Jones, & Merkle, 2012; Dawson, & Levy, 1989). The main disturbance is shown in the child's difficulty to orientate oneself to the same general direction (in the eye span) both on other person and on the shared object of interaction (Dawson & Burner, 2011; Dawson, & Levy, 1989). Children also cease to fixate on the first interesting (noticeable) object which they are faced with (Dawson & Burner, 2011; Dawson, Jones, & Merkle, 2012; Dawson & Levy, 1989).

Thus, the standard child development assumes formation and expansion of more complex behavior, such as correction of direction of gaze when the initial gaze of posteriority for a social partner was not successful, ability to the look after gaze direction of adults (Dawson & Levy, 1989) that reflects understanding of others as deliberate participants of interaction (MacPherson & Moore, 2007; Slone et al., 2018; Suarez-Rivera, Smith, & Yu, 2019; Yu & Smith, 2017).

Research of the joint attention is concentrated on standard regularities of emergence of joint attention deficiency: identifications as such skills are connected with the subsequent child development (Kasari, 1990; MacPherson & Moore, 2007; Delgado et al., 2002), with formation of the generalized "symbolical abilities" (Hobson, 2005; Lewis & Bouche, 1988; Mundy, Sullivan, & Mastergeorge, 2009; Leslie, 1987) and the general social and cognitive processes at children (Dawson & Levy, 1989; Bruner, 1985; Jayaraman, Fausey, & Smith, 2017; Johnson, Sullivan, Hayhoe, & Ballard, 2014; Mundy et al., 2007; Mumme, 2007; Mundy, 2003a; Mundy, 2003b; Scaife & Bruner, 1975; Mundy & Sigman, 2006).

The potential mechanisms which are the cornerstone of the atypical joint attention include: atypical reflexive look, integration impairment of joint attention (Ozonoff, 1997; Charman, 2001; Mumme, 2007; Mundy, 2003; Mundy, Sullivan, & Mastergeorge, 2009) and decrease in skills of recognition of the focusing gaze significance (Charman, 2001), decrease in social motivation and recognition of value of remuneration for social interaction (Charman, 2001; Dawson & Levy, 1989). It is possible to assume that the main aspect of violation consists in recognition, synthesis and interpretation of the focusing social information proceeding from eye contact necessary for functioning of the mechanism of joint attention and formation of base of social experience as bases of theory of mind.

The revealed inability of most of children of 5–6 years with reduced intelligence to understand other person's desires in the direction of his eye movements also proves that they did not reach that mental age when formation of theory of mind helps them to draw a conclusion on other person's mental conditions on their manifestations in behavior (Sergienko et al., 2009).

Results of the previous research allow to find prerequisites for a question of synchronism of cognitive development and formation of theory of mind based on the joint attention mechanism, namely recognition of external behavioural manifestations (the direction of a gaze). The potential mechanisms which are the cornerstones of atypical joint attention insensitivity to the main social signals will interfere with standard age development. It is possible to speak about the threshold size of I. Q. necessary for formation of theory of mind. However there is an open question of whether it is possible to consider that the development level of psychometric intelligence estimated on the basis of tests testifies if not to central, then to the most important and necessary role of cognitive development for formation of theory of mind? (Sergienko et al., 2009; Dawson & Levy, 1989)

The deficiency of theory of mind correlates with disorders of thinking (Mazza et al., 2007; Russell & Sharma, 2003). But are there difficulties of recognition of the mental world of other people as a result of cognitive deficiency (Frith & Corcoran, 1996; Bora & Pantelis, 2013; Bora,

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Yucel, & Pantelis, 2009; Bruner, 1985), or are they independent disorders (Harrington, Siegert, & McClure, 2005; Skvortsov, Apeksimova and Petrakova, 2002)? Are disorders of theory of mind secondary in relation to cognitive impairments (Bora & Pantelis, 2013; Bora, Yucel, & Pantelis, 2009)? It is either disorder in development of the visual attention detector (Baron-Cohen, Leslie, & Frith, 1985), or lack of mimetic response (Gopnik, Capps, & Meltzoff, 2000), or the development deficiency in symbolical functions interfering development of theories of mind (Hobson, 2005), or the development deficiency in mental modules organization (Leslie & Frith, 1988).

What determines the cognitive child development, or cognitive impairment of developmental age interferes with development of theory of mind?

Thus, the goal of research is a study of process of orientation decline to social signals at children with a developmental delay for display of a specific impairment of joint attention as a social and cognitive phenomenon.

Methods

Empirical survey sample: 514 children of preschool age. From them the group of children at the age of 4–5 years (n = 107) and the group of children of 6–7 years (n = 354). The sample was also made by 53 preschool-age children visiting groups of the compensating orientation: the children who made this sub-sample have development disorder which are characteristic of the different forms of developmental delay including mixed by F80–F89 on MKB-10. These are preschool children with combined forms of peculiar properties of mental development and (or) deviations in behavior – cognitive function impairments, speech disturbances, disorder in emotional-volitional sphere, behavior, communicative function. At presentation, the psychiatrist estimated the level of intellectual development by means of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). Children with a developmental delay had the developmental level of intelligence under average (< 85). Upon record: obvious hypotrophy of functions of attention and memory, disturbance of perception rate, slowness of processes of reception and processing of perceptual date and also difficulty in synthesis of the percepts. Children with lower limit of normal developmental age demonstrate the disproportional structure of their intellect that is shown in verbal function maldevelopment and also in mental capacity decline, an nondevelopment of visuomotor coordination and visuospatial analysis and synthesis.

Techniques

1. Classical tasks on theory of mind were applied to assessment of level of understanding of intentions, desires, the interests of others on behavioural manifestations (a gaze, gestures, etc.): "wrong opinion test", "Sallie-Ann test"; the task on a research of a possibility of use of the direction of a gaze as the indicator of desire "What wants Charlie?"; a task on understanding of the principle "to see – means, the nobility": "What girl knows that she lies in a box?" (Baron-Cohen, 1989, et al.); a task on understanding of intentions with a support on external signs.

2. The task developed by us was used – the analog of a classical diagnostic task "What wants Charlie?" on a study of a possibility of use of the gaze direction of the character on the picture as indicator of intention to choose an object from a number of offered.

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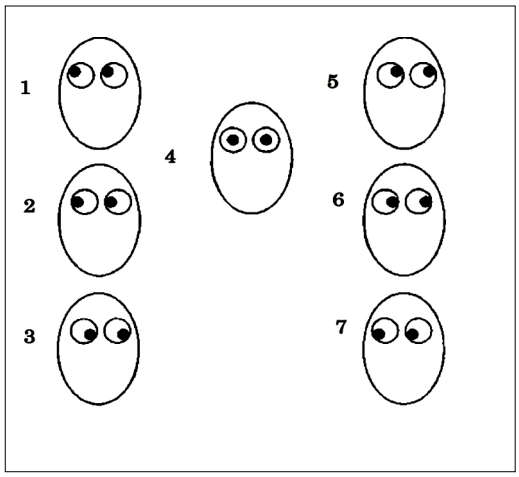

Figure 1. Stimulus material for a problem of determining the choice of an object of the gaze direction of the character

For check of the conclusion that results of performance of the task are connected with detection of the gaze direction, we offered a number of the additional tasks including the hidden orientation of attention (Fig. 2). Orientation of attention was set by the central or peripheral specific determiner.

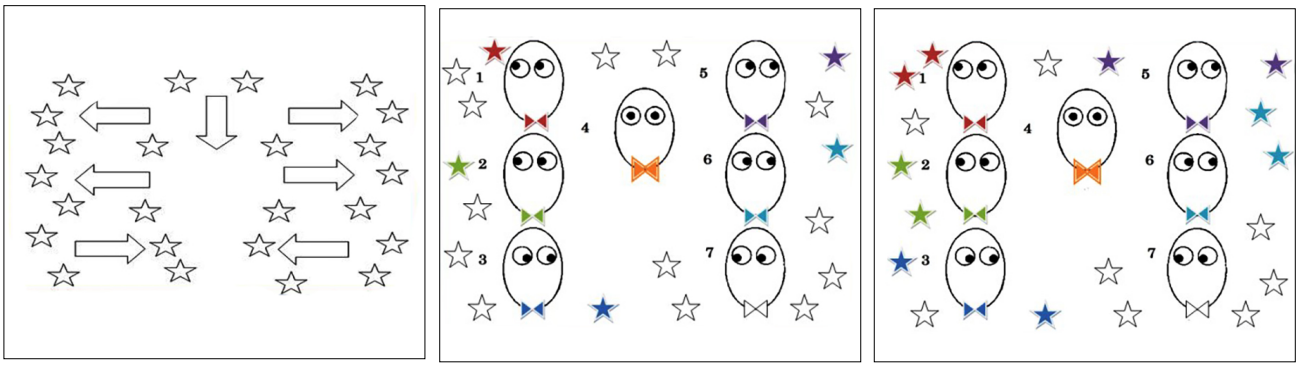

Figure 2. Stimulus material for a problem of determining the choice of an object with the central and peripheral specific determiner

The central specific determiner represented the obvious instruction an arrow on an object which the child had to choose. The peripheral specific determiner represented a way of attraction by means of coincidence of color of an object which was chosen by the character, with color of an element of clothes of the character. One more task along with noise and the specific determiner – illumination – was in color also at a target object, and at alternative.

3. Neuropsychological tests for the study of the block of reception and processing of information: processing of acoustical information (reproduction of rhythms, understanding of the

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words similar on sounding / on value; development of oral-aural memory); processing of visual information (identification of realistic images, identification of the crossed-out images, identification of unfinished images, identification of images in "noise", allocation of images from a background, visual memory); processing of visual and space information (Head tests, constructional praxis, visuospatial memory). The main are tests on identification of sensibilized images, enough the main characteristics of visual identification, sensitive for identification, at the child.

Data processing was carried out with use of the program of statistical information processing (SPSS V.23.0).

Results

1. At the first stage by means of Student t-test it was found significant difference between groups of the children meeting standard of age development and children with lower limit of normal developmental age in definition of intentions to the gaze direction of (Fig. 3).

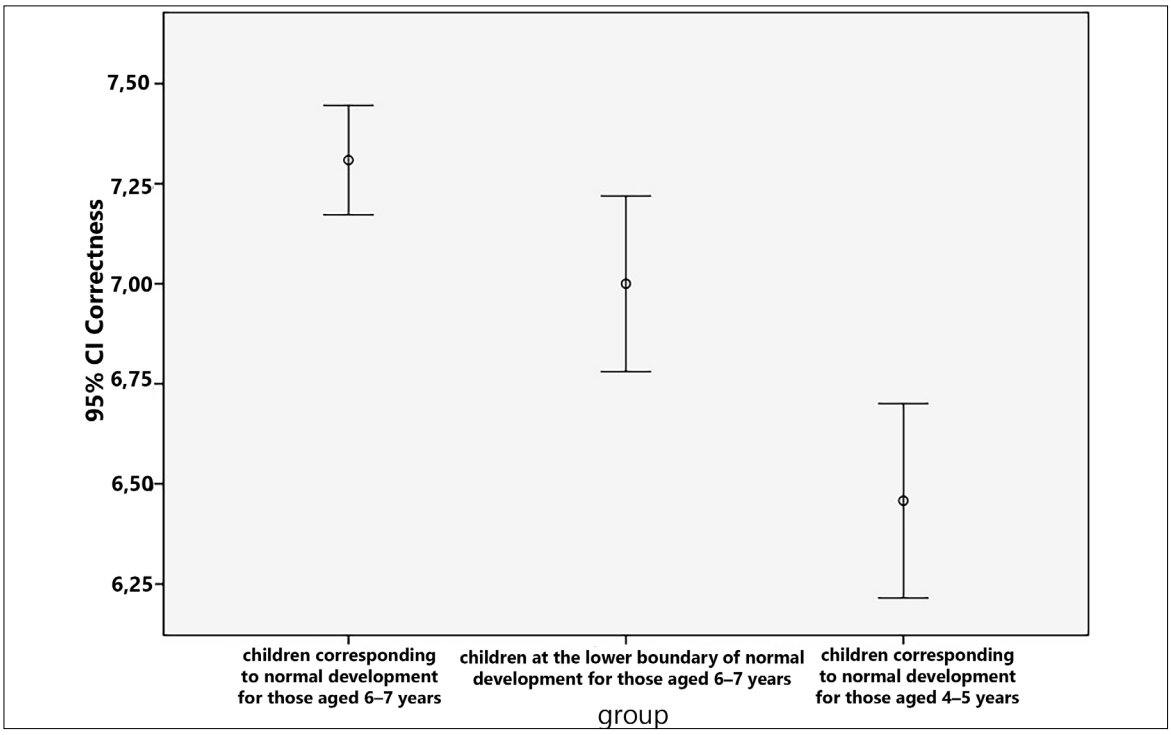

Figure 3. Correctness of determination of intentions in the gaze direction in the groups of children with the different level of developmental age

So, the group of children whose developmental age corresponding to standard more precisely and unmistakably determine intentions by the gaze direction in all 8 offered tasks ($p = 0.02$). Besides, if to compare 2 age groups of children of 4–5 years and 6–7 years, then the indicator of correctness and faultlessness of definition of the choice of an object in the gaze direction in group of children of 6–7 years ($p = 0.018$) is statistically reliable (Fig. 3).

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Having analysed a variation degree and scope of data, we see that in the group of children of 6–7 years indicators are more uniform, than in the group of children of 4–5 years. It is possible to assume that these distinctions demonstrate confirmation of process of formation of skills of joint attention: if at the age of 4–5 years it is possible to observe a heterochrony and heterogeneity of indicators of this skill, then by 6–7 years this skill becomes a uniform new growth. This fact is complemented with high degree of a variation of indicators in the group with lower limit of normal developmental age and uniformity in group of children whose developmental age corresponding to standard.

It is possible to assume that the answer to joint attention (sensitivity to the focusing value of the direction of a look) is connected with the level of cognitive development and is capable to reveal consecutive disturbances in initiation of joint attention with other people, removal of mental conditions of other people from the gaze.

It is also revealed that if to compare children of 6–7 years whose developmental age corresponding to standard, children with lower limit of normal developmental age and children of 4–5 years (with standard development), then differences in full formation of skills of joint attention not only in an age group, but also between group of children of 4–5 years and children of 6–7 years with the lower bound ($p = 0.0001$) and age norm of development ($p = 0.0001$ come to light) (Fig. 3).

This fact displays variability of formation and a possibility of distinctions of age changes of skills of joint attention, to be exact, opens existence of ontogenetic differences in understanding of intentions of another in the direction of a look as most important skill of response to joint attention and initiation of joint attention. Distinctions of 2 groups of children – one with developmental age corresponding to standard and two with lower limit of normal developmental age confirm a hypothesis of the leading role of participation of the child in joint attention, in acquisition of ability to coordinate attention with social partners that is crucial for active participation of children in a possibility of training by it.

By means of the dispersive analysis differences between groups of children whose developmental age corresponding to standard, the lower limit of indicators of developmental age corresponding to standard and group of children with a developmental delay were revealed. Distinctions of these groups of children – the one of 6–7 years with the group of children of 4–5 years (Levene's Test ≥ 0.05, $F = 42.120$, $p = 0.000$, $\eta 2 = 0.221$) are also received (Fig. 4).

The results show that the correctness of the gaze direction is defined better by children whose developmental age corresponding to standard. Group of children with lower limit of normal developmental age and also group of children of 4–5 years showed results below the group of the children with developmental age corresponding to standard. Children with a developmental delay showed cardinally different results; the correctness of the gaze direction is less at mentally retarded children, than at the groups of contrast. These distinctions of age changes of skills of joint attention are connected with the development level of the child.

2. The assumption was checked that at children with a developmental delay the analysis and interpretation of information proceeding from the gaze direction at safe processing of information proceeding from the focusing indications of unsocial character are violated.

Comparison of the series of experiments where children were offered to determine the choice of an object by the direction of an arrow was made for this purpose, to determine intentions of the choice of an object by a gaze of the character without specific determiner and with the central, peripheral color specific determiner (see methods); Student t-test was applied to dependent sample.

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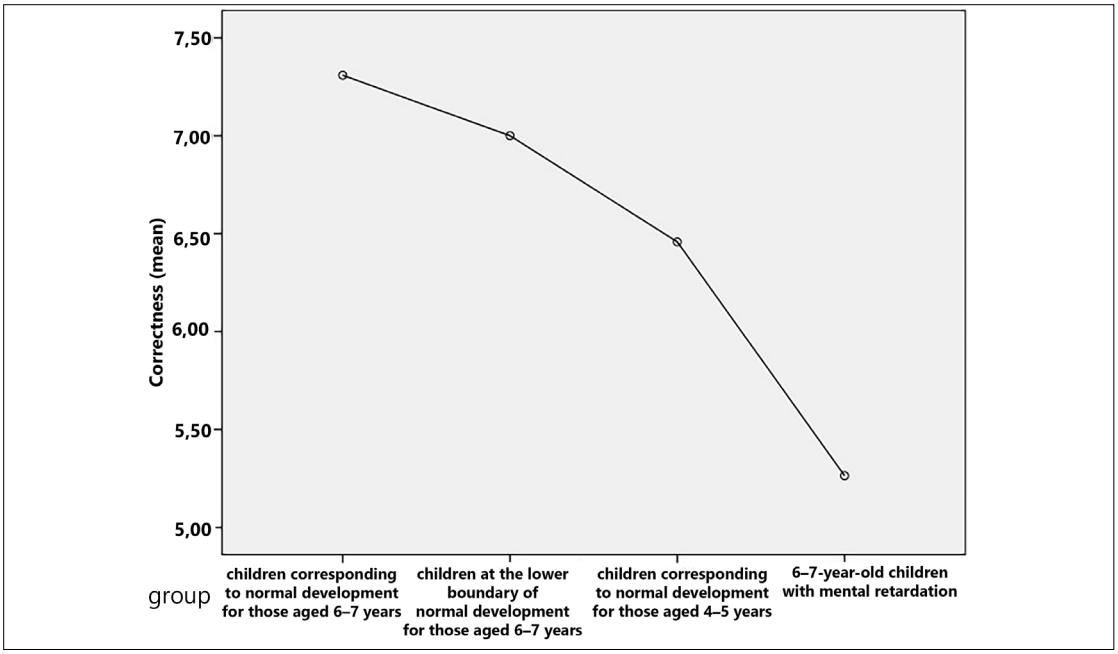

Figure 4. Comparison results of the children groups

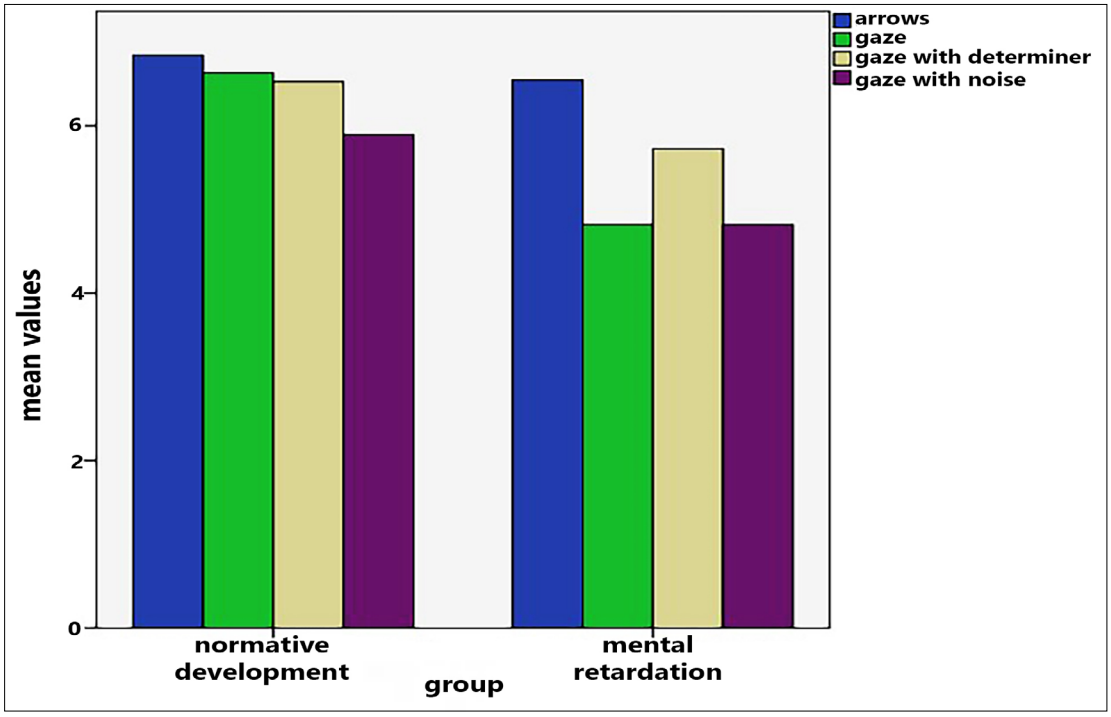

Figure 5. Differences of indicators of the groups in the series of tasks

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Table 1
Paired Sample Criterion

		Norm	Developmental delay
		Two-tailed correlation	
Pair 1	Task with arrows – Task with gaze	0,003	0,001
Pair 2	Task with arrows – Task "gaze with determiner"	0,012	0,068
Pair 3	Task with arrows – Task "gaze with noise"	0,0001	0,004
Pair 4	Task with gaze – Task "gaze with determiner"	0,324	0,085
Pair 5	Task with gaze – Task "gaze with noise"	0	1,000
Pair 6	Gaze with determiner – Task "gaze with noise"	0	0,053

The obtained data (Fig. 5, Table 1) show significant differences in success of choice recognition of an object according to the indication of an object with an arrow and choice determination of an object for detection of the gaze direction of a character.

In the group of children with a developmental delay, the children are more successful in the choice of an object in the tasks where there is a concrete specific determiner (the central specific determiner, the obvious instruction – shooters), and determine the choice of an object by the gaze direction of the character less successfully. At the same time, they are more successful also in the choice of an object in the gaze direction of the character in the tasks with the color specific determiner, than in the tasks where this specific determiner was absent. In the group of standard developmental age in a task with the specific determiner such distinctions are not revealed.

It is possible to assume that the insensitivity to the main social signals from other person and therefore they do not perceive others eyes is really characteristic of children with a developmental delay as it is adaptive informative, the eye contact is a source of information on other people's intentions. At the same time, they are successful in recognition of concrete information specific determiners.

3. Further we decided to check a hypothesis of the unity of deficiency of the social information processing mechanism and the general information processing mechanism leading to disturbance of synthesis of information of social experience for exchange of social information.

By means of the regression analysis it is revealed that processing of social information (a problem in theory of mind) is connected with such difficulties of information processing ($R^2 = 0.759$, $p = 0.0001$) as: recognition of the crossed-out images ($\beta = 1.074$, $p = 0.0001$), recognition of not finished drawing images ($\beta = –0.578$, $p = 0.004$).

Information processing in the direction of gaze is connected with such difficulties of information processing as ($R^2 = 0.467$, $p = 0.020$): recognition of not finished drawing images ($\beta = –0.794$, $p = 0.007$), recognition of drawings by essential features ($\beta = 0.436$, $p = 0.007$), understanding of the prepositions

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which denotate mutual arrangement in the space ($\beta = 0.407$, $p = 0.006$).

It is possible to come to a conclusion that in the course of processing of social information an important role is played by individual differences of children in processing of visual information.

The available difficulties are found, mainly, at presentation of the imposed and crossed out schematic images and, most likely, are caused by prevalence of one of the strategy of processing of visual and visuospatial information. The weakness of holistic strategy is more often observed (mistakes as fragmentariness): children pay attention to the general similarity or snatch out an accidental fragment, without checking a perceptual hypothesis.

Discussion

This research displays the most important role of ability to integrate and to use joint attention for the general development of the child. The context of one of the reasons of joint attention development and functional consequences of joint attention is displayed.

Difference in 3 groups (with standard, with lower limit and with a delay of developmental age) confirm a hypothesis of the leading role of participation of the child in joint attention, in acquisition of ability to coordinate attention with social partners that is crucial for active participation of children in a possibility of training by it.

The main aspect of disturbance consists in recognition, synthesis and interpretation of the focusing social information proceeding from eye contact necessary for functioning of the mechanism of joint attention and forming of base of social experience as a basis of theory of mind.

The data display differences in the joint attention conducted by the "ascending" processes and the joint attention conducted by the "descending" processes (Tomasello et al., 2005, etc.). It is possible to assume that the "ascending" joint attention (bottom-up joint attention) preponderates at children with a developmental delay that is based on information on perceptual characteristics of incentives: the incentive or an event draws involuntary attention owing to its "saliency", singularity, and the child can draw a conclusion that this incentive or this event also draws attention of our interlocutor. At the same time children with a developmental delay experience difficulties of the top-down joint attention which is based on information on a semantic context of communication, for example, knowledge that any subject is new or significant for the interlocutor (but not for him).

The analysis of the data also allows to make the conclusion that to difficulties of processing of social information, difficulties of recognition of intentions in the gaze direction can bring the following features of processing of information:

1) fragmentary nature of perception: the child intuitively supplements a fragment to the whole, without seeing the whole;

2) attention to details to the detriment of the whole or the excess generalized perception;

3) simplification, mixing of essential details;

4) tendency to perceptual replacements at insufficiency of the entering perceptual information, mixture of the close visual objects;

5) use of visual standards suffers;

6) the generalized categorical perception: in assessment of hierarchy of object features can miss a detail, essential, critical for identification;

7) information is processed, and decisions are made separately on a form, a size, a location of an object for what the signs which are not depending on the size, situation and brightness – a categoriality are used;

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8) the mechanism is broken which provides more complete and concrete description of the image in which each element of the image and a relative positioning of all elements is noted;

9) the holistic principle of perception prevails, it is optimum at the first stages of processing of visual information and in general when processing new information;

10) analytical strategy when a person describes incentives in terms of the formed, ready system of the description, in particular, of the verbal-perceptual description is broken.

In the group of children with a developmental delay the success of performance of neuropsychological tasks depends on the level of their general intellectual development, unlike the group of the developing preschool children corresponding to the norm whose neuropsychological features are determined by their individual characteristics.

Conclusion

The data allowed to find differences in mechanisms of working-through of visual field cues, split growth of the components of visual perceptual functions which can determine children's individual differences in processing of social information on other people's behavioural manifestations.

As well as in the previous research (e.g.: K. S. Lebedinskaya, N. A. Shumskaya, I. A. Skvortsova, O. A. Apeksimova, V. S. Petrakova), occurrence of specific characteristics in information-processing in children with a developmental delay was confirmed.

With that in mind, it was succeeded to connect the obtained data with difficulties in its processing of social information, which is necessary for establishment of episodes of joint attention in this research.

The analysis of results of this research allows to come to a conclusion that neuropsychological features at children with a developmental delay not only have a specific impact on structure of intellectual functions, but also indirectly influence on processing of social information.

By results of this research it is possible to draw a conclusion that symptom expressions of disorder in joint attention through identification of intentions in the visual direction is connected with standard age formation of the child and it is moderated by cognitive functioning. In turn, the mechanism of joint attention helps to interpret and understand sense of social information. This research shows that the deficiency (non-formation) of information-processing functions can act as one of possible mechanisms of defect of joint attention.

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