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Theory of Mind in Persons with Permanent Hearing Disorders

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Abstract: Introduction. The problems of hearing loss and deafness were always relevant in both medical and psychological-pedagogical fields. Hearing deprivation influences speech development and consequently all cognitive functions that are a basis for intelligence. They also facilitate a formation of the ability to understand the Others, a theory of mind. A significant attribution of non-verbal communication as a factor in the theory of mind formation is the ability to interpret non-verbal signals correctly in the understanding of Others. In this sense, the study of eyes as an integral part of facial expressions and a method of non-verbal communication becomes relevant. The study is novel in the theory of mind assessment in people with hearing deprivation as a group that actively uses the language of non-verbal communication. **Methods.** A method such as the Reading the Mind in the Eyes Test (RMET) is applied – a technique aimed at diagnosing the understanding of a person's mental state by sight. It is of considerable use to measure individual differences in social cognition and emotional recognition in different groups. In this study, the distribution of scores according to the Russified test version among people with permanent hearing disorders was studied. **Results.** In the studied persons with hearing deprivation, the average indicators for the test Reading the Mind in the Eyes Test were in the zone of reduced ability to recognize emotions according to the data obtained by the test authors. Statistically significant differences were found between groups with varying degrees of hearing loss. Also, statistically significant sex differences were observed when performing the Reading the Mind in the Eyes Test. **Discussion.** People with impaired hearing in adulthood still have difficulties recognizing complex emotions, which can be explained by the deprivation of speech communication in the family in early stages of development, which reduces the development of the theory of mind and, consequently, the ability to understand Others.

Keywords: theory of mind, impaired hearing, reading the mind, hearing loss, states of mind, hard-of-hearing, deaf, deafness, hearing deprivation, emotions

Highlights:

➤ persons with permanent hearing disorders are characterized by the reduced theory of mind indicators in the recognition of the states of mind by the eyes;

- for a deeper degree of hearing loss (deafness), lower indicators of the ability to recognize mental states by the eyes are peculiar;
- for female representatives with hearing impairment, lower indicators of the ability to recognize mental states by the eyes are peculiar than for male representatives.

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Introduction

One of the primary components of social cognition is emotion recognition, which is the ability to interpret emotional expressions (by face, voice or posture) about the mental states of Others to predict their behavior. This element is a component of the theory of mind, which assumes an assessment by the subject of the study of his mental world and the world of other people. A person can perceive his experiences, emotions, and other people (Sergeyenko et al., 2009).

In the literature, the term “Theory of Mind” was first introduced by Premack & Woodruff (1978), who meant by this that a person assigns individual states of mind to himself and others. These states are not directly observed and can be used to predict other people’s behavior.

At the end of the 20th century, the theory of mind became one of the actively developed problems, which is also called the “Theory of Theories” (Flavell, 1999; Moore, 1996; Perner, 1991; Wellman, 1998). The synonymy of this terminology emphasizes the level of metacognitive organization that allows us to understand the subjective world of other people (Sergeyenko et al., 2009). It means that the theory of mind is one of the most significant components of cognitive development, which gives an individual an idea of other people’s states of mind and allows them to recognize and predict these mental states by external signs (Ermakov et al., 2016).

The process of forming a theory of mind begins at an early age and continues throughout life. The ability to recognize emotions and feelings by facial clues and expressions is one of the most significant components of the theory of mind. Mechanisms of emotions’ facial expressions, according to Oster & Ekman (1978), are innate. So, during 15-18 weeks of prenatal development, all the necessary facial muscles are formed, which subsequently allows the expression of a different range of emotions. From the 20th week of intrauterine life, there are changes in “facial expressions”.

According to E. A. Sergeyenko (Sergeyenko, 2005), even at an early age, infants can actively represent some aspects of the physical world’s existence. The representation of a holistic perception of the environment is a significant element of understanding the physical world, which is confirmed by data on the ability of newborns to imitate the facial expressions and gestures of adults.

Social interaction with the environment during adulthood in the postnatal period forms a child’s experience of looking at faces and the ability to single out and recognize subtle differences in facial expression. In children, it is possible to observe a difference in reaction to happy or surprised facial expressions, even if these feelings are expressed by different people who are upset or scared (Barrera & Maurer, 1981; Nelson, 1987; Widen & Russell, 2008).

At the earliest stages of childhood, the child focuses on interaction with Others, expressed in managing his vocalization in pseudo-dialogues and considering the characteristics of other

people (Mukhamedrakhimov, 2001). Understanding yourself and Others is inherently an integral part of social interactions. The ability to develop a theory of mind is the acquisition of significant qualitative information about social objects and their properties. Therefore, we can say that the theory of mind is the cognitive basis of social cognition. This perception suggests a possible insufficiency of the development of the theory of mind in children growing up in conditions of deprivation (Sergeyenko et al., 2009). This category of children includes children with autism, various forms of developmental delays, and also children with permanent hearing disorders.

One of the leaders in the research of the theory of mind in people with autism is S. Baron-Cohen (Baron-Cohen, 1985, 2000), who, together with his colleagues, argued that in children with autism, reasoning about mental states is limited in solving problems of the theory of mind, the reason for which is a deficit or lack of social skills and experience.

The absence of a theory of mind in children with autism and deafness has received a reasonable explanation in Peterson & Siegal's studies (1995, 1997). They argued that the verbal interaction between parents and the child is the basis for the development of the theory of mind; on the contrary, the absence of such interaction deprives the child of social experience and communicative feedback about mental states and the ability to attribute mental states to Others. This explanation is fair to apply to deaf and hard-of-hearing children. Peterson Research Array & Siegal (1998) showed that deaf children with hearing parents, and children with autism spectrum disorders, did not cope with the tasks of false beliefs, unlike their peers, who easily coped with these tasks.

Peterson Research & Siegal (1998, 1999) showed that higher results of successful completion of tasks related to the theory of mind were observed in deaf children who were brought up in families with deaf parents and used sign language as communication than groups of deaf children who used oral speech instead of sign language in communication with their hearing parents. It should be stressed that more than 90% of deaf children are raised by hearing parents. Due to the inability to use spoken language in everyday life and because their parents do not speak sign language, full interaction in such families is limited at its best (Marschark et al., 2000).

Peterson & Siegal (1998) and Russell et al. (1998) concluded that deaf children do not have a sufficiently developed theory of mind, and most of them acquire a theory of mind in adolescence, i.e. 10 years later than hearing children. This delay is a consequence of the limited ability of deaf children to learn about the Others' states of mind.

In 2000, a theory of mind component model was proposed, which included socio-cognitive and socio-perceptual components. The socio-cognitive component is associated with both general and specific aspects of language development. It develops by the age of 4-5 years, in the form of reasoning about false beliefs of the first order and late childhood – with an understanding of complex social situations (Tager-Flusberg, & Sullivan, 2000). The socio-perceptual component is based on the ability to draw conclusions about other people's states of mind using facial expressions, voice and body language. The development of this component begins earlier than the socio-cognitive one: in the first years of life, the child already distinguishes the expression of his mother's facial expressions and reacts to it (Baron-Cohen et al., 1994). The ability to identify facial expressions includes a socio-perceptual component that conveys not only emotional states but also behavioural intentions and the desire for action.

The measures prototypes of the socio-perceptual component of the theory of mind are facial recognition (Gao & Maurer, 2009) and recognition of the state of mind by the eyes (Baron-Cohen et al., 2001).

Studies involving the investigation of the ability to recognize facial expressions use photos of faces with pronounced basic emotions as stimuli. In children, in the process of development, the correctness of the definition of such emotions improves with age, but the degree and range of this change are not clear yet. Emotion identification, expressed in the ability to decode facial expressions, is a significant component of social interaction due to the impotent role of facial information that reflects social behaviour. Disturbances in the recognition of emotions can be associated with mental disorders in both adults and children (Herba & Phillips, 2004).

Children who have experienced auditory deprivation in early childhood may not receive adequate information underlying understanding of other people's emotional expressions (Rieffe & Terwogt, 2000). It, of course, reduces the level of the theory of mind and affects the social adaptation of deaf and hard-of-hearing persons to life in society.

Most studies of the theory of mind in people with hearing deprivation focused on development because researchers studied children more often, while few of them analyzed the understanding of deaf adults of their minds and the minds of Others (Batty & Taylor, 2006; Most & Aviner, 2009; Lecciso et al., 2016; Lecciso et al., 2013).

As methods of studying the affective component of the theory of mind – recognition and differentiation of emotions by facial expression in adulthood – such methods as the Penn Emotion Recognition Task-40 (Kohler et al., 2004) and the Penn Measured Emotion Discrimination Task are used in research (Erwin et al., 1992): These tests are based on the recognition of basic emotions from photographs presented to the respondent. These tests allow us to evaluate the accuracy of recognition of basic emotions and the speed of emotions' recognition with an assessment of each expression pattern, however, special software is required for these forms of testing, which complicates the availability of use.

In the present study, an attempt was made to study the theory of mind in people with hearing deprivation using the Cambridge Autism Research Center's Reading the Mind in the Eyes Test (RMET) developed by Baron-Cohen et al. (2001) in the Russian adaptation made by E. E. Rummyantseva (Rummyantseva, 2012, 2013). The analysis of the tasks of the Reading the Mind in the Eyes Test includes a comparison of terms describing mental states with fragments of facial expressions in various mental states. It is assumed that the subjects of the study should, at an unconscious and automatic level, compare the eyes in each presented picture with the eye area stored in memory and observed in the context of particular states of mind to determine which word most corresponds to this state (Baron-Cohen et al., 2001). According to Baron-Cohen (2003), understanding the state of Another by the intonation of his voice, face and especially by the eyes gives developed empathy, allowing you to imagine his thoughts and feelings. The look and expression of the eyes are significant sources of information that help us to understand a person's condition, intentions and feelings. This ability to 'look' into another person's consciousness is part of the concept of the theory of mind. However, since judgments can only be based on facial expressions, the test can also be considered an emotion recognition test.

We assume that the mental model in persons with hearing deprivation may differ relative to the norm, and the degree of hearing loss may affect the severity of the indicators of the theory of mind. It is assumed that there are sex differences in the degree of the theory of mind in persons with hearing deprivation.

Methods

The participants. The study involved 70 people with a hearing impairment aged 17 to 27 years (21.34 ± 2.18 years), 43 men (21.6 ± 2.31 years) and 27 women (20.8 ± 1.87 years). The survey of respondents was conducted in the period from April 2022 to June 2022 in person, in the format of computer testing. All the study participants were students of the Novocherkassk Technological College boarding –for people with disabilities. All the subjects were divided into three groups according to the degree of hearing impairment (III degree – 15 people, IV degree – 37 people, and deafness – 18 people) by the international classification of hearing loss. III degree of hearing loss (moderate) – a person hears sound only louder than 56-70 dB. IV degree of hearing loss (severe) – a person hears sound only louder than 71-90 dB. Deafness – a person can only hear the sound louder than 91 dB.

All participants took part in the testing procedure voluntarily in a computerized classroom using the Online Psychological Tests website (<https://psyttests.org>). The research project protocol was made in accordance with the guidelines of the Helsinki Declaration of 1995, and each study participant gave voluntary informed consent to participate in the study. All information about the participants was anonymized and de-identified before the analysis.

The study participants were presented with a series of 36 photographs of the eye area of 19 actors and 17 actresses on a computer monitor screen. Four words describing the state of mind were suggested for each photo – bored, angry, etc. One of these words indicates the state of mind depicted in the photo, and the others were background words, not opposite in meaning. Participants were asked to choose which of the four words best describes what the person in the photo thinks or feels. Study participants could use an unlimited amount of time and move on to the next item when they were ready. Participants had the opportunity to request an explanation of the meaning of words if they were not sure of the definition of any word used. The score on the test is the number of words correctly identified by the participants, i.e., the number of correctly identified mental states. The maximum score is 36. This test can also be carried out by directly presenting cards with photographs to the subjects; however, the method of testing in electronic form allows testing a larger number of subjects at the same time, thereby reducing the time of the study as a whole and eliminating errors in the calculation.

For statistical analysis of the data, the SPSS Statistics 23.0 was used. Descriptive statistics and the Kolmogorov–Smirnov criterion and the Mann-Whitney U-Test were used to assess the normality of the value. Differences were considered statistically significant at $p < 0.05$.

Results

According to the method of Reading the Mind in the Eyes Test (RMET), the results were obtained, they are given in (Table 1).

Table 1

Results of persons with hearing impairment on the test Reading the Mind in the Eyes Test (in points)

Participants group	N	M	SD
All	70	16,6	4,8

Participants group	N	M	SD
Men	43	17,6	5,1
Women	27	15,1	3,9
<i>Including:</i>			
	15	18,4	3,1
<i>III hearing loss degree</i>			
	37	16,7	5,3
<i>IV hearing loss degree</i>			
<i>Deafness</i>	18	14,9	4,2

Note. The following designations are accepted in the table: *N* – number, people; *M* – average value; *SD* – standard deviation.

Most of the subjects' results were below the area of typical values. They did not score 22 points – the lower threshold of the norm presented by the authors of this test, while the scores on the test were also lower than the group of people with high-functional autism (Baron-Cohen et al., 2001).

Comparison of data on passing the Reading the Mind in the Eyes Test of a group of persons with hearing impairment with the results of a Russian study by E. E. Romyantseva (Romyantseva, 2013) also showed that a group of persons with hearing impairment coped worse with understanding the mental state of other persons than representatives of the norm group (men 26.6 ± 3.6 ; women 28 ± 3), and worse – groups with the disease 'schizophrenia' (men 24.9 ± 3.2 ; women 25 ± 5).

The results of passing the Reading the Mind in the Eyes Test (RMET) of the studied group of persons with hearing deprivation revealed sex differences in understanding the mental state of the Other, which are presented in Table 2. The results indicate that the average values of the female representatives of the hearing deprivation group are statistically significantly lower than those of the male representatives of this group.

Table 2

Results of sex differences in Reading the Mind in the Eyes Test among the group with hearing impairment according to the Mann-Whitney U-Test

Test	Female	Male	U-Test	
	N = 27people	N = 43people	U	p
Reading the Mind in the Eyes, rmet	28,19	40,09	383	0,017

Note. The following designations are accepted in the table: N – count of persons; U – the value of Mann-Whitney U-Test; p – significance level (as a significant takes $p \leq 0,05$).

A comparative analysis of the differences according to the Mann – Whitney U-Test in passing the state of mind reading test by the degree of severity of hearing loss (III, IV and deafness) in the group with hearing impairment showed statistically significant differences in the group with III degree of hearing loss and the group with deafness. They are presented in table 3.

Table 3

Results of differences between groups with different degrees of hearing loss on the Reading the Mind in the Eyes Test according to the Mann-Whitney U-Test

Test	III hearing loss degree	Deafness	U-Test	
	N = 15 people	N = 18people	U	p
Reading the Mind in the Eyes Test, rmet	21,1	13,58	73,5	0,026

Note. N – count of persons; U – the value of Mann-Whitney U-Test; p – significance level (as a significant takes $p \leq 0,05$).

Discussion

The revealed sex differences, as a result of the technique of reading implementation the state of mind by the eyes, are interesting. Thus, female representatives showed lower results than male representatives. In a study by Baron-Cohen et al. (2001) gender differences in passing the Reading the Mind in the Eyes Test, the average scores on the test were higher in women. The author points out that this is predictable for a sample of the norm. Women are more empathic and competent in understanding other people, however, female representatives with hearing deprivation, according to Most & Aviner (2009), may be able to focus more on the mouth area to read lips, thereby limiting the amount of emotional information received from the eye area

of their communication partner, which may explain reduced indicators in female representatives with impaired hearing.

Significant differences in the recognition of mental states in persons with different severity of hearing loss can be explained by different involvement in the process of forming a mental model: the III degree of hearing loss allows you to build communication with other people, including hearing, which allows us to form the necessary vocabulary of emotions – this is certainly less accessible to persons with deep hearing impairment, pronounced in total deafness. Deaf people, and hearing people tend to correctly recognize the most common emotional states: joy, anger, fear and sadness. The highest difficulties arise when identifying intellectual and socio-moral feelings (Lubovsky et al., 2005).

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In general, the reduced level of understanding of the mental world of other people by deaf and hard-of-hearing people can be explained by difficulties in the formation and development of their mental model. As mentioned earlier, the process of forming a mental model is dynamic and continues throughout the entire period of the child's development, however, this process in the case of the persons we studied with hearing deprivation was complicated by limited communication in families. It can be assumed that such low scores on passing the test by students with hearing deprivation are due to the poverty of their vocabulary, since more often in their communicative practice they use sign language, which is impoverished by the presence of gestures describing emotional and mental states, which can complicate the process of determining and interpreting mental states in other people. According to T. G. Gadel'shina and Yu. A. Eremina (Gadel'shina, Eremina, 2013), constantly enriching personal experience and situational analysis of the hearing-impaired serve as a prerequisite for emotional experience, and the level of development of speech and communicative activity in the process of development is of particular importance for their successful formation.

Our results are confirmed by studies (Lecciso et al., 2013, 2016), which found that people with persistent hearing impairments in adulthood have stable difficulties recognizing complex emotions.

Conclusion

1. The studied persons with persistent hearing impairments have a reduced understanding of another person (mental model) compared to people without hearing impairments.

2. Tendencies of greater preservation of the mental model in men, compared with women with hearing deprivation, were found.

3. Significant differences were found in the preservation of the mental model in persons with hearing deprivation of the III degree of hearing loss and deafness, where persons with the III degree of hearing loss better understand the states of mind in another person. This indicates the connection between the formation of the mental model and the degree of hearing damage: the

more hearing is affected, the less pronounced the ability to recognize and verbalize the mental states of Others.

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Pavel Nikolaevich Ermakov – planning and management of the research, analysis and interpretation of the empirical data obtained, composition of the article according to the journal requirements, editing of the manuscript.

Vadim Yur'evich Gorelov – sampling, data collection, organization of empirical research, work with sources, writing the review part of the article, processing the results of psychodiagnostic techniques, design of the manuscript.

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Conflict of interest information

The authors have no conflicts of interest to declare.