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ORIENTATION IN A SIGNAL FLOW AND INTELLIGENCE OF CHILDREN WITH AUTISTIC SPECTRUM DISORDERS

Elena Nikolaeva
Herzen State Pedagogical University, Saint-Petersburg, Russian Federation

Margarita Gaidamakina
Herzen State Pedagogical University, Saint-Petersburg, Russian Federation

Darja Zavodovskaia
Herzen State Pedagogical University, Saint-Petersburg, Russian Federation

Abstract. *The hypothesis was tested that these children may be more effective than their normally developing counterparts when analyzing a signal flow unrelated to speech or social conditions, for example something that is Nature-based or abstract. There were 52 participants in the study: 22 children with autism spectrum disorders, ranging in age from 3.1 to 7.9 years old, and 30 normally developing children, who were 4-5 years old. In order to achieve the goals and objectives the following methodologies were used: the Sally-Anne test; reflexometry; Raven's Colored Progressive Matrices; a parent questionnaire. Results. Out of the 22 preschool children with ASDs, 21 of them had an unformed theory of mind. In the norm group, 80 percent of the children had a formed theory of mind. Mute preschool children with ASDs made fewer mistakes in the simple sensory-motor reactions (of the go-go type). Mute children with ASDs were better at orienting themselves in a sensory flow that was unrelated to speech and social information, which can be considered as a compensatory reaction, given their psychophysical inability to develop normal speech. In mute children with ASDs, the level of nonverbal intelligence was no different from that of the children in the norm group.*
Keywords: *autism spectrum disorders, signals flow, reaction time.*

Introduction

It is accepted without question today that, as L. Vygotsky (1934/1987) asserted, up until about the age of three a child's thinking and language develop more or less autonomously, but at that age they merge and this leads to a powerful surge in the development of both (Byrge, Sporns, & Smith, 2014). There is an overwhelming amount of evidence to back up this idea (Oppenheimer & Kelso, 2015; Santos & Risati, 2015; Baillargeon, Scott, & Bian, 2016). At the same time, psychologists are more and more frequently encountering an astonishing fact: mute children with autism spectrum disorders (ASDs) are on a par with healthy

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children in some forms of mental processes and in the level of intelligence that is based on cognitive processes (Frith & Happé, 1994; de Vries & Geurts, 2012).

Research into this phenomenon is significant, above all because the number of such children has grown. Thus, in 2000 it was observed that there were from 5 to 26 children with ASDs for every 10,000 normally developing children, and in 2005 it was found that there was one such child for every 200-300 children with normal development. In the last three years, the number of children with autism spectrum disorders has almost doubled, and now there is one child with ASDs for every 150 healthy children (McPartland, Klin, & Volkmar, 2014; Constantino & Charman, 2016).

This increase in the number of children with ASDs can be seen as a real increase in the number of such children, but also as a result of either improvement or changes in the diagnostic procedures (Gillberg & Fernell, 2014; Leong, Carter, & Stephenson, 2015).

An analysis of the attributes that allow autistic children to have sufficient intelligence without any effective social interaction or proficient language skills (Gallivan, Logan, Wolpert, & Flanagan, 2016; He et al., 2017) makes it possible to speculate that these children may be more effective than their normally developing counterparts when analyzing a signal flow unrelated to speech or social conditions, for example something that is Nature-based or abstract. Analysis of a sensory flow leads to generation of sensory-motor integration, which makes it possible to identify when situations involve conflict and learn how to avoid them (Fotowat & Gabbiani, 2011; Luna, Marek, Larsen, Tervo-Clemmens, & Chahal, 2015; Mišić, Doesburg, & Fatima, 2015).

It is known that children with ASDs are extremely sensitive to external signals, and they very often perceive them as excessive (Green et al., 2013; Gillberg & Fernell, 2014; Case-Smith, Weaver, & Fristad, 2015), which may be associated with a keen mechanism they have for analyzing these signals, and this permits them to find alternative means of adapting to their social environment (Krivischekov et al., 2016; Brascamp, Sterzer, Blake, & Knapen, 2018).

At the present time, a majority of researchers in the field believe evaluation of a person's theory of mind to be a reliable means of establishing a diagnosis of ASDs (Sabbagh, Bowman, Evraire, & Jennie, 2009; Constantino & Charman, 2016). On the premise that theory of mind is a conscious understanding of another person's otherness (Flavell, 2004). It is fair to assume that its formation will go hand in hand or in combination with sensory-motor integration, since comprehension of otherness requires consolidating large amounts of information and extracting the significant characteristics from them (Nikolaeva & Merenkova, 2015; Sinclair, Oranje, Razak, Siegel, & Schmid, 2016; Zashchirinskaia & Nikolaeva, 2018). Studying sensory-motor integration in autistic children presents particular difficulties due to the limitations of their social interaction. For this

reason, there is no data on the connection or lack of the same between these parameters (sensory-motor integration and theory of mind). Moreover, it is essential to examine the level of intelligence in children with ASDs, since an unformed theory of mind and the specific features of sensory-motor integration can be attributed to a low level of intelligence in these children (Nikolaeva, Novikova, & Vergunov, 2018).

Method

Altogether, there were 52 participants in the study: 22 children with autism spectrum disorders, ranging in age 4.7±1.1 years old, and 30 normally developing children, who were 4.6±0.9 years old.

In order to achieve the goals and objectives of our ascertaining experiment, the following methodologies were used.

The developmental level of theory of mind was determined by using the Sally-Anne test, which is also called the "false belief test". The idea here is very simple: the child is told a story about two dolls, Sally, who has a basket, and Anne, who has a box. The child is informed that Sally puts a ball inside her basket and leaves the room. After that, Anne takes the ball out of the basket and puts it in her box. Sally then returns, and the child is asked, "Where will Sally look for the ball?" The correct answer is considered to be, "In the basket" (Flavell, 2004).

The reflexometry method was applied, and both simple and complex sensory-motor reactions were assessed by means of the ReBos technique (Krivischekov et al., 2016). A singular feature of this technique is that it makes it possible to evaluate a child's ability to orient themselves in a flow of sensory signals and to assess the quality of their sensory-motor integration. The test consists of two series of signal flows, Series 0 and Series 1. In Series 0, which is a trial run (though, even so, in this study the results were analyzed), the child learns how to take the test, i.e. to press down the space bar every time there is a stimulus to do so. In this series, the stimuli are applied at identical intervals. Series 1 is already a genuine test of the sensory-motor reactions (of the go-go type), but the stimuli here have a fractal structure. We used this structure because it is a really Nature-based one. The child is told to press down on the space bar every time a stimulus is applied. This series is composed of two parts, so it is possible to analyze whether the child has understood that the second part is a complete duplication of the first or not.

Raven's Colored Progressive Matrices (Raven, Raven, & Court, 2003).

For the 4-8 years old children we used the colored version. The stimulus material was divided into three sets (A, AB, and B) Each task is basically a rectangular-shaped matrix containing different figures and sets of figures that are composed so that they logically form a whole; the elements are arranged

according to a consistent pattern. Each set begins with a relatively easy problem, and then the tasks become gradually more involved. Such a progression can also be observed from one set to the next. All three of the Raven's sets are organized in accordance with the following principles: set A is based on the principle of a correlation of matrices; set AB, on the principle of analogy between pairs of figures; and set B, on the principle of progressive changes in the figures of a matrix.

Set A calls for analyzing the pattern in an image, recognizing the connection between elements in the pattern, and, based on this, identifying a missing element.

Set AB requires examining disconnected elements and establishing analogies.

Set B necessitates understanding the logical principles behind the changes in position of figures from one space to another.

Administering the test involved the following procedure: the experimenter showed a child a card on which a "carpet" and six "patches" were depicted. In order to "mend the carpet," the child had to scrutinize its pattern and the pattern of all the "patches," and then choose the one that fits the pattern of the "carpet." The child designated the number of the missing element in the picture, and it was written down in the protocol.

When processing the results, we tabulated the scores in percentages, and interpreted them in accordance with how frequently a particular score was attained in a given age category.

To determine how much influence the family's status has had on the child's development, a parent questionnaire was used (Nikolaeva & Merenkova, 2017), in which the parents indicated their age, their education, and the presence of other children and relatives who are living with the child. The results of this questionnaire were taken into consideration when the findings from the other tests were being processed.

Results

In Table 1, the children's speech patterns are presented. It can be seen here that among the children with ASDs, the majority were boys (14 out of 22), which corresponds to the distribution of children with ASDs in the population (Nikolskaya et al., 2012; Lerner et al., 2012).

Of the 22 children, 10 spoke in phrases, 8 of them used isolated words and 4 were only able to produce a series of sounds and vocalizations. The diagnosis "mutism" was received by 12 children.

The mean age of the children with ASDs was 5.5±1.5 yr., and for the children who exhibited normal development it was 5.1±0.4 yr.

Only one child with ASDs was able to successfully complete the Sally-Anne test (i.e. to give the correct answer), and this outcome confirms findings derived from sources in the literature (Weitlauf, Sathe, McPheeters, & Warren, 2017). This could mean that theory of mind does not form in such children or that it does so insufficiently. It can also be assumed that it forms only in those children with autism spectrum disorders who have an above-average level of intellectual development. Theory of mind conformed to the developmental norm in 80 percent of the children who showed normal development.

Table 1 ***Description of the of children with ASDs***

No	Child's code	Gender	Age (years)	Speech development
1	TB	1	7.9	spoke in phrase
2	AC	0	7.5	spoke in phrase
3	OM	0	6.7	spoke in phrases
4	AK	1	4.4	a series of sounds
5	AO	1	4.1	isolated words
6	KSH	1	4.1	spoke in phrases
7	AB1	0	3.1	isolated words
8	CA	1	4.3	a series of sounds
9	CH	1	4.1	isolated words
10	AO1	1	6.3	spoke in phrases
11	VK	1	7.4	spoke in phrases
12	HC	1	7.7	spoke in phrases
13	MC	0	4.6	isolated words
14	VU	1	5.2	isolated words
15	MC	0	4.5	spoke in phrases
16	VB	0	5.1	isolated words
17	LT	1	5.9	spoke in phrases
18	PP	0	3.1	isolated words
19	BT	0	7.2	spoke in phrases
20	GB	1	5.9	a series of sounds
21	MA	1	6.4	isolated words
22	LC	1	5.2	a series of sounds

An analysis of Table 2 demonstrates that the children in the two groups did not differ in terms of intelligence. And, what is more, when it came to the more difficult tasks (Part B), the children with ASDs acquitted themselves better. One of the children with an ASD, who scored the maximum number of points, went through the test with interest, indicating the number of the task with his fingers and pointing to the answers. He would check to see that the teacher wrote down the right answer, and then proceed to the next task. He performed each task quickly and did not change his answers. Another child, who scored the minimum number of points, carried out each task slowly and reluctantly, one part one day,

the other part the next; he would give a quick answer (gesticulating rather than speaking) and then immediately lose interest in the task. Some other children would likewise carry out a task quickly and with interest, but sometimes they would change their answers. After they were asked what the final answer was, they indicated that it was what they had chosen the second time – this could mean that the children noted and corrected mistakes that had come about as a result of their own inattentiveness.

Table 2 ***Comparative analysis of the level of general intelligence in children with ASDs and children of normative development (scores)***

Subjects	A	AB	B
Norm	7.3±1.4	5.0±1.6	3.8±1.9
children with ASDs	6.9±1.9	5.5±2.0	5.4±1.9*

*Note: *= differences between groups for p≤0.05 (Student's criterion)*

An analysis of the sensory-motor reactions provided extremely intriguing results (Table 3). It turned out that children with ASDs made considerably fewer mistakes when performing both the trial run (Series 0) and the ultimate series (Series 1) of signal flows. Moreover, their reaction time to the stimuli was no different from that of the normally-developing children. The children in this second group did not demonstrate reduced reaction times during the second part of the series, which shows that their intuition did not tell them that it duplicated the first. Children with ASDs, however, had shorter reaction times when carrying out the second part of the task, both during the trial run and during the ultimate series. Consequently, despite the lack of effective interaction with other people, these children are substantially better at orienting themselves in a flow of signals, if it is unrelated to the social environment, and they are better at detecting its structure.

Table 3 ***Parameters of simple sensorimotor reaction in children***

Children	Omissions, series 1	Time reaction, series 0, part 1, mc	Time reaction, series 0, part 2, mc	Omissions, series 2	Time reaction, series 1, part 1, mc	Time reaction, series 1, part 2, mc
ASD	1.5±1.4*	485.4±173.9	470.3±150.0	26.1±5.6*	441.0±76.7	405.9±101.5
Norms	3.1±0.9	394.6±63.2	402±79.1	38.2±7.4	440.5±52.7	452.1±56.7

*Note: * -see table 2*

According to Table 4, which was based on a regression analysis, the independent variable "theory of mind" has an impact on the dependent variable

"performance of the AB series" on the Raven's Test: the more highly formed their theory of mind, the worse a child does on the Raven's Test, although you would expect the opposite.

Table 4 ***The influence on the independent variable «theory of mind» on dependent variables***

Dependent variable	R^2	B	P
Intelligence, seria AB	0.260	-0.509	0.031

In Table 4, the quality of the children's reactions is assessed according to how many of them were erroneous. It turned out that the older the children were and the higher their level of intelligence, the better they were at performing the tasks.

Table 5 ***The influence on the independent variable «the quality of the children's reactions» on dependent variables***

Dependent variables	R2	B	P
Age	0.326	0.571	0.021
Intelligence, seria A	0.365	0.604	0.000
Intelligence, seria B	0.266	0.516	0,041

Conclusions

In this study, an attempt was made to resolve the paradox between the unformed speech processes in children with ASDs and their rather high levels of intelligence. Only one of the children in our study who had been diagnosed as having an ASD was able to successfully carry out a test that is aimed at diagnosing the presence of ASDs, the Sally-Anne Test. At the same time, 80 percent of the children with a normal level of development were able to do so. Accordingly, children with an unformed theory of mind participated in our study, and the results illustrate the accuracy of their diagnosis. It turned out that the children with ASDs were no different from the normally-developing children in terms of intelligence. Furthermore, they were even somewhat better at performing the most difficult series of all, the B series.

An analysis of these children's orientation in a signal flow showed that they are better at intuitively predicting the structure of a sensory flow since they make fewer mistakes when performing both a series with isochronous intervals between stimuli and one in which the signal flow has a fractal structure. It can be assumed that the sensory integration in these children is more highly formed compared to that of the children with normal development. This can be assessed as a

compensatory reaction to the delayed formation of speech as a fundamental means of orientation in the social environment.

Findings:

Out of the 22 preschool children with ASDs, 21 of them had an unformed theory of mind. In the norm group, 80 percent of the children had a formed theory of mind.

Mute preschool children with ASDs made fewer mistakes in the simple sensory-motor reactions (of the go-go type).

Mute children with ASDs were better at orienting themselves in a sensory flow that was unrelated to speech and social information, which can be considered as a compensatory reaction, given their psychophysical inability to develop normal speech.

In mute children with ASDs, the level of nonverbal intelligence was no different from that of the children in the norm group.

Limitations

We have shown that children with autism spectrum disorders are more effective than their normally developing counterparts when analyzing a signal flow with fractal structure unrelated to speech or social conditions. Therefore, it allows them to be more successful in some cognitive processes, even when they have a marked lag in speech development up to mutism. We think at the same time, it is necessary to increase the sample of subjects in the future and, most importantly to understand the reasons for the benefits in analyzing the flow of signals not related to speech and social conditions.

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