

Joint Attention in Preschoolers with Different Forms of Atypical Development

Ya Smirnova^{1,a*}

¹ Altai State University, 61a Lenina prospect, Barnaul 656049 Russia

^{a*}yana.smirnova@mail.ru

*Corresponding author

Keywords: joint attention, shared attention, social attention, social cognition, age development, atypical development, preschool age, cognitive development, oculography, eye tracker

Abstract: The article analyzes the relationship between the skills of joint attention and social and cognitive development of the child. It is devoted to the problem of identifying markers of oculomotor activity, which allows us to identify patterns that can reliably predict the development of joint attention deficit in various forms of atypical development. By tracking eye movements in a sample of 90 preschoolers with typical development, mental retardation, delayed speech development, visual impairment, hearing impairment, the following potential mechanisms underlying the atypical joint attention were found: atypical gaze following, impaired integration of joint attention, decreased recognition of the orienting value. More than that, the author states that the conducted analysis of contrasting clinical groups made it possible to identify the primary psychological causes of joint attention deficit, as well as universal and specific symptoms of joint attention disorders for different clinical groups.

1. Introduction

In modern science, the study of the development of "social-cognitive functions," reflecting aspects of how a person processes information in a social context, builds causal relationships regarding their own behavior and the behavior of other people, and also assigns social rules, is becoming increasingly relevant.

Such social and cognitive phenomenon is joint attention or shared attention, reflecting the facts of how, in the process of social cognition, the joint processing of information about their attention and the attention of other participants in joint activities occur. Initially, joint attention is understood as the process of gaze following [11], which is provided by automated processes for tracking the direction of the gaze [19]. In short, joint attention is manifested in a person's ability to use the direction of his/her gaze or to point out the focus of attention to other participants in communication. It is achieved by tracking the direction of the gaze of one subject by another, indicating the object and other verbal and non-verbal methods of identifying the object. Besides, the individual must be aware that the focus is shared between him/herself and another person [3; 13]. The main fundamental manifestations of joint attention are distinguished: in fact, maintaining eye contact and shifting the gaze between the direction of the gaze of the social partner and any object.

The question of a comparative analysis of the pattern of atypical joint attention on a sample of children with different forms of developmental disabilities remains poorly understood. Comparison data for children with different forms of atypical development can contribute to a deeper understanding of individual differences, as well as phylogenetic differences in joint attention and social cognition.

At the present stage, the problem of perception of gaze and joint attention in clinical groups of the population is actively raised. Clinical observations have shown that it is the understanding of other people that is not available for a number of nosological groups [10; 3; 12]. Specific impaired attention orientations in response to gaze were observed in people with autism [14], ADHD [15], schizophrenia [6], and hearing impairment [16; 9]. In some cases, it has been found that social attention predicts language abilities and social competency. [7; 16]. At the present stage, we can state that the lack of joint attention is often associated with the overall level of development of the child.

Currently, the use of eye-tracking in children as a potential diagnostic tool in the study of joint attention is gaining popularity [14; 2; 10; 8].

In experiments devoted to joint attention, the idea is actively used that an adult can direct the child's attention to a specific object using the direction of view. In other words, the direction of view can be used to determine the focus of the attention of another person under various conditions. For example, S. Tipper used the gaze-cueing paradigm to study mechanisms of joint attention. [11]. His concept emphasizes tracing the line of sight of one person to another, as the main condition for joint attention.

The development of eye movement registration technologies has opened up new possibilities for the study of joint attention using dynamic social scenes that are closer to real life. [14]. Episodes of joint attention can be studied using paradigms for recording eye movement, and this kind of assessment can provide a new understanding of the atypical development of joint attention in the very early stages of ontogenesis. The methods for recording eye movement will help identify behavioral markers and improve the understanding of pathological symptoms.

The method of recording eye movement was used to assess the relationship of joint attention with the pace of development of the child, including language acquisition [10], the formation of the child's affection for the mother [10], facial recognition by infants [18] and the motor development of the child [2]. Various stimuli were used in studies to study joint attention using the eye movement detection method: the elements of biological movement (forms representing a walking person, compared with the same figures in random positions [14]); and social scenes (paradigms of visual preferences [17] or the paradigm of reaction to social scenes [14; 4]).

The state of the eye-tracking technology allows us to show this feedback in real-time. To date, impairment of joint attention in autism has mainly been studied in samples of infants in natural and semi-structured social interactions [7; 16]. However, surveillance paradigms often lack sensitivity to joint attention problems that may affect older children.

The technology of tracking the movement of the gaze will allow (1) to analyze the difficulties of establishing episodes of joint attention, which can be especially important in studies of children's education [9]; (2) to provide information on factors of adjustment by exchange of gaze during the learning process; explore collaborative visual search track interactive processes in a group of children [1; 20; 9].

Thus, the main goal is to conduct a comparative analysis of the pattern of atypical joint attention on a sample of children with different forms of developmental abnormalities by eye movement tracking. The task was to highlight the manifestations of a deficit in joint attention that impedes the involvement of a child with an adult in dyadic interactions.

2. Materials and Methods

Empirical study sample. The sample consisted of preschoolers 5-7 years old (average age 6 years 2 months) of different nosological groups, such as typically developing preschoolers ($n = 20$), preschoolers with mental retardation (class F83 according to ICD-10) ($n=20$), preschoolers with delayed speech development (class R47 according to ICD-10) ($n=20$), preschool children with hearing impairment (sensorineural hearing loss, class H90 according to ICD-10) ($n=10$); preschool children with visual impairment (with amblyopia and strabismus, class H53 according to ICD-10) ($n=20$). All children have an official diagnosis based on the results of the territorial medical-psychological-pedagogical commission.

Research methods and procedure. The study procedure included 2 series of experiment. In front of the child, on the table, 2 different objects (toys) were located, after which he/she was offered a game in which the child, observing the direction of the adult experimenter's gaze, had to guess which object he/she would choose. The main task was to follow the direction of the adult's gaze and point to the subject on which it stopped. Five repetitions of this task were proposed, where the experimenter changed the direction of gaze, each time pointing to different objects. The number of error-free responses of the child was recorded. In the second series, the preschooler and the adult experimenter changed roles, i.e., the child needed to look at any subject with his/her eyes, and the leader's task was to determine what the preschooler's gaze stopped at. The number of successful attempts to initiate joint attention was recorded. Thus, in these experimental

conditions, the following was recorded: sensitivity to the direction of the partner's gaze, intentionality detector, responding to getting joint attention, and initiating joint attention.

During the experiment, the eye movement detection method was used using the Pupil Headset portable tracker - PLabs - eye tracker in the form of glasses (binocular performance).

3. Results

According to the results of the study, heat maps were built, and tracking strategies and scanning routes of objects perceived in a situation of joint attention in typically developing children and children with different forms of atypical development were analyzed (Figure 1).

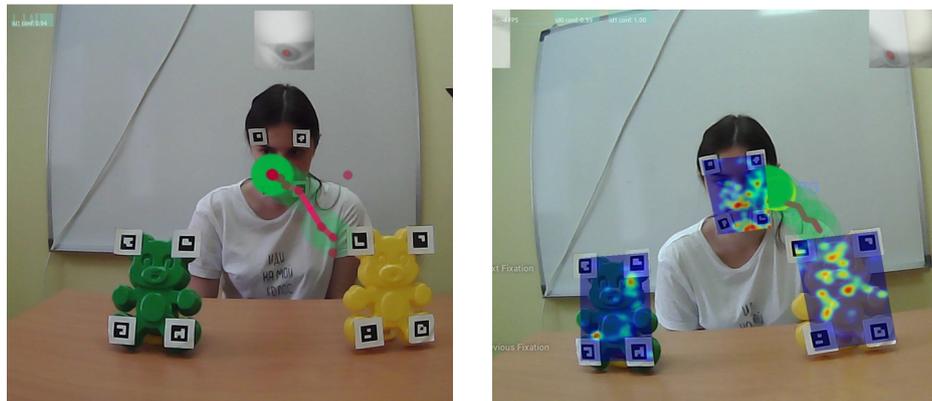


Fig. 1. An example of a heat card of the violation of establishing joint attention in children with mental retardation.

On the cards, differences are recorded in the following: (1) the preferred content (subject) of perception in episodes of joint attention; (2) a way of establishing joint attention; (3) the area of interest of typically developing children and children with different forms of atypical development; (4) changing the tracking path of the partner's gaze; (5) the atypical gaze orientation and the dynamics of the operational field of vision of typically developing children and children with atypical development in a situation of joint attention; (6) the accuracy of fixing the elements of the object with a deficit of joint attention.

The following is visualized on heat cards: critical attention shifts, attention focus changes, gaze translation, recognition of eyes as an informative sign, and perception of the partner's gaze direction in episodes of joint attention in typically developing preschool children and children with different forms of atypical development.

4. Discussion

The initial analysis of the tracking strategy and scanning routes of objects perceived in a situation of joint attention in the typically developing children and the children with different forms of atypical development allows us to conclude that there are universal and specific, for a particular clinical group, manifestations of disorders in the joint attention mechanism.

It has been found that diagnostic markers of joint attention disorders include the following: the difficulty in following the partner's look; anticipatory actions, decision making and response by the method of "guessing" or "trial and error"; the predominance of orientation to the object, and not to the interaction partner (as a result, violation of triadic relations); the dispersion of fixations and zones of interest; difficulties in general visual attention; searching for additional information; using of additional multimodal means of establishing joint attention (turning the head, gestures, speech, etc.); the decreasing of fixing the elements of the object with a deficit of joint attention; the decreasing motivation to participate in joint attention (with different forms of atypical behavior, the child does not track the result, is not interested in the partner's reaction, does not seek additional means to initiate joint attention and maintain the partner's attention focus).

At this stage, we can assume that the specifics of the joint attention deficit will manifest itself in violations of the following individual components of joint attention: following the gaze of the communication partner, fixing on the object, preference is given to neutral incentives, rather than social.

5. Conclusion

Due to the eye-tracking method, the methodological possibilities of measuring episodes of joint attention in real-time of social interaction through tracking eye movements are expanded. The methodological tools of interactive methods for registering eyes in episodes of joint attention were tested.

It is supposed to establish the possibility of modeling empirical markers of joint attention in the conditions of joint activity as experimental conditions. Using the eye-tracking method, markers of joint attention deficit manifested through the oculomotor activity will be highlighted.

The normative and pathological social symptoms of initiating joint attention, initiating behavioral requests, responding to joint attention are systematized in preschoolers.

In a sample of children with different forms of developmental retardation, the following potential mechanisms underlying the atypical joint attention were identified: the atypical gaze following, the impaired integration of joint attention, the decreased recognition of orienting values of gaze, and changes in the temporal characteristics of episodes of joint attention.

5. Acknowledgments

The research results were obtained with the financial support of the Russian Foundation for Basic Research in the framework of the scientific project No. 19-013-00220 "The role of joint attention and the ability to integrate social information in the development of preschool children."

References

- [1] Acarturk, C., Tajaddini, M., & Kilic, O. (2017). Group eye tracking (GET) applications in gaming and decision. In R. Radach, H. Deubel, C. Vorstius, & M. J. Hofmann (Eds.), *Abstracts of the 19th European Conference on Eye Movements*. Wuppertal, Germany.
- [2] Adolphs, R., & Spezio, M. (2006). Role of the amygdala in processing visual social stimuli. *Progress in Brain Research*, *156*, 363-378.
- [3] Baron-Cohen, S., Richler, J., Bisarya, D., Gurunathan, N., & Wheelwright, S. (2003). The systemizing quotient (SQ): An investigation of adults with Asperger syndrome or high-functioning autism, and normal sex differences. *Philosophical Transactions of the Royal Society of London (Series B)*, *358*, 361-374.
- [4] Chawarska, K., Macari, S., & Shic, F. (2013). Decreased spontaneous attention to social scenes in 6-month-old infants later diagnosed with Autism Spectrum Disorders. *Biological Psychiatry*, *74*(3), 195-203.
- [5] Chen, CH., Castellanos, I., Yu, C., & Houston, D. M. (2019). Effects of children's hearing loss on the synchrony between parents' object naming and children's attention. *Infant Behavior and Development*, *57*, 101322
- [6] Dalmaso, M., Galfano, G., Tarqui, L., Forti, B., & Castelli, L. (2013). Is social attention impaired in schizophrenia? Gaze, but not pointing gestures, is associated with spatial attention deficits. *Neuropsychology*, *27*(5), 608-613.
- [7] Dawson, G., Jones, E. J., & Merkle, K. (2012). Early behavioral intervention is associated with normalized brain activity in young children with autism. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*(11), 1150-1159.
- [8] Elsabbagh, M., & Johnson, M. H. (2016) Autism and the social brain: The first-year puzzle. *Biological Psychiatry*, *80*(2), 94-99.
- [9] Falck-Ytter, T., Bölte, S., & Gredebäck, G. (2013). Eye tracking in early autism research. *Journal of Neurodevelopmental Disorders*, *5*(1). <https://doi.org/10.1186/1866-1955-5-28>.
- [10] Farroni, T., Johnson, M. H., & Csibra, G. (2004). Mechanisms of eye gaze perception during infancy. *Journal of Cognitive Neuroscience*, *16*, 1320-1326.
- [11] Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze cueing of attention: visual attention, social cognition, and individual differences. *Psychological Bulletin*, *133*, 694-724.
- [12] Frith, C. D. (2007). The social brain? *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1480), 671-678.

- [13] Hobson, R. P. (2005). What puts the jointness in joint attention? In N. Eilan, Ch. Hoerl, T. McCormack, & J. Roessler (Eds.), *Joint attention: Communication and other minds*. Oxford, UK: Oxford University Press.
- [14] Klin, A., Lin, D. J., Gorrindo, P., Ramsay, G., & Jones, W. (2009). Two-year-olds with autism orient to non-social contingencies rather than biological motion. *Nature*, *459*, 257-261.
- [15] Marotta, A., Casagrande, M., & Lupianez, J. (2013). Object-based attentional effects in response to eye-gaze and arrow cues. *Acta Psychol (Amst)*, *143*(3), 317-321.
- [16] Mundy, P. (2017). A review of joint attention and social-cognitive brain systems in typical development and Autism Spectrum Disorder. *European Journal of Neuroscience*, *47*(6), 497-514.
- [17] Pierce, K., Conant, D., Hazin, R., Stoner, R., & Desmond, J. (2011). Preference for geometric patterns early in life as a risk factor for autism. *Archives of General Psychiatry*, *68*(1), 101-109.
- [18] Quinn, P. C., Anzures, G., Izard, C. E., Lee, K., Pascalis, O., Slater, A. M. ... Tanaka, J. W. (2011). Looking across domains to understand infant representation of emotion. *Emotion Review*, *3*, 197-206.
- [19] Shepherd, S. V. (2010). Following gaze: Gaze-Following behavior as a window into social cognition. *Front Frontiers in Integrative Neuroscience*, *4*. <https://doi.org/10.3389/fnint.2010.00005>.
- [20] Von Suchodoletz, A., Fäsche, A., & Skuballa, I. T. (2017). The role of attention shifting in orthographic competencies: Cross-sectional findings from 1st, 3rd, and 8th grade students. *Frontiers in Psychology*, *8*. <https://doi.org/10.3389/fpsyg.2017.01665>.