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Tel./fax (495) 283–55-30
E-mail: izd.kredo@gmail.com

Founder address:
b. 11/9, Mokhovaya Str., Moscow, Russian Federation, 125009
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Russian Psychological Journal

Russian Psychological Journal is a peer-reviewed open access journal that publishes original research papers on all aspects of psychology.

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Modern motherhood in rural areas of Azerbaijan: career, family and values of upbringing

Olga V. Almazova[1]✉, Aidan A. Azimzade[2], Margarita V. Gavrilova[3], Murad A. Babayev[4]
[1, 3] Lomonosov Moscow State University, Moscow, Russian Federation
[2] Baku State University, Baku, Azerbaijan
[4] Bağçam, Baku, Azerbaijan

✉ almaz.arg@gmail.com

Annotation: **Introduction**. The desire of women to combine a professional career with the upbringing of children and to accelerate the development of a child with awareness of the normative stages of development are the characteristic features of modern motherhood. These traits manifest themselves differently in different socio-cultural conditions. The set scientific task was to trace how modern trends affect the ideas of raising children among mothers living in rural areas of Azerbaijan, which is overall a considerably unexplored problem. **Methods.** The research sample consists of 411 mothers of preschool children living in rural areas of Azerbaijan. Diagnostic material includes a questionnaire of parental beliefs about parenting (E. Hembacher, M. C. Frank), along with the author's questionnaire aimed at obtaining additional information about attitudes to motherhood and expectations from a child. **Results.** It has been established that Azerbaijani women are more focused on being wives and mothers, rather than engaging in professional activities. In matters of parenting, mothers trust older family members and specialists and do not trust Internet resources. The most preferred qualities for their children are: patriotism, respect for the elders and the desire to improve education and cultural level. The statements shared by the majority of Azerbaijani mothers living in rural areas regarding the upbringing of children are the following: "it is important to teach a child to obey and to respect elders"; "it is important to give children the opportunity to explore the world"; "it is necessary to read to a child and talk to them, even while they themselves cannot speak yet"; "parents should comfort children when they are scared or upset" and "parents should know what their child likes and dislikes", etc. **Discussion of the results**. Azerbaijani mothers of 3-7-year-old children living in rural areas do not seek to force the development of a child and are aimed at fulfilling their family roles. They have basic, but sometimes incomplete knowledge about the peculiarities of the development of preschool children.

Keywords: parenthood, maternal position, preschool age, forced development acceleration, upbringing, intuitive theories of upbringing, educational strategies, the value of parenthood, preferred qualities, early education

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Highlights:

- Azerbaijani mothers living in rural areas appreciate activities related to the upbringing of preschool children more than work and their own professional opportunities;
- Educational work on the normative and optimal development of preschool children in Azerbaijan is underway, but it does not concern all areas yet;
- There is no desire for forced acceleration of development in the upbringing and education of children in rural areas of Azerbaijan.

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Introduction

Distinctive features of modern parenting

Family is the primal institution of children's socialization. The most important source of development is communication with significant adults, primarily with parents (Lisina, 2009; Karabanova, 2008; Shishkova & Pervichko, 2020; etc.). Parents largely determine the social situation of the child's development, thereby setting the conditions for the formation of the child's psyche (Bozhovich, 2009; Veraksa, Veraksa, 2008; Rean, 2010). Preschool age is the subject of close study, because it is at this age that the foundation of all further human development is laid (Vygotsky, 1991; Elkonin, 1989; Filippova, 2002; Khomentauskas, 2006). In this regard, it is extremely important to know how the preschoolers' parents ideas ofupbringing are changing (Polivanova, 2015; Karabanova, 2019; Moskvicheva et al., 2019; Vasyagina, 2013; etc.). The changes taking place in societal life in the last 50 years have lead to the change in mothers' ideas of children upbringing.

Firstly, the appearance of a huge number of educational materials (books, lectures by psychologists, materials on the Internet, etc.) devoted to the norms, variability and harmony of the psychological development of a child, allows mothers to better navigate what is happening with the child, and timely seek advice and help from specialists when something goes wrong (Karabanova, 2019; Milovidov, 2021;Veraksa et al., 2021).

Secondly, modern parents often try to "invest" knowledge and skills in their child as early as possible, which can help them to be successful in later life. There are many resources that support this desire, and they encourage parents to teach their kids to read, write, count, etc. as early as possible (for example, Lazarev, 2009). However, psychologists are concerned about the desire to boost the development of the child, and point to the extinction of the child's learning motivation by the time they enter school and other risks, such as anxiety, mental tension and dissatisfaction with themselves (Starostina, 2015).

Thirdly, it is impossible not to note changes in the value orientations of women. More and more young women see it as important for themselves to build a professional career and continue its functioning, along with having children (Kuzmin et al., 2019). This leads to the fact that both the desired age of birth of the first child (the phenomenon of deferred parenthood) and the attitude to motherhood itself change. Karabanova O. and colleagues' study conducted on girls of student age, showed that only about a third of girls consider the maternal role to be a priority

and attractive to them, a quarter, with a generally positive attitude, think of having children after achieving a certain success in their career; the rest of the girls either perceive motherhood as a must (one tenth), or treat motherhood ambivalently (one fifth or reject the maternal role for themselves (one tenth) (Karabanova et al., 2018). The motivational focus of young women on self–development and self-realization goes with professional career as a priority, or, the combination of both family and professional careers. Their communication focus targets family career and parenthood (Zakharova et al., 2021).

To sum up, we note that in modern society, the following three features of maternal position are distinguished: (1) better awareness of the options for the normative psychological development of the child; (2) pronounced tendencies of excessive acceleration of child development; (3) women are trying to combine a full-fledged career and to fulfill their family role as a mother.

Intuitive theories of parenting

The variability in parents' behavior is largely explained by the ideas that they are guided by in the process of upbringing and educating their children (Eidemiller, Justickis, 2009; Karabanova, Molchanov, 2017). A set of these ideas forms an intuitive theory of education (intuitive theory) (Wellman & Gelman, 1992), which is created based onlife experience and overall knowledge possessed by the parent. Intuitive theories of education, like other intuitive theories, may not be fully realized (Deeva, 2020). Nevertheless, they largely determine the perception of information and decision-making in matters of children upbringing (Hembacher & Frank, 2016). Modern empirical studies have shown that these intuitive theories of parenting are reflected in the real behavior of parents (Hembacher & Frank, 2020). For example, those parents who are convinced that children who are given too much attention grow up to be spoiled, often turn out to be more restrained in communicating with theirchild. Which, in turn, affects the nature of interaction, emotional closeness and other aspects of child-parent relations.

Among the most relatable research tools in terms of content and goals are the AFE questionnaire (analysis of family education) (E. Eidemiller), the Russian language version of the parental attitudes questionnaire PARI, the parental attitude questionnaire PAQ (V. V. Stolin, A. Ya. Varga), and the questionnaire of child-parent emotional relationships QCPER (E. I. Zakharova). However, these tools often cover a broader area of the structure of family relationships and, in addition, most of them apply to the upbringing of older children.

In foreign research practice, the Early Parental Attitudes Questionnaire (EPAQ) (Hembacher & Frank, 2016, 2020), developed by Stanford University specialists, has become such a tool. The questionnaire contains three sections: affectionand attachment, early learning, and rules and respect, which are based on the fundamental theoretical principles of preschool children development and the results of modern research in the field of developmental psychology. The authors of the EPAQ questionnaire conducted a series of studies that confirmed the validity and reliability of the tool on a sample consisting of American parents (Hembacher & Frank, 2016, 2020). One of them demonstrated the connection of parental responses with the level of education and cultural roots (Hembacher & Frank, 2020).

Children upbringing in Azerbaijan

Azerbaijan is famous for its traditions. The birth of children, especially sons, in a young family is considered a great event. Before entering the house after the wedding, a young wife is often

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given to hold a little boy in her arms so that her first child is more likely to be a boy (Pchelintseva, 2001).

From infancy children are taught to respect and obey their elders and are accustomed to work. At the same time, from the earliest childhood, the duties of boys and girls are very different. Girls are encouraged to organize and maintain the household (cleaning and cooking), and boys are attracted to other household chores, such as harvesting livestock feed, or to participate in anything that would help them earn income later in life. Girls are usually involved in household duties from a younger age than boys are.For general comparison, the girls start taking care of tasks assigned to them from the age of 6-7 years old, while boys only start doing chores at 10-12 years old. In modern Azerbaijani families, the distribution of responsibilities between children of different genders may not be as rigidly divided as before. However, parents pay great attention to monitoring the performance of tasks in order to develop a responsible attitude in their children (Pchelintseva, 2001).

In many families of provincial towns and villages, children were taught crafts their parents did. In addition, special attention is paid to teaching boys how to make decisions and to act in uncertain situations (Mikailov, 2014).

In rural areas of Azerbaijan, women rarely receive higher education and the vast majority of them do not try to combine professional activity with family life. At the same time, psychological counseling centers are appearing in villages and cities, where mothers can apply for advice and assistance. The dramatically scarce amount of psychological studies does not allow us to determine the way modern Azerbaijani mothers view the goals and objectives of raising children. We also cannot determine whose opinion they are ready to listen to in the matter of children education and what qualities they would like their children to have.

The research aim was to identify the views of mothers of preschool children of Azerbaijan living in rural areas on the upbringing of children, in modern times. We chose Azerbaijani mothers living in rural areas as our sample, to see how traditional views on children upbringing, which Azerbaijan is famous for, are changing, influenced by the modern trends.

Methods

The Azerbaijani language version of Early Parental Attitudes Questionnaire (questionnaire of parental beliefs about parenting, EPAQ) (Hembacher & Frank, 2016) was used to identify aspects of intuitive theories of parenting among parents.The original structure of the questionnaire includes three scales covering various areas of intuitive theories of education. The first scale ("affection and attachment")contains questions on child-parent relationships and emotional interaction between the parent and the child. The second scale ("early learning") evaluates the parent's ideas on how necessary it is to integrate learning into play and preschoolers' free experimentation activities. Finally, the third scale ("rules and respect")is aimed at assessing the parent's ideas on how to control and reward the child's behavior. The questionnaire contains 24 statements (8 in each scale), with each of which the respondent is asked to express the degree of agreement on a 7-point Likert scale from 0 to 6 (where 0 – "completely disagree", 6 – "completely agree").

In addition, a custom questionnaire was used to identify the value orientations of mothers of preschoolers, the preferred qualities of their children and sources that they trust and do not trust in the matters of parenting.

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Sample

411 mothers of preschoolers living in rural areas of Azerbaijan took part in the research. Their children's age varied from 29 to 59 months old. (M = 48; SD = 7,3), with 216 (52,6 %) of them beingboysand 195 (47,4 %) being girls.

Socio-demographic characteristics of the sample

As part of the survey, additional data on the socio-demographic characteristics of families were obtained, namely: information on the number and age of children in the family; information on the age, professional employment and educational level of mothers; as well as subjective assessments of the level of family security and ideas about the future.

The age of mothers ranged from 21 to 26 years (43.0%), from 27 to 35 years (48.8%) and older than 36 years (8.2%). Among the study participants, 66.2% had general secondary education; 25.1% had specialized secondary education; 7.4% had higher education and 1.3% had incomplete higher education. Regarding professional employment, the answers were distributed as follows: 78.2% of mothers at the time of the research conduction were not working and were engaged in household work; 9% worked full-time; 7.4% worked on non-permanent conditions (from time to time); and the remaining 5.4% worked on a part-time basis. 7.9% of mothers rated the level of financial security of their families as low, 90.9% – as average, and 1.1% – as high. The participants of the study also answered the question about how they see their future: 93.1% of participants look at tomorrow with confidence and optimism; 6.6% of participants have doubts that their life will turn out well; 0.3% of participants are waiting for tomorrow with fear and pessimism.

Thus, according to such socio-demographic characteristics as age, level of education, professional employment, subjective assessment of the level of financial security of the family and assessment of the future, the data obtained is quite homogeneous. Most mothers of preschoolers in rural areas have secondary education, do not work or work on a part-time basis, while raising their preschool children, report theirfamily's financial prosperity as average and are optimistic about their future.

Results

Educational strategies and attitudes towards parenting

The questions asked to mothers regarding parenting can be divided into several blocks according to their meaning.

Parenting and career.Mothers of preschoolers were asked to express the degree of agreement with the statement "because of work, I miss the opportunity to raise a child." The answers were distributed as follows: completely disagree (65.2%); somewhat disagree (10.7%); find it difficult to answer (5.0%); somewhat agree (13.1%); completely agree (6.0%). Table 1 shows the distribution of responses of mothers of different ages to the above question.

With the χ^2 criterion, is was determined that the mother's age and the responses to this question are linked (χ^2 = 19,609; p = 0,012; Cramer's V = 0,163). Older mothers more often than younger ones think that career gets in the way of upbringing the children.

Another statement given to the mothers was: "because of the responsibilities associated with raising a child, I had to give up work and opportunities that I would prefer to use." The responses to this statement were distributed as follows: completely disagree (48.2%); somewhat disagree (12.1%); find it difficult to answer (10.8%); somewhat agree (12.1%); completely agree (16.6%).

Table 2 shows the distribution of responses of mothers of different ages to the above question.

Table 1

Distribution of responses of mothers of different ages to the question of how much a career hinders the upbringing of children

Answer	21–26 y.o.	27–35 y.o.	36–45 y.o.
Completelydisagree	72,7 %	59,8 %	56,7 %
Somewhat disagree	10,6 %	11,7 %	3,3 %
I find it difficult to answer	1,9 %	8,4 %	3,3 %
Somewhat agree	9,9 %	13,4 %	30,0 %
Completely agree	5,0 %	6,7 %	6,7 %

Table 2

Distribution of responses of mothers of different ages to the question of how much a career hinders the upbringing of children

Answer	21–26 y.o.	27–35 y.o.	36–45 y.o.
Completely disagree	55,1 %	44,1 %	40,0 %
Somewhat disagree	7,6 %	16,2 %	10,0 %
I find it difficult to answer	8,2 %	11,2 %	23,3 %
Somewhat agree	12,0 %	11,7 %	13,3 %
Completely agree	17,1 %	16,8 %	13,3 %

With the χ^2 criterion, is was determined that the mother's age and the responses to this question are *not* connected (χ^2 = 13,422; p = 0,098; Cramer's V = 0,135).

From the answers to these two questions, the following can be concluded: (1) a professional career is not an obstacle to raising a child; (2) older mothers are more likely to admit that work can possess a problem for raising children; (3) the duties of children upbringing interfere with work duties to a greater extent than vice versa.

Considering the answers to the given questions as rank variables, using the Spearman correlation coefficient, one can make sure that the estimates are connected by a statistically significant weak connection ($r = 0.301$; $p < 0.001$). The more mothers believe that taking care of a child interferes with building a career, the more they think that work interferes with the upbringing of a child.

Sources of information. Mothers were asked which sources of information (no more than three options) they are ready to turn to when having difficulties with raising children, and what sources they doubt. Table 3 shows the results.

Table 3

Distribution of mothers' answers to questions about sources of information about parenting that they trust or doubt

Sources of information	Trust	Doubt
Friends and acquaintances	36,6 %	27,3 %
Internet sources	10,4 %	41,1 %
Books and magazines	30,0 %	9,8 %
Personal consultations with specialists	55,6 %	5,8 %
Educational courses and events	12,5 %	6,1 %
Radio	1,3 %	28,9 %
Video resources on the Internet	17,2 %	47,2 %
Religious organizations and mentors	4,2 %	36,9 %
Social media, Internet forums	7,3 %	39,5 %
Elder family members	66,8 %	10,9 %
TV	5,7 %	16,4 %

To Azerbaijani mothers, "older family members", "personal consultations with specialists", "friends and acquaintances" and "books and magazines" are the most trustworthy resources, while "video resources on the Internet", "online publications", "social networks and forums on the Internet" and "religious organizations and mentors" are seen as doubtful.

Using the criterion $\chi 2$, we checked whether the age of mothers is related to their doubt or trust towards different sources of information.

Regarding trust: the relationship between the age of mothers and trust in friends and acquaintances in matters of parenting was obtained ($\chi 2 = 7{,}671$; $p = 0.021$; Cramer's $V = 0.144$). Thus, 43.6% of mothers aged 21 to 26 years are inclined to trust, and 56.4% – to not trust friends and acquaintances in matters of parenting; 30.2% of mothers from 27 to 35 years trust, and 69.8% – do not trust friends and acquaintances in these matters; 46.7% of mothers from 36 to 45 years trust, and 53.3% – do not trust friends and acquaintances in matters of parenting. Mothers aged 27 to 35 are the least likely to trust the advice of friends and acquaintances in the matters of raising children.

Regarding doubt: a relationship was obtained between the age of mothers and how questionable such a source of information as religion is for them in matters of parenting ($\chi 2$ = 8,218; p = 0.016; Cramer's V = 0.151). 45.0% of mothers from 21 to 26 years doubt, and 55.0% do not doubt religion as a source of information; 30.2% of mothers from 27 to 35 years doubt, and 69.8% – do not doubt religion as a source of information; 31.0% of mothers from 36 to 45 years doubt, and 69.0% – do not doubt religion as a source of information in matters of parenting. Thus, mothers from 21 to 26 years of age consider religion to be a dubious source of information in matters of raising children.

Preferred qualities. We asked mothers of preschoolers, from the list of 10 qualities, to choose no more than three that their child should have when he grows up. Table 4 shows the distribution (percentage of respondents) of the study participants according to the preferred qualities of the child in the whole sample and separately for boys and girls; the result of assessing the relationship between the variables "gender" and "choice / non-choice" of a quality as preferred (criterion $\chi 2$) is presented.

Table 4

Percentage of mothers who chose the preferred quality of the child, for the entire sample and separately for boys and girls; the relationship between gender and choice of a certain quality (or the lack of it)

Personalquality	All	Boys	Girls	χ^2	p
Strong will (perseverance, endurance, purposefulness)	39,8 %	40,4 %	39,1 %	0,064	0,800
Kindness, responsiveness	41,6 %	43,8 %	39,1 %	0,882	0,348
Patriotism	66,4 %	68,0 %	64,7 %	0,473	0,492
Religiosity	7,5 %	7,9 %	7,1 %	0,093	0,761
Strife to improve education and cultural level	45,0 %	44,8 %	45,1 %	0,003	0,956
Strife to improve personal abilities	12,1 %	11,3 %	13,0 %	0,266	0,606
Respect for the elders	45,0 %	43,3 %	46,7 %	0,448	0,503
The ability to achieve a high financial position	2,8 %	3,9 %	1,6 %	1,866	0,172
Ability to defend one's personal of view	20,2 %	19,2 %	21,2 %	0,236	0,627
The ability to adapt to a situation	7,0 %	6,0 %	8,2 %	0,701	0,402

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"Patriotism", "respect for elders" and "the desire to improve the educational and cultural level" were the most desired personal qualities for children. The most disliked were "the ability to achieve a high financial position", "religiosity" and "the ability to adapt to any situation".

Gender turned out to be unrelated to any of the preferred qualities: this means that in Azerbaijan there is no difference in mothers' preference for qualities from the list for boys, or girls.

Intuitive theories of parenting

We would like to note that the EPAQ questionnaire (Hembacher& Frank, 2020) (author's translation) was used to identify intuitive theories of education.

Since D. Bukhalenkova and her colleagues (Bukhalenkova et al., 2021) have revealed that the EPAQ-R variant they obtained does not yet meet all the requirements of internal validity, and the model obtained with the help of confirmatory factor analysis is of low accuracy so far, we, having also received unsatisfactory results of internal validity verification, will not use scales. With the way V. Serkin (Serkin, 2004) proposed to distinguish universals for the semantic differential, we will proceed with the questionnaire questions to identify the universals of intuitive theories of education in Azerbaijan in the same manner. To do this, we recall that the answers 0, 1 and 2 mean disagreement with the statement to varying degrees (analogs -3, -2, -1 in the classical bipolar semantic differential), 3 – a neutral variant (analog 0 in the classical bipolar semantic differential), and 4, 5, 6 – agreement to varying degrees (analog 1, 2, 3 in the classical bipolar semantic differential). Then, if the sum of the frequencies of "disagreement" responses to the answer is more than 75% of the sample, we can say that the universal is the negation of a statement. And if the sum of the frequencies of "agreement" responses to the answer is more than 75%, we can say that the statement itself is the universal.

The scale of "Emotions and affection". The reliability of the instrument was assessed by analyzing the internal consistency of the questionnaire scales using the Cronbach's alpha method. For the first scale "emotions and attachment", the Cronbach's α index was 0.443 (< 0.700), which indicates an unsatisfactory level of internal consistency of the scale. A slight increase in the internal consistency of the scale (up to 0.495) would be possible if the item "children who are close to their parents subsequently create stronger relationships" was excluded.

Table 5 presents descriptive statistics of assessments of questions on the "emotions and attachment" scale and the frequency of agreement, disagreement and neutral assessments.

Table 5

Descriptive statistics of questions on the scale of "emotions and affection" of preschoolers' mothers

Question	M	SD	–	0	+
2. Children can grow up weak if shown too much love; for example, hugging and kissing them too often	2,80	2,505	45,7 %	8,2 %	46,1 %
7. It is important for parents to teach their children how to control their emotions	5,13	1,473	6,0 %	4,9 %	**89,1 %**

Question	M	SD	–	0	+
8. Children who are close to their parents subsequently create a stronger relationship	4,50	1,964	14,7 %	13,4 %	71,9 %
11. Parents should not comfort a child if they are worried or upset. It is more useful to give them the opportunity to learn to calm down on their own	2,31	2,394	54,7 %	8,1 %	37,2 %
12. There is no necessity for emotional closeness between aparentand their child. What is most important, is that the child is safe	1,66	2,247	68,0 %	6,3 %	25,7 %
16. When children are sad or upset, they need to be comforted	5,19	1,737	9,3 %	1,5 %	**89,2 %**
19. If parents pay too much attention to their kids, they grow up to be spoiled	3,73	2,468	29,5 %	7,4 %	63,1 %
24. Parents should know what their child likes and dislikes	5,61	1,047	4,0 %	5,2 %	**90,8 %**

The following statements are universal in intuitive theories of parenting concerning "emotions and attachment" for Azerbaijani mothers of preschoolers: " It is important for parents to teach their children how to control their emotions," " when children are sad or upset, they need to be comforted," and "parents should know what their child likes and dislikes."

The "Early Learning" scale. The reliability of this instrument was assessed by analyzing the internal consistency of the questionnaire scales using the Cronbach's alpha method. For the first scale ("emotions and attachment"), the Cronbach's α index was 0.529 (< 0.70), which indicates an unsatisfactory level of the scale's internal consistency. An increase in the internal consistency of the scale (up to 0.610) could be possible if the item "small children can learn a lot by just playing" was excluded.

Table 6 presents descriptive statistics of assessments of the questions of the "early learning" scale, and the frequency of agreement, disagreement, and neutral opinions.

The following statements are universal in intuitive theories of parenting concerning "early learning" for Azerbaijani mothers of preschoolers: "to give children the opportunity to experiment and to explore the world is the right thing to do", " Parents could prepare their children for school, so they can study better. They could teach them to count, or to distinguish geometric shapes", "by talking to babies, parents can teach them to speak" and "it is necessary to read books to a child while they themselves cannot speak yet".

The "Rules and Respect" scale. The reliability of this instrument was assessed by analyzing the internal consistency of the questionnaire scales using the Cronbach's alpha method. For the first scale "emotions and attachment", the Cronbach's α index was 0.422 (< 0.70), which indicates an unsatisfactory level of internal consistency of the scale. A slight increase in the internal consistency

of the scale (up to 0.453) would be possible if the item "small children should be able to make independent decisions, for example, what to play and when to eat" was excluded.

Table 6

Descriptive statistics of questions on the scale of "early learning" of preschoolers' mothers

Question	M	SD	–	0	+
3. To give children the opportunity to experiment and to explore the world is the right thing to do	5,60	0,985	2,9 %	2,5 %	**94,6 %**
5. Parents could prepare their children for school, so they can study better. They could teach them to count, or to distinguish geometric shapes	5,22	1,532	8,1 %	7,8 %	**84,1 %**
9. By talking to babies, parents can teach them to speak	5,33	1,399	6,2 %	5,0 %	**88,8 %**
10. There is no need to teach children numbers and counting before school	1,49	2,076	71,9 %	8,7 %	19,4 %
13. There is no point in reading books to children, while they cannot talk yet	1,33	2,183	**75,1 %**	4,6 %	20,3 %
14. There is no reason in teaching a child to obey a certain rule, while they still cannot understand the explanations	2,01	2,192	57,7 %	15,7 %	26,6 %
21. Little children could learn a lot just by playing	3,32	2,431	36,2 %	11,1 %	52,7 %
22. Little children cannot learn anything about the world, until they learn to speak	1,97	2,401	62,4 %	7,3 %	30,3 %

Table 7 presents descriptive statistics of assessments of the questions of the "rules and respect" scale and the frequency of agreement, disagreement and neutral assessments.

Table 7

Descriptive statistics of questions on the "rules and respect" scale

Question	M	SD	–	0	+
1. Parents should not worry if their child behaves badly often	1,40	2,197	73,9 %	6,7 %	19,4 %
4. It is very important that the violation of agreements or significant and insignificant rules established by parents has consequences for the child	4,55	1,644	9,0 %	17,6 %	73,4 %
6. It is normal for a small child to boss around their parents or other guardians	1,51	2,195	69,0 %	9,5 %	21,5 %
15. It is very important for children to learn to respect their elders: parents, teachers	5,68	1,015	3,0 %	0,7 %	**94,3 %**
17. Small children should be able to make independent decisions, for example, what to play and when to eat	3,49	2,476	34,7 %	7,3 %	58,0 %
18. It is normal if a child communicates with adults on an equal footing, instead of treating them with respect	1,90	2,125	61,0 %	15,0 %	24,0 %
20. Children should be grateful to their parents	4,61	1,891	13,0 %	14,8 %	72,2 %
23. It is very important that small children obey the adults; for example, they wait if they are told to wait	4,73	2,120	15,5 %	3,5 %	**81,0 %**

In intuitive *theories* of education, in regards to "rules and respect", the following statements are universal for Azerbaijani mothers: "it is very important for children to learn to respect their elders: parents, teachers", "it is very important that small children obey the adults; for example, they wait if they are told to wait".

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Discussion

Most mothers of Azerbaijani preschoolers living in rural areas do not have higher education and have not returned to professional activity. At the same time, most of them do not believe that raising a child interferes with having a career or vice versa. Family life and the responsibilities of a wife and mother are still a priority for Azerbaijani women from the regions. We cannot talk about the desire of these women to build both professional and family careers at the same time.

The sources of information trusted and doubted by mothers from rural areas of Azerbaijan in matters of raising children are also determined by cultural specifics. For example, a high degree of trust towards elder family members fits very well into traditional ideas about the way of life of the family in Azerbaijan (Mikayilov, 2014). At the same time, distrust of Internet sources and, on the contrary, trust in specialists (psychologists, teachers, etc.) speaks about the ongoing educational work of our colleagues.

Mothers of preschoolers called the most frequent desirable qualities of a child "patriotism" and "respect for elders", and the least desirable qualities were: "the ability to adapt" and "the ability to achieve a high financial position", which also indicates the orientation of mothers to the traditional values of Azerbaijani culture.

Somewhat unexpected is the result that there are no differences in the preferred qualities of female and male children. Although this does not contradict the statements of historians and teachers about the fact that both duties and expectations from sons and daughters are different in Azerbaijani families (Pchelintseva, 2001) directly, in our opinion, they still indicate some changes over the past 20 years in the perception of differences inresults of upbringing of boys and girls.

The questionnaire aimed at the identification of intuitive theories of education in general has not yet passed the validity test, as well as the Russian sample (Bukhalenkova et al., 2021). At the same time, the results of checking internal reliability on scales in studies on Russian and Azerbaijani mothers are very similar. This result may be caused by cultural specifics. For example, in the USA, where this questionnaire was developed, the practice of raising and teaching preschool children differs significantly from Russian and Azerbaijani practices due to social, cultural and economic factors. Taking about Azerbaijan in particular, there, a mother often does not return to professional activity after the birth of a child (Pchelintseva, 2001), in Russia, maternity leave lasts from two to three years, while in the USA its duration is only 12 weeks (if the parents work in an organization with more than 50 employees) or is absent altogether (Jou et al., 2018; Bernstein et al., 2017). These and other socio-economic factors form intuitive ideas about the upbringing of children.

The analysis of intuitive theories of upbringing of Azerbaijani mothers revealed universals concerning different aspects of upbringing: emotions, early learning and rules.

The universals concerning "respect and rules" turned out to be the most predictable. They emphasized the importance of teaching a child to obey and respect elders, which is well combined with the specifics of Azerbaijani culture and traditions (Pchelintseva, 2001).

Universals in intuitive theories of education concerning "early learning" for Azerbaijani mothers of preschoolers are statements saying that it is important to give children the opportunity to explore the world, it is necessary to read and talk to the child, even while they themselves cannot yet speak. In addition, most moms are sure that parents can prepare their children for school by teaching them counting and geometric shapes. At the same time, not all mothers of preschoolers understand that a preschool-age child can learn a lot by just playing. It can be assumed that

although there is no early desire to boost the development of the child, mothers from provincial towns and villages of Azerbaijan lack knowledge about the importance of different types of activities for the harmonious development of the child (Starostina, 2015).

Universals in intuitive theories of education concerning "emotions and attachment" for Azerbaijani mothers of preschoolers are embodied in the importance of teaching children to control their emotions, while parents should comfort children when they are scared or upset and know what their child likes and dislikes. At the same time, there is no unanimity in the idea that the nature of the relationship with parents is related to the nature of the child's further relationship with a romantic partner, which also indicates the lack of psychological information.

Based on the results of the analysis, the following conclusions can be drawn regarding modern motherhood in the regions of Azerbaijan:

1. Mothers are primarily aimed at fulfilling family roles (wives and mothers), instead of professional ones.

2. Although the work on psychological education of mothers about age norms, variability and conditions of optimal development of the child is clearly underway, it does not yet connect with all areas necessary. For example, Azerbaijani mothers living in rural areas have only a partial idea of how important playing is for the development of a child in their preschool age.

3. There is no pronounced desire to boost the cognitive development of the child. Moreover, mothers are more focused on fostering patriotism in children, respect for elders and the desire to develop their cultural level, rather than the ability to adapt and/or achieve material benefits.

Limitations and directions of further research

We see thecontinuation ofadditional questionnaire editing for further determination of intuitive theories of education as one of the main areas of research. A comparative analysis of the views on the children upbringing, with mothers of preschoolers from large cities of Azerbaijan and the province on the one hand, and mothers from Azerbaijan and Russia on the other, will reveal both cultural and territorial (city/village) specifics.

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Author Contribution

Olga Viktorovna Almazova - theoretical review, description of empirical data, correction of conclusions.
Aidan Altai kyzy Azimzade – research organization and data collection.
Margarita Nikolaevna Gavrilova - statistical data analysis.
Murad Azad oglu Babayev – curator of the study.

Author Details

Olga Viktorovna Almazova – Candidate of Sciences in Psychology, Associate Professor, Lomonosov Moscow State University, Moscow, Russian Federation; Scopus Author ID: 56925565700, ResearcherID: S-1047-2016, SPIN: 9410-4142, ORCID: https://orcid.org/0000-0001-8852-4076, e-mail: almaz.arg@gmail. com
Aidan Altai kyzy Azimzade – doctoral student, Baku State University, Baku, Azerbaijan; ORCID: https://orcid.org/0000-0002-8558-162X, e-mail: aydan.azimzade@inbox.ru

Margarita Nikolaevna Gavrilova – Candidate of Sciences in Psychology, Junior Researcher, Lomonosov Moscow State University, Moscow, Russian Federation; Scopus Author ID: 57209637887, ResearcherID: AAR-6654-2020, SPIN: 6955-9705, ORCID: https://orcid.org/0000-0002-8458-5266, e-mail: gavrilovamrg@gmail.com
Murad Azad oglu Babayev - child development specialist, Bağçam, Baku, Azerbaijan; ORCID: https://orcid.org/0000-0003-1251-6496, e-mail: babayevmurad.az@gmail.com

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Conscious Perception: Discreteness vs. Continuity

Daria I. Kostina[1]✉, Margarita G. Filippova[2], Mikhail V. Allakhverdov[3] , Victor M. Allakhverdov[4]
[1, 2, 3, 4] St. Petersburg State University, St. Petersburg, Russian Federation

✉ d.kostina125@gmail.com

Abstract: **Introduction**. Is perception discrete or continuous? This question has a long history, but in the light of experimental data obtained in recent years, it is gaining relevance again. The available models rely on different understandings of discreteness, and they highlight different units of discrete perception. **Theoretical justification**. This article reviews the development of discrete models of perception and discusses the various theoretical evidence for discreteness of perception. **Results and discussion**. The article provides a review of experimental studies supporting discrete models and their general critique. The results of the latest studies support the idea that it is precisely conscious perception that is discrete, while unconscious information processing can be continuous or carried out with higher temporal resolution. The authors compare two popular contemporary approaches to discrete perception. One approach assumes that the discrete unit of perception is relatively small and related to temporal resolution, but that it is not universal - discretization can occur at different frequencies, for example, for different modalities. The second approach associate's discretization with the need to calculate the most meaningful interpretation of incoming data. The discrete unit in this approach (the time window of unconscious processing) is universal, but its duration is not fixed and depends on the nature of incoming data. Authors also propose an alternative approach based on V. M. Allakhverdov's negative choice theory, which implies the existence of the unconscious processing window, the duration of which is not constant. This approach suggests a novel idea that the duration of the window depends on the complexity of control operations, the goal of which is to select information for conscious processing. Authors discuss the capabilities of this approach to explain the temporal dynamics of priming and the attentional blink effects where the difference in the duration of discrete window can be seen as the manifestation of the general logic of discretization.

Keywords: discrete perception, visual perception, perceptual moment, postdictive effects, integration window, consciousness, negative choice, priming effects, negative priming, EEG oscillations

Highlights:

▹ Recent data indicate that the duration of a discrete unit of conscious perception can be up to several hundred milliseconds.

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- Discretization at the level of unconscious processing has higher frequency.
- According to the approach we develop, discretization at the level of conscious perception appears because of the need to control the prepared representation for them to become conscious.
- The complexity of the control operations performed before awareness affects the duration of the unconscious processing window.
- Таmhe idea that the duration of the «window» depends on the complexity of control operations has the potential to explain the temporal dynamics in a number of experimental effects, such as the masked priming effect or the attention blink effect.

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Introduction

When we perceive something consciously (e.g., movement), how does the content of our consciousness change over time? Is it updated continuously or discretely (at certain moments)?

The problem of temporal organization of perception has been on researchers' minds since antiquity (see Zeno's Arrow paradox) till the present day. However, over time and with the change of paradigms scientists focused on different issues of the problem. Dainton (2018) formulates the basic version, which has occupied philosophers for centuries, in this way: it seems that we can be directly aware of only what is in the present and, therefore, our awareness must lack temporal depth. But how, then, can we directly perceive changes in objects? Some of the possible answers suggest that, despite the subjective experience of perception as a continuous flow, the process requires some discreteness.

In cognitive psychology due to emergence of the recent experimental data in support of discrete models the issue of perceptual discreteness has become a hot topic once again (e.g., Herzog et al., 2016; White, 2018; Fekete et al., 2018; Doerig et al., 2019). In this article we will attempt to justify the logical necessity of discretizing the perceptual process and review the main theoretical and empirical arguments in favor of discrete models. We will also look at the criticisms of the available models of discrete perception and propose a possible mechanism of discrete perception, which we believe takes into account the shortcomings of other models.

Let's begin with understanding what is meant by discreteness and continuity. The question of perceptual discreteness in a general sense is whether perceptual images arise continuously or at particular moments in time (Doerig et al., 2019). Miller (1988) notes that when we talk about information processing by a cognitive system, a strict mathematical definition of discreteness and continuity inaccurately describes their distinction, so it is more appropriate to separate these processes based on the size of the discrete units rather than on the very fact of their existence. It is possible to regard some process as continuous, even if at the level of its neural mechanism it is discrete in the strictest sense, i.e. the discretization unit is extremely small. Thus, the fact

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that perception is based on discrete (impulsive) brain activity is not enough to define perception itself as a discrete process.

Understanding what exactly a discrete unit is when we talk about conscious perception varies depending on the approach. Dainton (2018) identifies three main groups of philosophical theories on the temporal organization of perception: Cinematic Models, Retentional Models and Extensional Models. Cinematic models assume that the 'stream of consciousness' consists of a continuous sequence of static 'snapshots'. In Retentional Models units are 'episodes', which lack temporal extension, but involve integration of new incoming data with the previous data, thus, representing the time changes in objects' properties. As noted by Herzog et al. (2020), temporal characteristics of objects within these models are encoded in a non-temporal format, similarly to other features such as shape or color. A third group of models – Extensional Models – argues that episodes of consciousness are themselves extended in time, so time changes can be represented directly. Considering both philosophical and psychological models, Herzog et al. (2020) add a discreteness parameter to this classification, noting that all three types of models can assume both discreteness and continuity of perception.

The discrete cinematic approach assumes that perception is discrete if the evaluation of two events as sequential or simultaneous depends not only on the temporal interval between them, but also on the correlation of their presentation to some discrete neural process (VanRullen & Koch, 2003). In an alternative approach (Herzog et al., 2020) discreteness is not based on the sequential/simultaneous perception, but on how the data integration occurs prior to emergence of perceptual image: within a discrete time window (discrete retentional models) or continuously, within a sliding time window (continuous retentional models) (Herzog et al., 2020).

Theoretical justification

Development of the idea of discrete perception

We start with looking at factors that led to the popularity of discrete models in the first half of the 20th century. The development of discrete models is discussed: from the classical Stroud (1967) model to modern approaches that recognize the possibility of simultaneous discrete sampling with different frequencies (VanRullen & Koch, 2003; VanRullen, 2016). The paragraph concludes with the two-stage model of M. Herzog and colleagues (Herzog et al., 2016; Herzog et al., 2020), which combines the strengths of both discrete and continuous models.

The idea of discrete perception has gained and lost popularity several times during its existence. After the philosopher C. E. Baer explicitly proposed the idea in the nineteenth century (VanRullen, 2018), it soon received first experimental confirmations. For example, experiments showed that people perceive two stimuli presented consecutively at the same position as one if the time interval between them is less than a certain threshold, and as two if the interval exceeds the threshold (in Sokoliuk & VanRullen, 2019) (later it was also explained without the discreteness assumption, see section «A Critique and Defense of Discrete Models,» - *author's note*). Similarly, the phi-phenomenon was demonstrated (in Schultz, Schultz, 2002). The idea of discrete perception became widespread in the early 20th century (see VanRullen, 2018; White, 1963), facilitated by the appearance of the cinematograph (which became a metaphor for the perceptual process), and the discovery of alpha rhythm (which scientists immediately tried to link to the cyclic processes that go with perception (see Harter, 1967)).

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The spread of computer metaphor has also contributed to the popularity of discrete models. For example, J. M. Stroud, author of one of the influential models of discrete perception, suggests that the human brain, like a computer, «solve logical problems by a finite number of steps in a limited time», which defines the necessity discreteness of information processing (Stroud, 1967, p. 625). Psychological time, according to the model proposed by Stroud, is discrete and consists of perceptual moments, each of which is equal to approximately one hundred milliseconds (however, he believes that this value may vary within the range of 50-200 ms). Within one such moment all information about temporal parameters, such as duration and order of appearance of stimuli, is lost. If from the point of view of physical time such a «moment» has a certain duration, from the point of view of psychological time it is the minimal unit devoid of any temporal length. Using classification proposed above, this model represents discrete cinematic models.

J. M. Stroud relates the duration of the perceptual moment to the perception of motion. It is assumed that motion in a film is perceived as motion if at least one frame of the film is presented at one such «moment». This distinguishes the J. M. Stroud's model from modern cinematic models, where it is assumed that motion can be represented within a single «moment», despite its static nature, because at the neural level any motion is encoded (similarly to the features of static objects) as the firing rate of the corresponding detector neuron (Crick & Koch, 2003).

A similar concept to J. M. Stroud's model of discrete units of perception universal for all modalities was proposed by Pöppel (1997, 2009). The duration of such units is 30-40 ms, and it is assumed that within its frame all events are perceived as simultaneous. Processing information with higher temporal resolution is possible (when, for example, one needs to localize sound in space), but for events to be perceived as sequential, they must be part of two separate units. One current approach, developing the ideas proposed in early discrete cinematic models, also links discretization to the temporal resolution of perception and states that all temporal information is lost within a single perceptual moment (e.g., VanRullen & Koch, 2003; VanRullen, 2016; Schneider, 2018; Ronconi et al., 2018). Following J. M. Stroud, VanRullen and Koch (2003) suggest that the duration of perceptual moment (i.e., the frequency with which the brain mechanism responsible for discrete perception operates) varies depending on the perceptual characteristics of the stimulus, observer's attention and the characteristics of the task. However, an important difference from the earlier models is the rejection of the idea that the perceptual moment, even if it has flexible duration, is a universal unit of perception. They argue that discrete sampling can happen simultaneously with different frequencies (e.g., for different modalities or for different perceptual features) (VanRullen & Koch, 2003; VanRullen, 2016).

In recent years researchers obtained a lot of new evidence of discrete perception, which allows to clarify previously proposed and criticized models. One of the modern approaches developing the idea of discrete perception, which claims to resolve the contradictions of the previous theories, was proposed by M. Herzog and colleagues (Herzog et al., 2016; Herzog et al., 2020). In this approach discreteness of perception is associated with the need to integrate information over time and, most importantly (since integration itself can also be carried out continuously) – with the construction of a meaningful interpretation of the gathered data (and this is necessarily a discrete process).

They proposed that discrete awareness is preceded by a period of unconscious processing, the duration of which may vary depending on the characteristics of the incoming information. Moreover, most of this time is required not for feature detection, but for identifying the best interpretation.

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Using the classification, we provided in the previous paragraph, the model of M. Herzog and colleagues refers to discrete retentional models. In this approach the size of the unconscious processing window is not directly related to temporal resolution - although the content of consciousness is discretely updated, temporal parameters (such as duration or sequence of stimuli presentation) are not lost as in cinematic models but are encoded in a non-temporary form similarly to attributes like color or shape. As the authors write: «...40-ms stimulus is not continuously perceived during the 40 ms when it is presented. <...> Rather, the duration is encoded as, for example, the output of a duration detector» (Herzog et al., 2020, p. 833). In this case, all properties enter the consciousness simultaneously as part of a single coherent image of perception regardless of how their analysis took place.

Experimental data of M. Herzog and colleagues show that the duration of a discrete processing window can reach 450 ms, i.e., awareness can occur with approximately such a delay. The proposed model does not impose any logical limits on the possible duration of such windows. The authors note, however, that longer windows may be required in situations where incoming data have multiple meanings or a lot of noise. They argue that a typical window duration of 300-400 ms may be optimal: long enough to compute a single-meaning interpretation, but small enough to allow a timely response to the received data. At the same time the authors note that simple automatic reactions can take place even before full processing and comprehension are complete and conscious percept is formed.

What is the purpose of discretization?

This paragraph reviews various theoretical justifications for discrete perception, such as the presupposition of a greater efficiency of discrete processing (VanRullen & Dubois, 2011; Chota & VanRullen, 2019); reduced uncertainty associated with different speed of processing different types of information (Pöppel, 2009), the need to build meaningful and unambiguous interpretation of incoming data (M. Herzog and colleagues, B. J. Baars, V. M. Allakhverdov) and verification of the chosen interpretation before awareness (V. M. Allakhverdov).

Starting with the same question of whether conscious perception is continuous or composed of discrete units, authors from different approaches theorize differently in favor of discreteness (e.g., VanRullen & Koch, 2003; Chakravarthi & VanRullen, 2012; Herzog et al., 2020).

In the approach developed in early cognitive psychology, discretization was justified by the assumption of the logical nature of information processing in the brain (Stroud, 1967). The argument in favor of discrete algorithms was their potentially greater efficiency (Harter, 1967; Shallice, 1964).

The authors of one of the current approaches (VanRullen & Dubois, 2011; Chota & VanRullen, 2019) also appeal to the higher efficiency of discrete processing: instead of processing incoming data continuously, the visual system divides it at a certain frequency, testing the environment for changes. The continuous stream is broken down into discrete portions, which then are processed further.

A different approach is suggested by Pöppel (2009), arguing the need for discretization in terms of the temporal perception issues. E. Pöppel points out the problem: the speed of information transferring and processing differs for different modalities and different types of information within one modality. For example, auditory and visual information reaches the central structures in the brain at different rates. So, E. Pöppel suggests that to minimize uncertainty the brain uses

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neural oscillations – all data received within one period unites into one block and treated as simultaneous (i.e. one period of oscillations sets one «perceptual moment», - *author's note*).

When talking about efficiency, different authors generally do not explicitly distinguish between unconscious processing and the process of updating conscious information. At the same time, considerable evidence suggests that information can be processed with higher temporal resolution at the unconscious level than at the conscious level (see Elliott & Giersch, 2016), but the rationale in terms of computational efficiency or uncertainty reduction does not explain why an additional reduction in resolution occurs when moving from unconscious to conscious processing.

Another alternative hypothesis is proposed by Chota (2020): discretization of information may be important for executing predictive coding algorithms, allowing comparison of incoming data with the predicted one.

Within the approach developed by M. Herzog and colleagues (Herzog et al., 2016; Herzog et al., 2020), discretization at the level of conscious perception is associated with the need to construct a meaningful and unambiguous interpretation of incoming data, which is impossible if the incorporation of new information and changes in conscious contents occurs continuously (see «Critique and defense of discrete models»). Similar ideas are also expressed by Elliott & Giersch (2016). The proposed approach is consistent with the inferences of other authors who arrive at the necessity of discrete processing of information, because it is necessary to verify the results of processing for their further use. For example, Baars (1988) gives the following example: if we consider A + B = C, and C + D = E, then we cannot perform the second action without having performed the first action in the previous step and without verifying the correctness of the task. V.M. Allakhverdov (2021) expresses a similar idea. He suggests that before information gets into consciousness, we need to check the unconsciously prepared representations for coherence and inconsistency. Such verification is impossible if representations were constantly changing by the new data.

Thus, it is theoretically possible to assume that perception should be discrete, but it is necessary to understand the execution of the process in much more detail. For this purpose, let us consider some of the main directions of research that have contributed to the development of the idea of discrete perception.

Results and discussion

Recently, researchers have provided more and more data supporting discrete models of perception. It is possible to distinguish several directions of research.

Studies of perceptual rhythms caused by EEG oscillations

This section presents experimental evidence for a correlation between EEG oscillations and cyclic changes in perception. Hypotheses suggesting a relation between EEG rhythms and the mechanisms providing discrete perception are considered.

EEG oscillations are often attributed to the functioning of the neural mechanism underlying discrete perception (e.g., Valera et al., 1981; VanRullen, 2016). When researchers discovered alpha rhythm first hypotheses relating to discrete perception were almost immediately to follow. Thus, W. Pitts and W. S McCulloch in 1947 proposed the idea of «cortical scanning» (cyclic sequential activation of cortical areas) underlying the algorithm for shape recognition and linked this process

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to the alpha rhythm (in this model such cyclic sequential activation is added to the activation caused by specific afferents, allowing the latter to cross the threshold. N. Winner, who developed a similar model, compared this process with the process of image processing in a television set based on a telescope (according to Harter, 1967), - *author's note*). Expanding on this idea, J. M. Stroud designated one time period of the scanning as one discrete «moment» (according to Harter, 1967). An alternative hypothesis, which appeared at the same time, suggested that alpha oscillations reflect cyclic changes of cortical excitability (Lindsley, 1952), which may also influence perception, including structuring it in time (Harter, 1967). This idea, in contrast to the «scanning» concept, is still relevant today (e.g., Mathewson et al., 2009; Milton & Pleydell-Pearce, 2016).

There has been exceeding evidence of a connection between brain rhythms and cyclic changes in the process of perception. The phase of EEG oscillations before the appearance of stimuli correlates with the specifics of reaction to the stimuli in a variety of perception and attention tasks. Moreover, this relationship has been observed most frequently for alpha and theta frequency ranges (Alpha rhythm has been associated with discrete sampling in sensory processing, and theta rhythm with attentional sampling (VanRullen, 2016), - *author's note*) (see reviews: VanRullen et al., 2011; VanRullen, 2018; Haegens & Golumbic, 2018). Researchers demonstrated this relation for reaction speed (e.g., Callaway & Yeager, 1960; Drewes & VanRullen, 2011), for the probability of identification near-threshold and masked stimuli (Busch et al., 2009; Mathewson et al., 2009; Busch & VanRullen, 2010; Fiebelkorn et al., 2013; Zhou et al, 2021) and the likelihood of seeing the TMS-induced phosphene (Fakche et al., 2022), for performance in visual search tasks (Dugué et al., 2015), for the extent to which stimulus perception is determined by previously formed expectations (Sherman et al., 2016), etc. In addition, there are many studies demonstrating rhythmic fluctuations in behavioral measures such as stimulus recognition accuracy and reaction time (e.g., Dehaene, 1993; reviewed by VanRullen, 2018).

Do these data confirm the existence of discrete perceptual units? Periodic changes in the accuracy of recognition of a briefly presented stimulus may indicate that when it appears in a certain phase of the period, it falls between two perceptual moments and is therefore not perceived (VanRullen, 2018). However, there is an alternative explanation: perception is not discrete, but only subject to rhythmic modulations, which are related, for example, to changes in neuronal excitability (VanRullen, 2016; Harter, 1967). R. VanRullen suggests that to prove discreteness of perception the observed changes must concern not only the quality of perception, but also its temporal structure. And such data has been obtained (although not that much yet). For example, if two objects come into contact and then the second object starts moving, the assessment of causality between these events is related not only to the temporal interval between them, but also to the phase of the alpha rhythm before the contact (Cravo et al., 2015). It has also been found that when the interval between two stimuli is equal, the pre-stimulus phase of the alpha rhythm correlates with perceiving them as presented simultaneously or sequentially (Valera et al., 1981; Milton & Pleydell-Pearce, 2016). Moreover, the frequency of the alpha rhythm correlates with the temporal resolution of visual perception (Samaha & Postle, 2015). When participants' alpha rhythm was entrained with 10 Hz TMS stimulation, their ability to estimate the order of two rapidly presented, consecutive stimuli varied depending on whether they appeared within the same artificial time window (between two TMS pulses) or different ones (Chota et al., 2021).

As mentioned above, one possible evidence of discretization focuses on predictive processing: the need to compare predictions and incoming data (Chota, 2020). According to one of the hypotheses,

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the alpha rhythm may be a marker of this kind of processing (Alamia & VanRullen, 2019). Alamia & VanRullen (2019) used a simple model that implements a predictive coding algorithm (in such models, neurons at each level predict the result to be obtained at the previous level, the prediction is sent down, and the prediction error value returns to the top) and used it to reproduce a number of features of alpha oscillations. One such feature is the so-called «perceptual echoes» of the incoming signal (VanRullen & Macdonald, 2012). When participants look at a stimulus whose brightness changes randomly, the correlation was found between the brightness values and the EEG responses. As the temporal shift between the stimulus brightness and the EEG signal increases, this correlation changes with a frequency equal to that of the alpha rhythm, and these fluctuations gradually subside over 600-1000 ms (moreover, the frequency and amplitude of the «perceptual echo» in a particular subject correlated with the frequency and amplitude of the alpha rhythm observed at rest with eyes closed - *author's note*). Alamia & VanRullen (2019) provided data corresponding to randomly varying luminance to the model input, while the second (upper) level output was treated as analogous to the EEG signal. When the delays between levels added to the model roughly matched the real biological system, the cross-correlation function between the data and the model EEG signal showed similar oscillations in the alpha range. Using a more complex model with a larger number of levels researchers reproduced another feature of the alpha oscillations – their propagation in the form of travelling waves. The model produced forward travelling waves (in the direction from the lower to the upper layers) during sensory data processing and backward travelling waves when top-down predictions were sent and there were no input data. Similar waves were found in the actual EEG signal: forward waves when subjects looked at the sensory stimulus, and backward waves when the eyes were closed (another study (Luo et al., 2021) showed a relationship between «perceptual echo» and conscious perception. Participants looked at two stimuli under binocular rivalry, with the brightness of each stimulus changing independently at random. The cross-correlation with the EEG response was calculated separately for each of them. The alpha oscillation power of the «perceptual echo» was higher for the stimulus that was currently conscious. At the same time, the propagation of the «perceptual echoes» as a travelling wave from the posterior to the frontal regions took place independently of awareness, - *author's note*).

The data that we discuss in more detail in the paragraph «Studies of long-lasting postdictive effects» shows that unconscious integration of information can last up to several hundred milliseconds, which makes the idea that perceptual content (if we recognize it as discrete) can be updated with the frequency of alpha or theta rhythms unlikely. Therefore, we assume that the evidence given in this paragraph relates rather to the unconscious stages of processing. This is also supported by the inability to identify one universal sampling frequency (see paragraph «Criticism and defense of discrete models»).

We think it is important to specify that variability of duration of the discrete window at the physiological level, observed in the presented experiments, does not condition the necessity of the same temporal window at the consciousness level, because this window is defined not by the limited resolution that brain processes can provide, but by the logic of information processing and verification for solving the existing tasks. We assume that several discrete elements of information processed at the physiological level can appear in one window at the psychological level. Therefore, it is necessary to consider other phenomena, in which one can observe discreteness of conscious perception, and to suggest possible logical mechanisms for choosing the duration of discretization.

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Studies of behavioral evidence of discrete perception

This paragraph considers phenomena directly or indirectly confirming the discrete approach: studies of sequential or simultaneous perception of motion and its causes, some visual illusions (flickering wheel illusion, wagon wheel illusion). We also look at postdictive effects (the influence of subsequent stimuli on the perception of previous stimuli), which assume that information is integrated before awareness.

Many early studies limited themself to identification of a temporal window in which all stimuli are perceived as presented simultaneously or, for example, several successive flashes merge in perception into one (see White, 1963; VanRullen & Koch, 2003). The temporal parameters of causal perception have also been investigated, under conditions in which a moving object touches another object, after which that object also begins to move (Shallice, 1964). It was found that with a delay lesser than a certain threshold (up to 56 ms), subjects felt that the first object directly triggered the movement of the second object. When the interval is increased to 140 ms, the second object seems to «stick» to the first object and starts moving with a delay, and when the interval is increased even more, causality is no longer perceived (see White, 2018). T. Shallice suggested that causality is not perceived if the interval between contact and the start of movement of the second object includes two or more perceptual moments. If this interval includes only one moment, person can perceive both causality and delay («sticking» impression), if the interval is less than one moment then the person can only perceive causality (criticizing this explanation, White (2018) notes that if the perceptual moment is devoid of subjective duration (the version proposed by J. M. Stroud), then if the interval is one perceptual moment, there should be no perception of delay and «sticking.» Another problem noted by P. A. White is that in several studies the perception of causality is preserved at much longer delays, depending on the conditions of presentation, - *author's note*). Later it became clear that these effects could be explained without the assumption of the discreteness of the integration window.

Some visual illusions are associated with discrete perception, such as the flickering wheel illusion (perceived flickering of a circle consisting of alternating white and black segments of a certain spatial frequency and located at the visual periphery) (the frequency of illusory flickering corresponds to the alpha rhythm range (Sokoliuk & VanRullen, 2019), - *author's note)* or the wagon wheel illusion when one perceives an illusory change in the direction of wheel's motion (Sokoliuk & VanRullen, 2019). Such a change happened when participants were looking at a recording with a frame rate less than the rotation rate, but several studies have shown that it can also occur when observing the rotation «live» and when no external sources of sampling are present. The illusion was observed at different rotation frequencies but peaked at a frequency around 10 Hz. White (2018), however, believes that this illusion occurs too rarely (in 30% of samples) and at exceedingly large frequency range to be attributed to the presence of discrete perceptual «frames».

Also associated with perceptual discreteness is the existence of postdictive effects (e.g., review by Shimojo, 2014), when a stimulus presented later has an effect on the perception of stimuli presented earlier (Herzog et al., 2016; Schneider, 2018). Some of the best-known examples of such effects are the color phi-phenomenon (Kolers & von Grünau, 1976) and the backward masking effect (e.g., Breitmeyer & Ogmen, 2000). Other examples include the so-called «cutaneous rabbit» effect, a similar effect to the phi-phenomenon in the tactile dimension (Geldard & Sherrick, 1972), as well as illusory reordering of stimuli presented in sequence for a short time (with a delay of

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less than 50 ms the second stimulus is more often perceived as presented first, if its contrast is higher) (Bachmann et al., 2004).

Another widely studied phenomenon of this series is the flash lag effect (flash lag effect; Nijhawan, 1994) and its different versions. If one stimulus moves and the second flashes alongside it at some point for a short time, observers overestimate the position of the first stimulus: it seems that the second stimulus appears with a lag - later than it actually does. This effect persists even when the flash coincides with the beginning of the movement (i.e., both stimuli appear simultaneously), but is absent if the second stimulus flashes at the moment the first one stops moving (there are some evidence that the effect can also persist under these conditions, but only if one needs to estimate the absolute position of the moving stimulus at the end of its motion, rather than the position relative to a flashed object, as in most studies (Hogendoorn, 2020), - *author's note*), which does not allow to fully explain the effect by the extrapolation of motion alone. The generalized flash lag effect occurs when the first stimulus does not move but changes in some other aspects, such as color or spatial frequency (Sheth et al., 2000).

It was also shown that the magnitude of the flash lag effect correlates with the phase of the EEG oscillations (in the alpha and theta bands) around the moment of stimulus onset (Chakravarthi & VanRullen, 2012). Chota & VanRullen (2019) went further and entrained the oscillations using an annulus around the stimuli which luminance fluctuated at a frequency of 10 Hz. The size of the flash lag effect varied depending on which phase of the entrained cycle corresponding to the stimulus onset. This is consistent with the interpretation that the effect arises in the process of discrete sampling. If the discretization process only saves information on stimulus position at the end of a discrete time window, then the closer a static stimulus is presented to the end of that window, the more accurate the estimate of the position of the moving stimulus at the time of its presentation (Schneider, 2018).

Studies of long-lasting postdictive effects

The discussion of postdictive effects continues. While it is possible to explain the short-term postdictive effects discussed in the previous section with models involving discrete sampling at alpha and theta frequencies, the discovery of the long-lasting (up to 450 ms) postdictive effects indicates that conscious percepts may update less frequently than classical discrete models suggest.

The research of postdictative effects is important in estimating the size of a discrete unit of conscious perception (namely, it helps identify of its possible boundary values (Herzog et al., 2020)), as it demonstrates how long integration can take before any (possibly intermediate) outcome becomes conscious. As White (2017) points out, temporal integration of information can occur at intervals ranging from a few milliseconds to several seconds, depending on the type of information. For example, tactile stimuli that arrive at intervals of 1-2 ms are being integrated into a single tactile texture percept. Motion perception under visual noise involves temporal integration that could last for 2-3 seconds (Burr & Santoro, 2001). A recent study found that when perceiving a slowly changing visual stimulus, integration can take up to 15 seconds (Manassi & Whitney, 2022). However, this is not the integration required for stimulus awareness per se, as conscious perception cannot be delayed by fifteen seconds, or even three seconds.

However, recent studies have been demonstrating postdictive effects lasting up to several hundred milliseconds, the occurrence of which cannot be explained by discrete sampling at alpha

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and theta band frequencies (e.g. Thibault et al., 2016; Sun et al., 2017; Stiles et al., 2018; Drissi-Daoudi et al., 2019; Drissi-Daoudi et al., 2020; for review see Herzog et al., 2020). For example, a correct cue about the position of a faint stimulus presented at 50 ms to the right or left of the fixation point helps more accurately determine its orientation, even when presented 400 ms after the stimulus itself (Thibault et al., 2016).

In another study (Scharnowski et. al., 2009), transcranial magnetic stimulation (TMS) was used to manipulate which of the two stimuli would dominate after feature fusion. Although the presentation of the first and the second stimuli together took only 60 ms, the effect of TMS on their integration persisted even when the TMS pulse took place at 400 ms after the first stimulus onset. Similar results were obtained when visual masking was used instead of TMS (Pilz et al., 2013). The mask affected which stimulus would dominate the percept, even when presented 200 ms after the first stimulus onset. These data show why studying the temporal resolution of perception is not enough to determine its temporal structure (by looking only at the temporal resolution, one could see that with stimulus onset asynchrony (SOA) of 30 ms, integration occurs, and with SOA of 200–400 ms, stimuli are perceived separately, but these data would not show how long the integration takes, and with what delay the final percept is formed, – *author's note*).

Promising results have been obtained using the Sequential Metacontrast Paradigm (SQM; Otto et al., 2009). Under this paradigm, a central vertical line consisting of the two segments is presented, followed by a sequence of frames with pairs of parallel flanking segmented lines moving away from each other. Participants must keep their attention on one of the two diverging lines. The first central line stays unnoticed, as flanking ones mask it, but if it contains a left or right vernier offset, this affects the perception of the line to which attention is drawn from the two perceived diverging lines – it seems to have an offset in the same direction. If a flanking line on the one of the following frames also has a vernier offset, they are integrated: two offsets that are in the opposite directions cancel each other (neither of them is perceived, and the line seems to be straight); offsets that are in the same direction are summed (the resulting offset seems to be more pronounced). Integration takes place before conscious perception: participants cannot report the individual offsets, only on the resulting percept.

Using this paradigm, researchers were able to show (Drissi-Daoudi et al., 2019) that such integration can occur within discrete temporal windows lasting for up to 450 ms. The presence of integration depended not on the interval separating the stimuli itself, but on whether the stimuli fell into the same discrete window or into different ones (the authors prolonged the trial and added three vernier offsets instead of two; moreover, there was a longer time interval between the first and the second verniers than between the second and the third ones. Yet, it was the first and the second offsets that were integrated in perception (as they probably fell into the same temporal window), and the third was perceived independently. With further extension of the trial, it was shown that integration within the second temporal window happens in the same way as in the first one (Drissi-Daoudi et al., 2019), – *author's note*). A displacement of stimuli on the screen led to an early closure of the temporal window, but a saccade causing an identical displacement relative to the retina did not interrupt integration (Drissi-Daoudi et al., 2020). In another experiment (Drissi-Daoudi et al., 2021), one of the flanking lines was missing in several frames, causing the perceived motion stream to be discontinuous. The occluder that covered the missing lines was either present on the screen (in this case, the line seemed to go behind the obstacle and then reappeared from behind it) or not wasn't. Vernier offsets were placed both

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before and after the gap. With the occluder present it seemed that the motion of the line was continuous (although some of the movement was invisible), and two offsets were more likely to be integrated, while in the absence of the occluder they were more often perceived separately. Also, unconscious integration windows seem to be longer under increased processing load condition: when between the two offsets whose integration being tested, there are another two offsets that cancel each other (Vogelsang et al., 2021).

All these data show that percepts can enter consciousness with a delay of up to several hundred milliseconds, and the duration of such a delay may depend on the nature of the input information.

Criticism and defense of discrete models

Here we review the main directions of criticism of discrete models and the answers to this criticism offered in the two-stage model proposed by M. Herzog et al. (2020).). The idea of discrete units of different sizes at the level of unconscious processing and conscious perception is discussed as a possible option for resolving the existing contradictions.

One of the main criticisms toward discrete models is that it is impossible to determine the universal duration of a discrete unit of perception as its estimate depends on the method used (Herzog et al., 2016; White, 2018). For example, thresholds for nonsimultaneity detection and temporal order judgments vary depending on a large number of factors, and in some studies can reach very small values (e.g. 6 ms) (White, 2018). The perceptual moment concept assumes that its size can change due to stimuli characteristics, but problems arise even when examining highly similar effects on the same stimuli. For example, the flash lag effect (see section «Behavioral Evidence for Discrete Perception») and the Fröhlich effect are quite close to each other (the latter differs in that the static stimulus is in the position from which the second one starts to move). The model based on the «perceptual moment» hypothesis suggests that the average magnitude of both effects depends on the «moment» duration (Schneider, 2018). Morrow & Samaha (2022) replicated both effects in the same sample using the same stimuli but found no correlation between their magnitudes.

Ronconi et al. (2017) have also compared two similar effects: the two-flash fusion (that occurs when two stimuli appear at the same position) and the apparent motion (when stimuli appear at the different positions). They studied the link between the occurrence of integration (as opposed to perceiving them separately) and prestimulus phase of EEG-oscillations. For both effects, a relationship was observed, but for different EEG bands and at different time points relative to the stimuli onset (for the two-flash fusion, integration could be the most accurately predicted based on the phase of alpha band oscillations (8–10 Hz) 300–400 ms before the first stimulus onset; for the apparent motion, the most predictive value had theta oscillations (6–7 Hz) 400–500 ms before the onset (Ronconi et al., 2017) – *author's note*), which suggests different sizes of a discrete unit.

White (2018) sees a problem with EEG evidence of discrete perception in the wide range of frequencies associated with various perceptual effects (including low-frequency oscillations from 1 Hz). As P. A. White points out, if the hypothesis of multiple perceptual cycles (proposed by the authors of one of the discrete approaches: VanRullen & Koch, 2003; VanRullen, 2016) is correct and sampling is carried out at different frequencies at once, then this indicates the discreteness of some local processing mechanisms, rather than conscious perception as such.

Another line of criticism is related to the fact that integration, including postdictive integration, can be executed continuously, within «sliding» rather than discrete temporal windows. For

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example, simple effects that demonstrate the limited temporal resolution of perception can be easily explained without the perceptual moment hypothesis, with low-pass filter algorithms (signal «blurring») (VanRullen & Koch, 2003). Allport (1968), who was one of the first to propose the continuous perceptual moment idea (the «Travelling Moment» model), notes that the existence of a period within which all events are perceived as simultaneous does not necessarily indicate discreteness. The D. A. Allport's model implies that some function similar to a moving average, is applied to data. All events separated by the time less than the «travelling moment» duration are perceived as simultaneous, but this relation is not transitive.

Fekete et al. (2018) suggest that integration within a «sliding window» can explain even more complex postdictive effects, which are usually used as evidence for the discrete perception. The authors point out that continuous integration can also result in a postdictive formation of a conscious percept. As an example, they give a smoothing model in which some feature value at a specific time point is calculated taking into account both earlier data and data received for a certain period after this point.

The authors of one of discrete approaches (Herzog et al., 2020) in response to this criticism argue that the sliding temporal windows hypothesis does not explain the phenomenology of postdictive effects, since it suggests that percepts in this case does not enter consciousness fully formed but morph over time. For example, in the case of apparent motion, if the continuous integration model is correct than at first, one static dot must be rendered conscious, then a moving dot, and then a second static dot. But that's not what happens. In reality, only one moving dot is perceived.

In some cases, visual illusions can be modified postdictively in a complex way depending on the stimuli context (Noguchi et al., 2007). In our opinion, it also speaks against continuous interpretation. Moreover, idea of sliding temporal windows, renders impossible the coherence check or other control of a prepared interpretation before it reaches conscious (more on this in the next paragraph).

The first direct experimental evidence for the discrete integration windows has also been appearing (Drissi-Daoudi et al., 2019; see section «Studies of long-lasting postdictive effects»).

In our opinion, a successful reconciliation of contradictions between continuous and discrete processing is proposed in the two-stage model of M. Herzog et al. (2020). According to this model, the discrete percept formation is preceded by a long period of unconscious processing, during which the brain operates with data in a rather high temporal resolution. The problem of multiple temporal resolutions is not relevant here, since they are inherent to individual unconscious processing mechanisms and do not determine the size of the conscious perception discrete unit (which is larger anyway).

This model contradicts the hypothesis of a universal perceptual moment, within which all temporal information is lost, but it may be compatible with existence of discrete sampling in local processes of unconscious processing. For example, the authors admit that unconscious processing may involve the predictive coding (Herzog et al., 2020), which, as mentioned earlier, may require discrete sampling (Chota, 2020).

The negative choice theory and prospects for its application

Here we describe a perspective of V. M. Allakhverdov's theory on the discreteness of perception. This approach explains discretization through the need to control the prepared representation before

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it becomes conscious. An idea is proposed that the discrete unit of conscious perception depends on the complexity of control operations. We look at several effects known in cognitive psychology that have similar temporal dynamics, which, according to our hypothesis, can be explained by stimuli falling into one unconscious processing window or into different ones.

Similar to the proposed two-stage model (Herzog et al., 2016; Herzog et al., 2020), but a different understanding of discrete perception follows from V. M. Allakhverdov's negative choice theory (Allakhverdov, 2000; Allakhverdov et al., 2019; Allakhverdov, 2021). According to this approach, before being rendered conscious, the prepared representations are checked for coherence. Those of them that cannot be consistently integrated with the other (for example, because they contain alternative interpretations of the same data) are marked in a certain way («negatively chosen») and do not enter consciousness. Thus, in this approach, discretization is associated with the need to control the prepared interpretation before it becomes conscious.

According to this model, the negative choice has an aftereffect. It is assumed that stimuli processed, but not integrated into conscious representation («negatively chosen»), are less likely to enter consciousness afterwards, therefore being rendered conscious with a delay.

This theory also suggests the existence of unconscious processing windows with a variable duration. But if in Stroud's model (1967) the duration of a discrete unit of perception varies depending on the physical parameters of stimuli, and in the two-stage model of M. Herzog et al. (Herzog et al., 2016; Herzog et al., 2020) it depends on the amount of time necessary to construct their meaningful interpretation than according to the V. M. Allakhverdov's theory, this duration is affected by the complexity of control operations performed before conscious perception. Moreover, this approach assumes that it is conscious perception that is discrete, while unconscious processing might be continuous. What is novel in this case is the idea that the «window» closes with the procedure of control of the prepared representation for consistency. The task of such control is to select information to enter consciousness.

There are not so many experimental studies of the factors determining the duration of unconscious processing windows (see section «Studies of long-lasting postdictive effects»). We assume that when considering this issue, it might be helpful to examine some other effects known in cognitive psychology that have a «suitable» temporal dynamic, which can be associated with stimuli falling into the same unconscious processing window or into different ones: such as a masked priming effect or the attentional blink. The idea that a conscious perception discrete unit depends on the complexity of control operations may in our opinion have the potential to explain the dynamics of such effects.

For example, the following dynamics of masked priming can often be observed: with short prime-target stimulus onset asynchronies (SOAs), unconscious primes positively affect target perception (positive priming), while as the SOA increases, this influence reverses and a counterintuitive negative priming effect occurs. So far the dynamics of masked priming has been best studied for simple stimuli that require binary responses (e.g. right / left arrow; square / diamond), i.e. for apparently simple tasks. Positive priming in such tasks occurs with prime-target SOAs lesser than 80 ms, and negative priming can be observed when SOA increases to 100–200 ms (e.g., Eimer, 1999; Schlaghecken & Eimer, 2000; Boy & Sumner, 2010; Atas & Cleeremans, 2015). And though such dynamics most often appear in simple tasks implying automated responses, the negative priming effect is observed primarily for the slow responses (Eimer, 1999; Atas & Cleeremans,

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2015; Wang et al., 2020) i.e. for those that as can be assumed involve conscious control. This is in line with the negative choice theory suggesting that the delay in this case occurs at the stage when target stimuli enter consciousness and should not be observed in automated responses.

For more complex stimuli such as words or numbers, masked negative priming is often registered at longer SOAs of 500–600 ms (e.g., Yee, 1991; Milliken et al., 1998; Frings & Wentura, 2005; Filippova & Kostina, 2020). The dynamics of this type of priming is less studied, but in a number of experiments we can see the same pattern as for simple tasks: a change from positive to negative priming effect with an increase in the SOA (Ortells et al., 2003; Ortells et al., 2001; Yee, 1991).

As we propose, the factor determining the change of priming from positive to negative with an increase in the SOA may be that the prime and the target fall not into the same unconscious processing window, but into different ones. In this case, the minimum SOA required for the negative priming to occur is associated with the unconscious processing window length, that varies depending on the specific experimental conditions. For instance, it takes more time for the negative priming to form when simple stimuli with a binary response are presented under difficult perceptual conditions (e.g., peripherally or smaller in size) (Lingnau & Vorberg, 2005). Moreover, when a smaller set of complex stimuli is used (e.g. repeated many times words in Frings & Eder, 2009; D'Angelo & Milliken, 2012), the negative priming is likely to form earlier, at intervals comparable to those for which this effect is observed when simpler stimuli are used (in the above examples already at SOAs of 140–200 ms). This suggests that the time of the negative priming occurrence may be affected by the number of stimuli used in the experiment (which should also be related to the complexity of control in identification task).

Similar temporal dynamics can be observed in the attentional blink studies using the rapid serial visual presentation (RSVP) paradigm. In this paradigm several stimuli (usually letters, numbers, words or images) some of which are targets being presented sequentially for a short time (e. g., for 100 ms or less). Subjects most likely miss the second target when it is presented 200–500 ms after the first one (Shapiro et al., 1997; Dux & Marois, 2009). If the second target follows the first directly, it is usually successfully reported (e.g., Raymond et al., 1992). It can be suggested that the effect disappears when the first and second target fall into the same temporal processing window (a number of attentional blink models offer a similar interpretation, according to which two targets that follow each other without a lag can fall into one «temporal episode» or «attention episode», though the nature of these episodes is understood differently in different models (for review see Snir & Yeshurun, 2017), – *author's note*). For example, it was shown that the following factors diminish the attentional blink effect: the visual similarity of two targets (Makarov & Gorbunova, 2020), the possibility to integrate them into a single visual image (Falikman, 2001; Akyürek & Wolff, 2016), belonging of three successively presented targets to a single category (Di Lollo et al., 2005) (for example, if three target letters or numbers are presented in a row, subjects report the third target as often as the first one, but if the second target belongs to a different category the reportabitily of the third target decreases (Di Lollo et al., 2005), – *author's note*), the instruction to name a pair of targets together, rather than separately (Ferlazzo et al., 2007).

According to the negative choice theory, both the switch from positive to negative priming and the attentional blink can be a result of the control mechanism that is triggered at the end of the temporal unconscious processing window. The discussed effects can be a useful material for research of the factors determining the duration of the temporal window, in particular, the hypothesized influence of the control task complexity.

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The mentioned studies differ in too many parameters to be able to draw firm conclusions from them. Therefore, it seems appropriate to create procedures allowing to vary the complexity of the control task, which would be useful to test experimentally the hypothesis about the possibility to change the duration of the conscious perception discrete unit. The result of this approach might be the unification of various phenomena in a broader context, which is a promising prospect.

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Viktor Mikhailovich Allakhverdov provided the concept or design of the work, final approval of the version for publication.

Author information

Daria Igorevna Kostina - Junior Researcher, Saint Petersburg State University, Saint Petersburg, Russian Federation; Scopus Author ID: 57204643113, ResearcherID: M-9871-2018, SPIN-code: 1209-6224, ORCID: https://orcid.org/0000-0002-5277-1048, e-mail: d.kostina125@gmail.com
Margarita Georgievna Filippova – Cand. Sci. (Psychology), Research Associate, Saint Petersburg State University, Saint Petersburg, Russian Federation; Scopus Author ID: 37088540500, ResearcherID: L-4658-2013, SPIN-code: 7063-5371, ORCID: https://orcid.org/0000-0001-9654-822X, e-mail: m.g.filippova@spbu.ru
Mikhail V. Allakhverdov - Cand. Sci. (Psychology), Associate Professor, Department of Problems of Convergence of Natural Sciences and Humanities, Saint Petersburg State University, Saint Petersburg, Russian Federation; Scopus Author ID: 57209199514, ResearcherID: C-6851-2014, SPIN-code: 9638-1836, ORCID: https://orcid.org/0000-0001-6228-1248, e-mail: m.allakhverdov@spbu.ru
Viktor Mikhaylovich Allakhverdov – Dr. Sci (Psychology), Professor, St. Petersburg State University, St. Petersburg, Russian Federation; Scopus Author ID: 23487699200, ResearcherID: N-3175-2013, SPIN-code: 3831-2224, ORCID: https://orcid.org/0000-0002-6753-0300, e-mail: vimiall@gmail.com

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Diagnosis and Correction of Auditory Perception in Children Aged 8 to 10 with Mental Retardation

Galina V. Karantysh[1], Marianna A. Muratova[2], Larisa A. Guterman[3], Alexandr M. Mengeritsky[4], Elena V. Vorobyeva[5]✉

[1, 2, 3, 4, 5] Southern Federal University, Rostov-on-Don, Russian Federation

✉ evorob@sfedu.ru

Abstract: **Introduction**. The article is devoted to identifying the features of auditory perception using neuropsychological and instrumental methods in children 8–10 years of age with mental retardation. The relevance of the work lies in the need to develop approaches to improve the learning ability of children with mental retardation. The novelty of the study lies in the evaluation of the effectiveness of psycho-corrective measures carried out using the methods of integrated impact on sensory perception in children with mental retardation. **Methods**. The study included 8–10-year-olds with no history of hearing impairment: control group (n = 34) and children with intellectual disability (n = 36). Children with mental retardation were divided into 2 subgroups, in one of which corrective work was carried out for 6 months using methods of integrated impact on sensory perception. All children were examined twice using tonal audiometry methods, recording long-latency auditory evoked potentials, neuropsychological testing. **Results**. During repeated examination (after corrective measures) in children with mental retardation, a decrease in the thresholds of tonal audiometry, as well as latency of individual peaks of long-latency auditory evoked potentials was established, which correlated with an increase in the efficiency of neuropsychological tests. In the subgroup of children with mental retardation with whom no corrective work was carried out, as well as in the control group, no changes in the studied indicators were detected. **Discussion**. In conclusion, it is concluded that the use of techniques aimed at the development of polysensory perception in children with mental retardation contributes to the improvement of auditory gnosis.

Keywords: auditory perception, children 8–10 years old, mental retardation, neuropsychological examination, audiological examination, neurophysiological examination, polysensory perception, auditory evoked potentials, Wechsler test, tone threshold audiometry

Highlights:

▹ The results of diagnosing auditory gnosis in children of primary school age with mental retardation

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can be considered as a basis for corrective measures using pedagogical technologies aimed at developing polysensory perception.

- The basis of impaired auditory perception in children with mental retardation is the delay in the functional maturation of the structures of the left hemisphere of the brain.
- The use of correctional work methods aimed at developing polysensory perception in children with mental retardation contributes to the improvement of auditory gnosis.

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Introduction

Specific learning disorders are characteristic of all children with intellectual disability but can also occur in children with a normal level of intellectual development (Dawes & Bishop, 2010). These learning disorders are due to perceptual characteristics, which leads to impaired understanding of oral and written speech (Kolodyazhnaya et al., 2020), for example, to the occurrence of comorbid dyslexia (Banai & Ahissar, 2006; Iliadou et al., 2009).

There are various factors that determine the complexity of assessing the causes of specific learning disorders. These factors include changes in eye movements during reading, impaired information processing (visual, auditory, etc.), as well as concomitant disorders associated with attention deficit and/or hyperactivity (Cunha et al., 2019).

Of significant interest among these factors are auditory information processing disorders. In normal peripheral hearing, difficulties in localizing sounds, disturbances in recognition of auditory patterns under conditions of presenting competing auditory signals are designated as a central disturbance in sound processing (Katz, 1992). As a result of the central disturbance of auditory information processing, acoustic reflexes may be changed or absent against the background of a normally formed basic audiological signal assessment (Engelmannn & da Costa Ferreira, 2009).

Currently, it has been proposed to assess the degree of auditory impairment using various tests for binaural hearing, dichotic listening, temporary processing of auditory signals, auditory perception against the background of interference signals, as well as the perception of the acoustic structure of speech of low redundancy (constituting the phonetic structure of speech) (Bellis, 2011).

Long-latency auditory evoked potentials are recorded in the period from 50 ms to 400 ms and are due to the activity of the primary and secondary auditory cortex, and the P1, N2, P2 components are associated with the process of auditory stimulus perception, the N2 component is associated with the correct recognition of the auditory stimulus, including correlation with the memory image, P3 – with decision (Samkova, 2014; Emelina et al., 2019). Studies using the technique of recording long-latency auditory potentials have shown that children and adolescents with Down syndrome, in comparison with the control group, have longer latent periods of the main peaks, with no significant differences in amplitude (Gregory et al., 2018). In Williams syndrome, a longer latency was also found, as well as a reduced amplitude of the P1, N1, N2 and P3 components (Fagundes Silva et al., 2021).

Most of the papers focus on research on impaired auditory perception in specific learning disorders in individuals with preserved intelligence (Miller & Wagstaff, 2011; Lachmann et al., 2012; Yoshimura et al., 2021). Intelligence assessment, as a rule, is carried out using adapted versions of the D. Wexler test, while it is important to strictly follow the instructions for each subtest (Vorobyeva & Druzhinin, 1997). The relevance of studying the features of auditory perception in children with mental retardation is determined by the fact that other executive functions suffer from them simultaneously with impaired verbal function. Children with intellectual disability perform unsatisfactory nonverbal tests and tasks, have reduced cognitive interest and desire for communication, and are not active in the use of gestures and in maintaining games (Knoth et al., 2018). And since there is an idea that the skills of central auditory processing develop mainly before the age of 10–12 years (Katz, 1992), the diagnosis of auditory gnosis in younger students with mental retardation can become a fundamental diagnostic tool, as well as the basis for corrective measures using technologies aimed at developing polysensory perception and reducing disorders of speech development and learning in these children (Senkal & Muhtar, 2021). It is known that long-term use of music lessons improves speech understanding against the background of noise, improves the connection between the auditory and motor brain systems (Zendel, 2022). The most well-known method of polysensory perception development at present is sensory integration (Ayres, 2017; Kiesling, 2018). We suggest that its use in working with children with intellectual disability will contribute to the improvement of their auditory gnosis, which is based on a decrease in disorders of peripheral and/or central auditory perception.

Based on the content of the research hypothesis, *the purpose of this study* was to identify the features of auditory perception using neuropsychological and instrumental methods in children of 10–12 years of age with mental retardation, as well as to assess the effectiveness of psychocorrection measures carried out using methods of integrated impact on sensory perception.

Methods

82 children of 8–10 years of age took part in the cross-sectional study, of which 48 students at a specialized (correctional) boarding school for mentally retarded children; the control group consisted of 34 schoolchildren from secondary schools (Rostov-on-Don, Russia). In accordance with the Helsinki Declaration of the World Medical Association, "Ethical Principles of Scientific Medical Research with Human Participation" (as amended in 2000), as well as the "Rules of Clinical Practice in the Russian Federation", all studies were conducted with the informed consent of the legal representatives of the examined children (approved by Order of the Ministry of Health of Russia dated June 19, 2003, No 266). Only children without a history of reduced/hearing loss, metabolic, cardiovascular, respiratory and infectious diseases were included in the examination. After the first audiological assessment, 12 children with intellectual disability were excluded from the examination due to misunderstanding of the meaning of the task. Thus, the baseline sample was 18 boys (mean age 8.76 ± 0.56) and 16 girls (mean age 8.39 ± 0.67) of the control group, as well as 19 boys (mean age 8.92 ± 0.39) and 17 girls (mean age 8.89 ± 0.42) with intellectual disability. The level of verbal and non-verbal intelligence in the examined children was assessed using the Wexler Scale (or WISC test, Wechsler Intelligence Scale for Children) in a modification for children and adolescents (from 6.5 to 16.5 years), adapted by A. Y. Panasyuk (Panasyuk, 2002) (Table 1).

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Table 1

Mean scores on the Wexler Scale for controls and children with mental retardation

Subtests / Groups of children	Control group	Group with mental retardation	P-level (*$p < 0.05$)
Verbal Scale			
Information	17.4	11.4	*
Comprehension	15.6	9.3	*
Arithmetic	16.2	11.7	*
Similarities	16.9	13.2	
Digit span	16.4	11.4	*
Vocabulary	16.6	11.2	*
Verbal assessment	101.1	68.2	*
Unverbal Scale			
Digit symbol	15.1	10.4	*
Picture completion	18.7	12.5	*
Block design	17.3	14.2	
Picture arrangement	18.8	13.6	*
Object assembly	16.7	12.3	*
Labyrinths	17.7	12.1	*
Nonverbal assessment	104.4	69.3	*
General intellectual indicator	102.8	68.4	*

Children with mental retardation were divided into 2 subgroups: A – with whom corrective work was carried out (n = 19, of which 10 were boys and 9 girls); In subgroup B, children with mental retardation (n = 17, of which 9 were boys and 8 were girls) did not perform this work.

At the first stage of the study, audiological examination of children by tonal audiometry and long-latency auditory evoked potentials was carried out, and the level of auditory perception was studied using neuropsychological methods. Audiological tests and registration of long-latency auditory evoked potentials were carried out in an audiological sound-insulated office.

Tonal audiometry method. Audiological evaluation was performed using tonal audiometry using a ORBITER922-2 audiometer (GN Otometrics & Madsen, Denmark) and a Martin Audio F8+ speaker (UK). The auditory threshold was measured using the ascending series method, when the pitch level is gradually increased in increments of 5 dB increase to appearance of test subject's reaction. The test started with a frequency of 1000 Hz, successively increasing the tone frequency: 2000, 4000 and 8000 Hz, and then tests were carried out in a region below 1000 Hz, successively lowering the tone frequency: 500, 250, 125 Hz. The retest was performed at 1000 Hz. The test tone was continuous and had a duration of 1–2 seconds.

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Method of recording long-latency auditory evoked potentials. Registration of long-latency auditory evoked potentials, isolation and analysis of evoked potentials were carried out using the encephalograph "Encephalan 131-03" ("Medicom MTD", Taganrog). The active electrode was located in the brain region Cz (vertex) according to the international scheme "10-20" and connected to the first output of the amplifier (-). Reference electrodes were placed on the earlobes. The quality of the electrode installation was checked by monitoring the sub-electrode resistances by software. The biopotentials were amplified in the frequency band of 0.5–70 Hz and, after analog-to-digital conversion, analyzed using a basic encephalograph software package. 50 ms clicks were applied through the speaker. The stimulus was given no more than 1 times per 1 second with a random component, so that there was no addiction to the periodicity of the stimulus. The epoch of analysis was 500 ms with the number of averages – 100. Long-latency auditory evoked potentials were investigated in the temporal regions of the children examined. Pre-processing of brain bioelectric activity data was performed in MATLAB environment (The MathWorks). The signals were downsampled at 500 Hz and filtered using a window FIR Hamming filter in the range of 1 to 70 Hz. Each record was automatically scanned for artifacts that were removed from the analysis.

Neuropsychological testing. The study of auditory perception was carried out using adapted neuropsychological methods by T. G. Wiesel, A. V. Semenovich (Wiesel, 2005; Semenovich, 2019) in accordance with the psychophysical capabilities of children with mental retardation.

Assignment No. 1: Investigating a child's ability to perceive rhythms. Adaptation of the method T. G. Wiesel from the diagnostic block "Impressive speech. Gnostic prerequisites for the development of the phonetic-phonemic side of the speech 'Familiar melodies'" (Wiesel, 2005). The purpose of the study was to identify the ability to perceive rhythmic melodies. To do this, the children were presented with the recording of children's songs. In the first part of the examination, the child was monitored during logorhythmic classes. Explored the child's ability to move to different music (fast, slow, sad, fun music). In a musical lesson, the child was offered to perform dance moves to the music. The child's ability to move rhythmically to various melodies was evaluated. In the second part, the child was monitored during dance-rhythmic activities. They examined the child's ability to clap according to the tempo of the melody. Evaluation criteria: 1 point – the child shows dance abilities – in the movements of the child you can notice the ability to hear the rhythm of the melody; the child makes the claps on his own; 0.5 points – the child shows dance abilities, but performs the same type of actions (swirls, swings); makes slaps on imitation; 0 points – the child does not perceive sounding music.

Assignment No. 2: Investigating a child's ability to perceive and recognize speech. Adaptation of the method of T. G. Wiesel "Speech auditory gnosis at the onomatopoeia stage" (Wiesel, 2005). The purpose of this study was to identify the child's ability to perceive and recognize speech. Pictures of animals were used as material for visual reinforcement for the study. Execution progress: various onomatopoeic words built on differential signs of speech sounds were presented for hearing: hissing, whistling, buzzing, humming, growling, etc. An answer is possible in the form of a picture showing an object making this noise. Evaluation criteria: 1 point – the child perceives speech and responds with onomatopoeia; 0.5 points – the child attentively listens to speech, emotional activity and facial expressions are traced, as a response to speech; 0 points – the child does not perceive speech, leaves the researcher, an inadequate reaction to speech is possible.

Assignment No. 3: Research on the ability to perceive and reproduce rhythms. Adaptation of the Methodology Presented in A. V. Semenovich's Book "Introduction to Neuropsychology

of Childhood" in the Section "Methods of Neuropsychological Examination. Auditory gnosis" (Semenovich, 2019). The goal is to reveal the ability to perceive and reproduce rhythm. Execution progress: the ability to perceive and reproduce rhythms was evaluated. The child was offered to complete the task "Pat like me" (light blows, up to 6 claps). The insufficiency of the auditory perception itself was differentiated from the difficulties of the child in the kinetic embodiment of the given program with either hand. Evaluation criteria: 1 point – the child is able to reproduce light rhythmic claps; 0.5 points – the child tries to reproduce rhythmic claps, but the task causes difficulties, or the child does not try to reproduce the claps, but listens carefully; 0 points – the child does not understand the task, does not pay attention to clapping, leaves the researcher, an inadequate reaction to speech is possible.

Data processing. High level (2.5–3 points) – the child copes with tasks. Shows the ability to perform rhythmic claps and rhythmic movements to various melodies, performs tasks on the perception and reproduction of speech. Average level (1–2 points) – completing tasks causes difficulties for the child, but he generally understands the task and tries to complete it. Low level (0–1 point) – completing the task causes significant difficulties. The child may not perform tasks at all. Inadequate actions are possible.

At the second stage, corrective work was carried out with children with mental retardation of subgroup A. Her goal was to create an optimal individual corrective and developmental environment using the Sensory Diet technique. *Content of corrective work*. Corrective exercises in Group A took place 3 times a week for 2 hours of extracurricular time for 6 months. Corrective work was aimed at the development of polysensory perception using neuropsychological technologies and the method of emotional-sensory impact: on the improvement of individual perceptual skills and training in their integrated use. This approach allows you to update the short-term reactions of children, encourage them to react emotionally, affecting sensory systems. That is, this approach involves the introduction of sensory stimuli into the activities of children, which allow you to awaken emotional reactions in children and create emotional-background support for the correctional process. Integrative interaction made it possible to form a joint activity with the child, during which it was necessary to create an emotional attitude for communication, to invite children not only to observe the subject, object, but also to actively participate in the study of its properties and objects associated with it (activity approach).

The system of conducting classes obeyed the principle of the optimal complex of stimuli on the child. The technique of sensory integration was built on the basis of an objective order of permanent relationships, which included three main chains of sensory connections: "tactile – proprioceptive – vestibular – visual"; "tactile – auditory – visual"; "tactile – taste – olfactory – visual". Both the entire direction of work and the thematic plan of individual classes on the development of polysensory perception methods were subordinate to these connections. Each task was aimed at the comprehensive use of certain sensory connections, but all sensory systems were always involved in them.

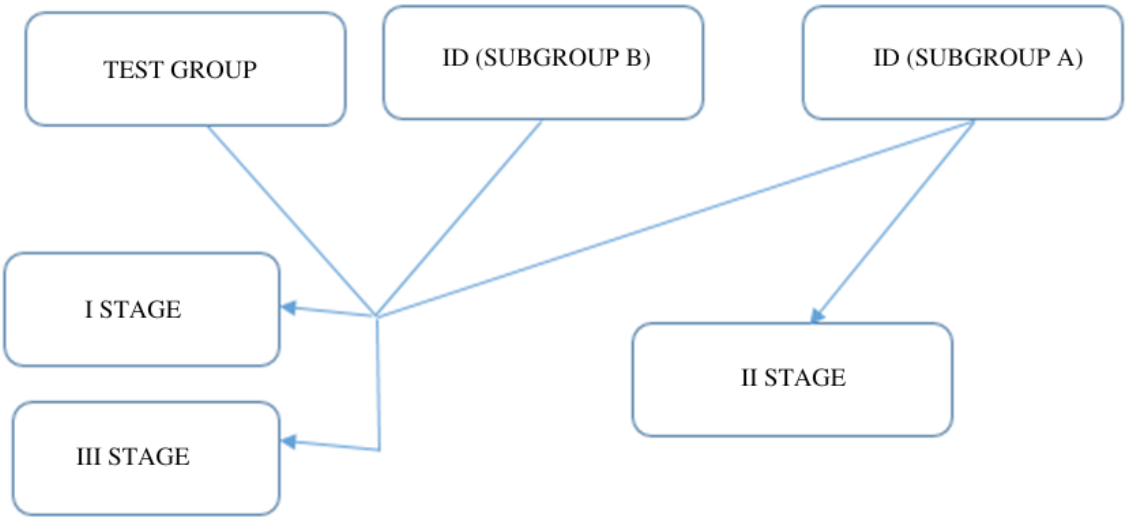
The specifics of the classes consisted in observing an individual approach to each child; classes were built on methods of sensory integration with minimal coercion when involving a child in them. To this end, classes began with such influences, to which the child responded well; after his active inclusion in the lesson gradually turned to less interesting for him. When avoiding any stimuli by the child, he was offered other stimuli.

At the third stage, repeated examination of children with mental retardation of subgroups A and B as well as children of the control group was carried out by tonal audiometry, registration

of long-latency auditory evoked potentials and neuropsychological testing. A schematic representation of the study design is presented in Figure 1.

Figure 1

Study design



Notes: ID – children with intellectual disability; Stage I – the first examination of children using tonal audiometry methods, registration of long-latency auditory evoked potentials and neuropsychological testing; Stage II – corrective work; Stage III – re-examination of children using tonal audiometry methods, registration of long-latency auditory evoked potentials and neuropsychological testing.

Statistical processing of results. The data distribution was checked for normality using the Shapiro–Wilk test. Subject to the normality of the distribution of baseline data, Student's t-test was used to assess inter-group differences; if the normality hypothesis was not fulfilled, the Mann–Whitney test was used. The Fisher test was used to test the homogeneity hypothesis of the data sets compared. The Holm–Bonferoni correction was used to solve the problem of multiple comparisons. Differences at the $p < 0.05$ significance level were considered significant. Statistical comparisons of the data of the three groups (control, group of children with mental retardation of subgroups A and B) were carried out using a multivariate analysis of variance (MANOVA) implemented in the Statistica-10 application package. At $p < 0.05$, the differences were considered significant.

Results

At the first stage of the study, when studying the indicators of neuropsychological testing of children, the following results were obtained (Table 1). When studying the ability to perceive rhythm (Task No. 1), 26 children of the control group (76 %) rhythmically moved to the given music (depending on the tempo and mood of the melody), and also clapped their hands according to

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the tempo of the melody (1 point). The remaining 8 children of the control group were able to get 0.5 points each, since during the performance of this task they tried to capture the tempo and mood of the work, listened to the music, but they did not perform movements, and if they did, they were micro-movements lagging behind the musical rhythm of the melody; they also could not make claps to the beat.

When performing Task No. 2 (study of a child's ability to perceive and recognize speech speech) 32 students in the control group (94 %) correctly perceived speech sounds and reproduced them, 2 children in this group (6 %) had difficulty reproducing sounds, but they were emotionally active and correctly mimically reflected speech sounds. During the study of the ability to perceive and reproduce rhythms (Task No. 3), 29 students in the control group reproduced the required amount of claps without difficulty. 5 children of this group had difficulties: when presenting more than 4 claps at different rates, they sometimes made mistakes during reproduction (the tempo of the given rhythm changed or made the wrong number of claps). The sum of points in the control group for three tasks was 2.82, which corresponds to a high level of ability to perform rhythmic claps and rhythmic movements to various melodies, as well as speech perception and reproduction.

In subgroups of children with mental retardation, the following results were obtained after primary neuropsychological testing.

During the implementation of Task No. 1 to study the ability to perceive the rhythms of 16 children of subgroup A and 14 children of subgroup B were able to perceive music; when the melodies sounded, they had a revival reaction, including in the form of positive emotions, they raised their shoulders or moved with their whole bodies. These actions characterize the fact that children are able to hear a melodic composition, and it evokes positive emotions in them. The rhythm of the movements in this case in children did not correspond to the pace (fast/slow) and mood (funny/sad) of the melody. Their movements were chaotic and had a character different from a musical work. The remaining 3 students of subgroup A and 3 schoolchildren of subgroup B did not perceive melodies: they had poorly developed auditory reactions. These children did not differentiate the mood of the musical work (melodies of different emotional colors were perceived with a smile); some of these 6 children had an inadequate response to the task (they could walk around the room or lie on the floor during the task, which was assessed as a rejection of the proposed activity).

When analyzing the results of Task No. 2 (study of speech gnosis at the onomatopoeia stage), 1 student of subgroup A and 1 child of subgroup B scored 1 point each: during the task, these children showed adequate emotional responses and an attempt to portray an animal presented using stimulant material, and they correctly repeated speech sounds with pronounced articulation as adults. 15 students of subgroup A and 14 students of subgroup B scored 0.5 points during this task: children's answers were characterized by an emotional reaction to the presentation of illustrations with animals, children were interested in completing tasks, but they did not demonstrate voice reactions (in response to requests from an adult to repeat one or another combination of sounds, children picked up pictures and began to show in the direction of other pictures or objects where similar species of animals could be located or were depicted, i.e. children showed an understanding of the task being performed). The remaining 3 children of subgroup A and 2 children of subgroup B scored 0 points, since their responses were inadequate: there was no adequate emotional response to the presentation of pictures with animals and vocal reactions.

These children, when presenting pictures, could not concentrate on the task, were distracted, moved away from the diagnosis site; when again trying to offer to complete the task, they showed negative emotions and, sometimes, aggressive reactions.

When performing Task No. 3 (a study of the ability to perceive and reproduce rhythms), 12 children of subgroup A and 10 children of subgroup B scored 0.5 points: they began to perform the task for the presented rhythms, but were soon distracted; when playing rhythms, they were lost. The remaining 7 students of subgroup A and 7 children of subgroup B scored 0 points each: the children were inattentive to the teacher's appeals, did not listen to the given rhythm, did not repeat the clapping not only on their own, but also with a hint. The sum of points in the group of children with mental retardation for three tasks was: in subgroup A – 1.19 points, in subgroup B – 1.17, which corresponds to the boundary values between the low and average level of ability to perceive rhythms, perform rhythmic claps and rhythmic movements, perform onomatopoeia (Table 2).

Table 2

Results of primary neuropsychological testing

Groups / Test scores		Control group, number of children (%)	Subgroup A of children with mental retardation, number of children (%)	Subgroup B of children with mental retardation, number of children (%)
Task № 1	1 point	26 (76 %)	0 (0 %)	0 (0 %)
	0.5 points	8 (14 %)	16 (84 %)	14 (82 %)
	0 points	0 (0 %)	3 (16 %)	3 (18 %)
Average score		0.88	0.42	0.41
Task № 2	1 point	32 (94 %)	1 (5 %)	1 (6 %)
	0.5 points	2 (6 %)	15 (79 %)	14 (82 %)
	0 points	0 (0 %)	3 (16 %)	2 (12 %)
Average score		0.97	0.45	0.47
Task № 3	1 point	29 (85 %)	0 (0 %)	0 (0 %)
	0.5 points	5 (15 %)	12 (63 %)	10 (59 %)
	0 points	0 (0 %)	7 (37 %)	7 (41 %)
Average score		0.93	0.32	0.29
Total score for 3 tasks		2.82	1.19	1.17

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When examining the indicators of tonal threshold audiometry in the first stage of the study, it was found that in children with mental retardation, the thresholds of tonal audiometry were significantly higher relative to the control group of children by an average of 9–16 dB. The most significant differences (16.3 dB) in the tonal audiometry threshold were found between the control group and children with mental retardation at tone presentation with a frequency of 4000 Hz. In the speech frequency band in the control group of children, tonal audiometry thresholds were 16 dB lower on average compared to children with intellectual disability. There are no differences between subgroups A and B in tonal audiometry (Table 3).

Table 3

Results of tonal threshold audiometry (dB) in the free sound field in the control group and in students with mental retardation at the first examination

Frequency indicators	Control group	Subgroup A of children with mental retardation	Subgroup B of children with mental retardation
500 Hz	8.4 ± 2.8	21.7 ± 9.6*	22.3 ± 8.9*
1000 Hz	6.7 ± 3.9	23.4 ± 11.2*	22.7 ± 9.7*
2000 Hz	10.7 ± 4.2	19.6 ± 9.5*	20.4 ± 9.3*
4000 Hz	7.8 ± 4.6	22.3 ± 8.4*	21.6 ± 9.4*
Average value at speech frequencies, dB	8.9 ± 1.5	24.7 ± 11.2*	25.1 ± 10.5*

Note: * – significant differences of indicators relative to values in the control group (at $p \leq 0.05$).

Parameters of long-latency auditory evoked potentials also differed between control children and students with mental retardation. It is known that the main peak of long-latency auditory evoked potentials in children is peak P1, the latent period of which decreases from 300 ms at birth to 60 ms in adulthood (Tavartkiladze, 2018). According to the results obtained in the control group of children, the latent period of this peak was 64.8 ± 3.1 ms, the average value in children with mental retardation of both subgroups, the latent period of peak P1 exceeded the values of the control group by 38 % ($p \leq 0.05$). Mean values of latent periods of N1, P2, and N2 peaks were also higher in children with mental retardation (both subgroups) compared to the control group of learners, respectively, by 49 % ($p \leq 0.05$), 45 % ($p \leq 0.05$), and 30 % ($p \leq 0.05$). There were no significant differences in the latent period of peak P3 between the control group and the group of students with mental retardation. The amplitudes of the N1–P2 and P2–N2 components in the control group exceeded the mean values in children with mental retardation (both subgroups) by 31 % ($p \leq 0.05$) and 38 % ($p \leq 0.05$), respectively. It was also established that

out of 38 children with mental retardation, 32 children revealed a latent impairment of hearing function – a selective impairment of the perception of sound stimuli. This was manifested in more significant deviations relative to the average values: an increase in latent peak periods by more than 50 % and a decrease in the amplitudes of the analyzed components by more than 40 % in 15 % of children with mental retardation relative to the control group of students (Table 4).

Table 4

Parameters of long-latency auditory evoked potentials in test group children and students with mental retardation at the first examination

Parameters of long-latency auditory evoked potentials		Control group	Subgroup A of children with mental retardation	Subgroup B of children with mental retardation
Latency, ms	P1	64.8 ± 3.1	87.8 ± 4.7*	91.2 ± 5.1*
	N1	92.3 ± 6.4	136.3 ± 9.4*	139.5 ± 11.4*
	P2	145.8 ± 10.5	208.6 ± 11.3*	213.7 ± 16.8*
	N2	216.7 ± 12.3	282.7 ± 19.5*	279.4 ± 11.3*
	P3	287.6 ± 12.8	357.3 ± 28.9	352.8 ± 26.5
Amplitude, μV	N1–P2	12.4 ± 3.2	9.6 ± 1.7*	9.4 ± 0.9*
	P2–N2	8.9 ± 1.6	6.3 ± 1.2*	6.6 ± 1.1*

Note: * – significant differences of indicators relative to values in the test group (at $p \leq 0.05$).

During corrective sessions (second stage) with children with mental retardation of subgroup A, aimed at auditory and visual perception, exercises were adapted in accordance with the psychophysical capabilities of children. Classes to stimulate auditory perception aroused great satisfaction and interest in children, encouraged children to interact and communicate. Children gladly played didactic games on musical instruments, got acquainted with their properties and capabilities. During the course of classes, they were first offered items in accordance with their psychophysical characteristics. Subsequently, the child could study with other subjects. In addition to the development of auditory perception, other important skills were practiced during the classes: the ability to observe the sequence of actions, the development of attention, self-regulation of behavior and perseverance. Such skills are aimed at developing strong-willed qualities, play an important role in the development of the emotional sphere, are necessary for the harmonious development of the child.

Repeated testing at the *third stage* was carried out according to the same methods as at the first stage. The test results of the control group children did not change relative to the primary testing (at the first stage) (see Table 2). Analyzing the results of children with mental retardation, it was found that the studying subgroups A scored more points on neurophysiological tests compared to the first test (Table 5); in the students of subgroup B, the test results did not change (Table 2).

Table 5

Results of neuropsychological testing at re-examination

Groups / Test scores		Subgroup A of children with mental retardation, number of children (%)
Task № 1	1 point	7 (37 %)
	0,5 points	10 (53 %)
	0 points	2 (11 %)
Average score		0.55
Task № 2	1 point	5 (26 %)
	0,5 points	14 (74 %)
	0 points	0 (0 %)
Average score		0.63
Task № 3	1 point	0 (0 %)
	0,5 points	15 (79 %)
	0 points	4 (21 %)
Average score		0.39
Total score for 3 tasks		1.57

When performing Task No. 1 (ability to perceive and reproduce rhythms), 7 children (37 %) of subgroup A completed this task, gaining 1 point each. After corrective work, they were able to listen carefully to the rhythm and reproduce the rhythm to the music, as well as recognize the tempo and mood of the piece of music. 10 schoolchildren (53 %) of subgroup A performed Task No. 1 by 0.5 points: they performed the same type of actions (swirling or swinging from side to side), tried to repeat the rhythm and pace, clapping hands, but often made mistakes. 2 children of subgroup A (11 %) could not cope with the task: they could not recognize the musical work, although they already listened more carefully to the musical work, sometimes made claps to the beat of the music; despite the positive dynamics in the performance of this task, they scored 0 points each.

When performing Task No. 2 (assessment of the ability to perceive and recognize speech), 5 children of subgroup A (26 %) performed a task for 1 point: they began to cope with the task, speech perception and onomatopoeia became available to them (1 point). 14 children of subgroup A (74 %) completed the task, receiving 0.5 points each: the children listened more carefully to the experimenter's speech, looked at the pictures and showed emotions more differentially; observe a qualitative improvement in the performance of the task, although numerous errors in the reproduction of onomatopoeia were still observed.

When performing Task No. 3 (study of the ability to perceive and reproduce rhythms), positive dynamics was also observed: after corrective work, the number of children who completed the task increased by 0.5 points. 15 children in subgroup A (79 %) listened more carefully to the task, began to approach it more consistently, but they maintained erroneous reactions when they clapped their hands (they got confused, clapped in the wrong rhythm, repeated claps

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many times, etc.). The remaining 4 children of subgroup A (21 %) did not cope with the task, gaining 0 points each. Understanding the instruction for these children was still a difficulty, although a more attentive listening to the rhythm had already been observed, but without trying to replicate the rhythm. Chaotic movements, inadequate reactions, a change of mood were also observed. The sum of points for all three tasks of neuropsychological diagnosis of the study of auditory perception after corrective work was 1.57 points, which corresponded to the average level of ability to perceive rhythms, perform rhythmic claps and rhythmic movements, perform onomatopoeia (Table 5).

After corrective work (*stage three*), children with mental retardation (subgroup A) also showed a decrease in the thresholds of tonal audiometry (in contrast to children with mental retardation of subgroup B). Tonal threshold audiometry values in the control group were unchanged from the first examination. The reduction in the thresholds of tonal audiometry in subgroup A of children with mental retardation relative to the indicators in the first audiological test was 28 % ($0.1 > p > 0.05$) by 500 Hz, 24 % by 1000 Hz, 31 % ($0.1 > p > 0.05$) by 2000 Hz and 27 % ($0.1 > p > 0.05$) by 4000 Hz, as well as averaged values at speech frequencies – by 32 % ($0.1 > p > 0.05$) (Table 6).

Table 6

Results of tonal threshold audiometry (dB) in the free sound field in the control group and in students with mental retardation on re-examination

Frequency indicators	Control group	Subgroup A of children with mental retardation	Subgroup B of children with mental retardation
500 Hz	8.3 ± 2.2	15.7 ± 5.3*	21.7 ± 8.4#
1000 Hz	6.4 ± 3.1	17.8 ± 7.5*	22.8 ± 9.3#
2000 Hz	10.2 ± 4.3	13.6 ± 4.9*	20.2 ± 9.7#
4000 Hz	7.3 ± 4.1	16.3 ± 6.3*	22.4 ± 9.5#
Average value at speech frequencies, Db	8.5 ± 1.6	16.9 ± 7.2*	24.7 ± 9.9#

Note: * – significant differences in indicators in children with mental retardation in subgroup A relative to values in the control group; # – significant differences in indicators in children with mental retardation in subgroup B relative to values in children of subgroup A (if $p < 0.05$).

Repeated examination also evaluated the parameters of long-latency auditory evoked potentials in all groups of children (Table 7). In both the control group of students and in children with mental retardation of subgroup B, there were no significant changes in these indicators with respect to the primary examination using the method of recording long-latency auditory evoked potentials. In subgroup A of children with mental retardation after corrective work, a decrease in latent periods of P1 peaks was found (by 18 %; $0.1 > p > 0.05$), N1 (by 17 %; $p < 0.05$), P2 (by

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19 %; 0.1 > p > 0.05), N2 (by 17 %; 0.1 > p > 0.05), P3 (by 15 %; 0.1 > p > 0.05) relative to the first examination. The amplitude values of the N1–P2 and P2–N2 peaks in the second study did not change from the first examination.

Table 7

Parameters of long-latency auditory evoked potentials in control group children and students with mental retardation at re-examination

Parameters of long-latency auditory evoked potentials		Control group	Subgroup A of children with mental retardation	Subgroup B of children with mental retardation
Latency, Ms	P1	62.3 ± 2.8	72.3 ± 2.8	93.7 ± 4.5#§
	N1	87.1 ± 5.2	112.7 ± 8.4*	128.6 ± 10.2§
	P2	141.6 ± 9.7	169.4 ± 7.8	202.3 ± 14.3§
	N2	211.2 ± 10.6	235.3 ± 13.4	263.6 ± 10.7§
	P3	282.3 ± 11.1	304.6 ± 21.2	344.5 ± 21.3§
Amplitude, μV	N1–P2	12.6 ± 3.5	11.7 ± 0.8	9.6 ± 0.8§
	P2–N2	8.7 ± 1.2	6.8 ± 0.6*	6.9 ± 0.9

Note: * – significant differences in indicators in children with mental retardation in subgroup A relative to values in the control group; # – significant differences in indicators in children with mental retardation in subgroup B relative to values in children of subgroup A; § – significant differences in indicators in children with mental retardation in subgroup B relative to values in children of the control group (if $p < 0.05$).

The results of correlation analysis of neuropsychological testing parameters, tonal audiometry parameters and long-latency auditory evoked potentials are presented below (Table 8).

As a result of the analysis, negative correlation associations were established between independent variables (indicators of tonal threshold audiometry and parameters of long-latency auditory evoked potentials) and dependent variables (indicators of neuropsychological testing). A high relationship was established between the score of all three neuropsychological testing tasks and the tonal threshold audiometry values at frequencies of 1000 Hz, 4000 Hz, and, especially, the averaged values at speech frequencies, as well as between the scores for Task No. 2 and the tonal threshold audiometry values at 500 Hz. In addition, a high correlation relationship was established between the values of latent periods of peak N1 and the scores of Task No. 3 obtained by examined children during neuropsychological testing; peak N2 and points for the fulfillment of Tasks No. 2 and No. 3; peak P3 and points for the fulfillment of Tasks No. 1 and No. 2.

Table 8

Correlation associations between study scores in the control group of learners and children with mental retardation of subgroups A and B

Parameters		Indicators of neuropsychological testing		
		Task № 1	Task № 2	Task № 3
Indicators of tonal threshold audiometry				
500 Hz		r = –0,67	r = –0,81	r = –0,62
1000 Hz		r = –0,74	r = –0,84	r = –0,79
2000 Hz		r = –0,57	r = –0,61	r = –0,59
4000 Hz		r = –0,72	r = –0,81	r = –0,76
Average value at speech frequencies, Db		r = –0,76	r = –0,87	r = –0,81
Parameters of long-latency auditory evoked potentials				
Latency, Ms	P1	r = –0,53	r = –0,61	r = –0,64
	N1	r = –0,61	r = –0,65	r = –0,72
	P2	r = –0,62	r = –0,64	r = –0,69
	N2	r = –0,68	r = –0,71	r = –0,81
	P3	r = –0,72	r = –0,73	r = –0,54
Amplitude, μV	N1–P2	r = –0,42	r = –0,45	r = –0,32
	P2–N2	r = –0,34	r = –0,47	r = –0,27

The following results were obtained during analysis of variance (Table 9). The analyzed dependent factors were the level of intellectual development (ID) (levels: control group, children with mental retardation of subgroup A before and after corrective sessions), neuropsychological test results in points (levels: Task No. 1, Task No. 2, Task No. 3) and tonal threshold audiometry (TA) indicators (levels: frequency ranges 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, averaged value at speech frequencies, dB). The parameters of long-latency auditory evoked potentials (latency of peaks and amplitude of components) served as an independent factor.

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Table 9

Results of analysis of variance (MANOVA) of neuropsychological testing parameters, tonal audiometry parameters and long-latency auditory evoked potentials

Parameters	Interaction of factors	F	P
Latency P1	ID × TA × Task № 1	1.568	0.34
Latency P1	ID × TA × Task № 2	1.146	0.21
Latency P1	ID × TA × Task № 3	1.221	0.13
Latency N1	ID × TA × Task № 1	1.324	0.36
Latency N1	ID × TA × Task № 2	0.854	0.32
Latency N1	**ID × TA × Task № 3**	**2.449**	**0.05**
Latency P2	ID × TA × Task № 1	1.983	0.07
Latency P2	ID × TA × Task № 2	1.221	0.13
Latency P2	ID × TA × Task № 3	1.317	0.35
Latency N2	**ID × TA × Task № 1**	**3.978**	**0.05**
Latency N2	**ID × TA × Task № 2**	**3.254**	**0.05**
Latency N2	**ID × TA × Task № 3**	**4.867**	**0.01**
Latency P3	**ID × TA × Task № 1**	**2.449**	**0.05**
Latency P3	**ID × TA × Task № 2**	**4.748**	**0.01**
Latency P3	**ID × TA × Task № 3**	**2.154**	**0.05**

Parameters	Interaction of factors	F	P
Amplitude of the component N1–P2	ID × TA × Task № 1	1.843	0.11
Amplitude of the component N1–P2	ID × TA × Task № 2	1.698	0.18
Amplitude N1–P2	ID × TA × Task № 3	1.439	0.43
Amplitude P2–N2	ID × TA × Task № 1	1.174	0.32
Amplitude P2–N2	ID × TA × Task № 2	0.929	0.48
Amplitude P2–N2	ID × TA × Task № 3	1.552	0.41

According to the results presented in Table 9, the productivity of Task No. 1 is associated to a greater extent with the values of tonal threshold audiometry and depends on the latency of the P3 peak of long-latency auditory evoked potentials. The efficiency of Task No. 2 performance is related to tonal threshold audiometry values and peak latencies of N2 and, especially, P3. The productivity of execution of Task No. 3 is determined by parameters of tonal threshold audiometry and latency of peaks N1, N2 and P3.

Thus, a connection has been established between the functional indicators of auditory perception and the effectiveness of performing neuropsychological tests by children with mental retardation. It is also shown that carrying out corrective classes with children with mental retardation, aimed at development of polysensory perception, affects improvement of parameters of threshold audiometry and individual indicators of long-latency auditory evoked potentials.

Discussion

The results of the study show that in children with mental retardation with a total intellectual index on the Wexler scale of 68.4, against the background of a low level of ability to perceive rhythms, perform rhythmic claps and rhythmic movements, perform onomatopoeia (according to the results of neuropsychological testing), the thresholds of tonal audiometry are increased. A statistically significant increase in latency of the P1, N1, P2, N2 peaks and a decrease in the relative amplitudes of the N1–P2 and P2–N2 peaks of long-latency auditory evoked potentials in children with mental retardation, which we obtained at the first stage of work in comparison with the control group, indicates the difficulties arising in the processing of an auditory stimulus in the primary and secondary auditory cortex, namely, in the perception and correct recognition of an auditory stimulus. After corrective work in subgroup A of children with mental retardation, a statistically significant increase in latency in comparison with the control group was noted only for the N1 peak, as well as a decrease in the relative amplitude of the P2–N2 peak. The results obtained after correctional work in subgroup A of children with mental retardation and

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their comparison with the data of subgroup B of children with mental retardation who did not participate in correctional activities indicate an improvement in the processing of the auditory signal in the primary auditory cortex.

Hearing processing disorder and the combined disorders of speech development and learning ability can be observed against the background of preserved peripheral hearing and is defined as «difficulties in processing auditory information in the central nervous system» (Miller & Wagstaff, 2011).

According to the results obtained at the first examination in children with mental retardation, the increase in the threshold of tonal audiometry was from 9 to 16 Db at different frequencies (with a maximum at speech frequencies). It is believed that a decrease in peripheral hearing (by 15–25 dB) is a conditional boundary between normal hearing and hearing loss, which negatively affects the development of speech processes that provide auditory and semantic function (Cunha et al., 2019). There is a perception that hearing processing disorder is not associated with deficits in sensory processing of information but is mainly the cause of attention deficit (Moore et al., 2010; Rosen et al., 2010; Ferguson et al., 2011). The question of whether auditory perception is generally related to cognitive processes is also actively discussed (Cacace & McFarland, 2013; Moore et al., 2013; Moore, 2018; Wilson, 2018). Some studies have argued that there is no direct relationship between auditory working memory and auditory perception (Mishra & Saxena, 2020). In our work, when re-examining children with intellectual disability after corrective work aimed at multy-sensor perception, a decrease in the thresholds of tonal audiometry, as well as latency of individual peaks of long-latency auditory evoked potentials, was established.

Based on the results of the analysis of the analysis of the neuropsychological testing parameters, the tonal audiometry parameters and long-latency auditory evoked potentials, it was established that the success of the neuropsychological tests and the passage of hearing survey is mainly associated with the values of the latency of the N2 and P3 peaks. These peaks are cortical potentials reflecting the arrival of auditory stimuli into the cortex of the greater hemispheres (Naatanen, 1998).

Thus, in children with intellectual disability, the entry of auditory information into the cortex of the greater hemispheres, its analysis and synthesis based on it occur with a delay. After the correction work, a decrease in the latency of these peaks was observed, which was accompanied by an improvement in the passage of neuropsychological tests related, among other things, to the recognition of both speech and non-speech sounds against the background of interference. This is partly consistent with the results of a study, which showed that knowledge of lexical characters and the ability to extract information from long-term memory are crucial for recognizing children's speech under interference signals: as a result of special classes with children, they have increased ability to recognize speech under interference (Nagaraj & Magimairaj, 2020).

We hypothesize that one mechanism of impaired auditory perception in children with mental retardation is the delay in the functional maturation of brain structures, primarily the left hemisphere. The perception and reproduction of speech involves many brain structures included in a network with a core consisting of three anatomical formations: the superior temporal gyrus (Heschl's gyrus, Wernicke's area), the medial temporal gyrus, the inferior frontal gyrus (Broca's area) (Friederici, 2011; Marslen-Wilson & Welsh, 1978; Mirman & Thye, 2018). At the same time, these structures are connected by bundles that form the ventral and dorsal pathways (Keitel & Gross, 2016).

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It is known that in an adult, when perceiving speech and non-speech sounds in the left hemisphere, phase synchronization of gamma rhythms occurs normally, due to which high-frequency sounds are analyzed. When low-frequency sounds are perceived, phase synchronization of theta rhythms is recorded in structures of the right hemisphere (Giraud & Poeppel, 2012; Hickok & Poeppel, 2007; Abrams et al., 2008; Tang et al., 2016). Unlike adults in children in early childhood, high-frequency cortical rhythms prevail in the left hemisphere, and low-frequency rhythms are balanced in both hemispheres. The reason for such differences between adults and children is immaturity of the brain in early childhood, however, the presence of asymmetry of high-frequency patterns in the hemispheres of the brain in normally developing children of this age is a mechanism for facilitating the understanding of speech in masking conditions, i.e. in the presence of other sounds (maskers) (Thompson et al., 2016). The region of the left temporal gyrus plays a leading role in the detection and subsequent ignoring of irrelevant auditory information (Sakakura et al., 2022). With mental retardation in children, there is a delay in the maturation of the regions of the left hemisphere, and thus bioelectric processes compared to the norm (Buduk-ool, 2010), which probably prevents the timely formation of sound perception mechanisms, including in the speech range, especially in camouflage conditions. There is also an idea that one of the mechanisms of delayed speech development in children with mental retardation and minimal decrease in peripheral hearing is the relationship between impaired speech perception and high-frequency sounds (Cherkasova, 2003), which, in turn, negatively affects the speech and intellectual development of children. This is supported by the results of the study, according to which corrective measures for speech development lead to an improvement in the processing skills of auditory information in conditions of noise masking (Loo et al., 2016).

Thus, the study confirmed the hypothesis that the use of methods aimed at the development of multi-sense perception in children with mental retardation contributes to the improvement of auditory gnosis, which is proved by the results of both hearing and neurophysiological research and neuropsychological testing after appropriate corrective measures. The results of the study strongly support the need to identify minimal hearing impairment in children with intellectual disability, since the application of a comprehensive diagnostic system and individual approaches to the development of multi-sense perception to correct auditory impairment can contribute to reducing the formation of incorrect sound stereotypes and speech standards, as well as improving the ability to educate children with mental retardation.

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Author Contributions

G. V. Karantysh planned the research, analyzed and interpreted the obtained data, worked with sources, wrote the review part of the article.

M. A. Muratova conducted the research, analyzed and interpreted the obtained data.

L. A. Guterman conducted the research, analyzed and interpreted the obtained data, worked with sources, wrote the review part of the article.

A. M. Mendzheritsky planned the research, analyzed and interpreted the obtained data.

E. V. Vorobyeva worked with sources, wrote the review part of the article.

Author Details

Galina Vladimirovna Karantysh – Dr. Sci. (Biology), Associate Professor, Head of the Department of Correctional Pedagogy, Southern Federal University, Rostov-on-Don, Russian Federation; ResearcherID: C-6978-2014, SPIN-code: 2050-3577, ORCID: https://orcid.org/0000-0001-9130-6491, e-mail: gvkarantysh@sfedu.ru

Marianna Alekseevna Muratova – Cand. Sci. (Biology), Associate Professor, Associate Professor of the Department of Correctional Pedagogy, Southern Federal University, Rostov-on-Don, Russian Federation; SPIN-code: 6553-4974, ORCID: https://orcid.org/0000-0001-5657-4845, e-mail: mamuratova@sfedu.ru

Larisa Aleksandrovna Guterman – Cand. Sci. (Biology), Associate Professor, Head of the Resource Educational and Methodological Center for Work with the Disabled and Persons with Disabilities, Southern Federal University, Rostov-on-Don, Russian Federation; Scopus Author ID: 57200226748,

ResearcherID: AAH-4614-2020, SPIN-code: 1588-8214, ORCID: https://orcid.org/0000-0001-6294-4910, e-mail: laguterman@sfedu.ru

Alexander Markovich Mendzheritsky – Dr. Sci. (Biology), Professor, Professor of the Department of Correctional Pedagogy, Southern Federal University, Rostov-on-Don, Russian Federation; ResearcherID: C-6978-2014, SPIN-code: 5778-5944, ORCID: https://orcid.org/0000-0001-5584-9763, e-mail: ammendzherickiy@sfedu.ru

Elena Viktorovna Vorobyeva – Dr. Sci. (Psychology), Professor, Professor of the Department of Correctional Pedagogy, Southern Federal University, Rostov-on-Don, Russian Federation; Scopus Author ID: 55571762900, ResearcherID: A-1568-2019, SPIN-code: 6379-9332, ORCID: https://orcid.org/0000-0001-8974-5655, e-mail: evorob@sfedu.ru

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Effect of Art Therapy on Adolescents' Mental Health

Shruti Mittal[1]✉, Mamata Mahapatra[2], Shadab Ahamad Ansari[3]
[1, 2] Amity Institute of Psychology and Allied sciences (AIPS), Noida, India
[3] Galgotias University, Greater Noida, India

✉ mittalshruti36@gmail.com

Abstract: **Introduction**. Adolescent children continue to be vulnerable to issues of mental health. A significant population of these groups suffers from peer pressure, depression, anxiety and parental pressure. Many adolescent people fail to express their emotions to other people. As a result, they experience low self-esteem, fail to communicate effectively and sometimes even fail to appreciate their personalities. **Theoretical Basis**. A research study that employs the systematic review follows formulated questions. In this research, the formulated question guides understanding the relevance of studies in the matter under investigation. The method effectively identifies the research question using the PICOTS (Population, Intervention, Comparator, Outcome, Timing and Setting) framework. **Results and Discussion**. Research obtained from the American Art Therapy Association informs on the efficacy of art therapy. In various ways, researchers observe that it has a positive effect on general mental health regardless of the artistic experience. Thus, art therapy has a general benefit to the community at large while influencing the impact of mental and physical health. Researchers should plan to evaluate the extreme effects of art therapy on mental health diagnosis, treatment alternatives, and integration into learning environments in future studies. Art therapy is one of the important mental health interventions with significant benefits to these adolescents. The intervention tends to offer an integrated approach treatment that focuses on mental and emotional complications. Professional therapists argue that art therapy offers an innate communication and expressive chance for individuals with mental conditions. Additionally, the therapeutic intervention covers the needs of the patient, setting the creative engagement platform.

Keywords: art therapy, anxiety, depression, self-expression, color, emotion, intervention, mental health, therapy, adolescents

Highlights:

- Art therapy tends to offer an integrated approach treatment that focuses on mental and emotional complications.
- There is the firm belief that self-expression in artistic creation generates therapeutic value for individuals seeking deeper healing.

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- The lack of certification for such professionals affects the treatment alternatives.

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Introduction

Adolescents phase several mental health challenges in contemporary society. Children that experience physical health long-term condition (LTCs) continue to be vulnerable to the risks of mental health complications compared to some of their other peers. Few of these children have immediate access to proper pediatric physical health services. Thus, adolescents face many mental health issues (Wigham et al., 2020). Art-based therapy emerges as the immediate alternatives and medical health intervention in the absence of mental health services. Few studies understand the concept of art-based therapies and their relation to mental health intervention in adolescences; this forms the foundation for the following systematic review research paper.

Art therapy is a healthcare intervention model that explores individual minds and emotions through visual expressive ways. Adolescents face several mental challenges that require the intervention of art therapy programs (Bergman et al., 2018). Healthcare providers understand the importance of using visual art applications to facilitate a supportive therapeutic environment for their patients (Wigham et al., 2020). Accordingly, different art and design professionals tend to engage adolescents diagnosed with mental illness in drawing and painting. Others choose different art forms that range from photography and sculpture, allowing individual development through creativity. Few studies tend to explore the effect of such commitment and determination. This scarcity of knowledge prompts the quest to explore the effect of art therapy on adolescents' mental health.

Mental health research reveals that adolescents tend to experience mental health challenges (Tollefsen et al., 2020). In various ways, these groups experience parental pressure, peer pressure and interpersonal or relationship burdens. The result of such complications results in compromised lifestyles and behavior that promotes unhealthy living. For that reason, many young people engage in drug abuse, intensive aggression and suicidal behavior. These are primary signs of poor mental stability and health at their age (Sharifi et al., 2019). Art therapy is a powerful remedy to dealing with some of these issues. Cognitive psychology posits that art therapy allows for self-discovery. It also creates a form of emotional growth for the individuals instilling a positive attitude. The various emotional triggers in the therapy also support healthy living and behavior among the affected groups.

Theoretical Basis

A scoping review of academic literature indicates that art therapy continues to have a significant impact on mental health recovery (Campbell et al., 2016). Accordingly, adolescents who face mental health challenges can receive therapeutic relief upon subjection to art therapy. Health care professionals also observe that it is possible to build an emotional connection by engaging adolescents in creative art. Importantly, the emotional build-up and connection tend to create an opportunity for reconnection to the real world (Lobban & Murphy, 2020). Some of the issues that affect young people revolve around peer pressure, self-perception, and emotional digress. Therefore, when subject to art therapy, many find the ultimate expressive point.

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Contemporary learning environments present challenges to promote mental health among young people. Accordingly, educators promote active learning, which develops from cognitive abilities and stability. A developing challenge to such strategies is the fact that many young people fall victim to mental problems. Research on effective mental hela6th strategies continues to omit the review on the effect of art therapy (Harpazi et al. 2020). This shortcoming creates a gap between mentally stable students and those who face challenges associated with good health. In this respect, educators adopt different mental health learning policies and practices upon the parents and student guardians (Mortazavi, 2018). Accordingly, this initiative follows the request of the World Health Organization that supports mental health stability for the adolescent groups (Owen et al., 2019). The WHO recognizes the positive impact of art therapy in dealing with mental health issues. In various ways, the organization observes that students with mental health challenges require special attention. This line of thinking follows reviewed evidence studies that point to the role of arts in mental health intervention. By far, students subject to art therapy can build learning skills and communicate effectively on their challenges while pursuing academic excellence.

Misluk-Gervase (2020) observes that the 21st century has witnessed increased research on arts and its effect on mental health and individual wellbeing. Several studies have attempted to expand the scope of research for mental health cases. Importantly, psychological studies tend to narrow areas of studies to expound on the relationship between art and mental health therapies (Shella, 2018). The findings obtained from study samples in various research fields remain to be restricted to specific themes. Thus, it is commonplace in research to find a direct correlation between mental health and art therapy. However, few studies have explained the effect on a specific patient group, such as the adolescent population. Further, past research studies have aimed to create awareness of the role of art in the management of mental health cases among young people (Chiang et al., 2019). Research studies have failed to elaborate on the exact effect of art therapy and mental health. These shortfalls in study research prompt a systematic review of the literature to understand the phenomena of interest fully. In this respect, the synthesis question for review aims to explore existing evidence on the role of art therapy in improving mental health and well-being among adolescent groups.

Khan & Moss (2017) argue that the research on art therapy and mental health in adolescent groups has to assume a significant approach. The choice to include the systematic review is to ensure that the study can cover various areas of study. Thus, subthemes act as the immediate guide into the matter under investigation. These include art influence on social determinants of health, support of child development, and support on health-promoting behaviors (Feen-Calligan et al., 2018). Importantly, other subthemes for consideration include prevention of ill mental health and support with regards to caregiving. Including these subthemes guarantees a wide scope of study of relevant issues associated with art therapy and mental health intervention. The focuses of the systematic review were also aimed at understanding art influence in managing mental health conditions and treatment even to other diverse patient groups (Koom et al., 2016). The interests of such sections are to understand art therapy impact on people diagnosed with different types of mental illness. Further, it is to understand the care requirements for patients diagnosed with acute conditions. These features provide an in-depth analysis of art therapy care impact, particularly during neurodevelopment and neurological disorder phases (Stunden et al., 2020). Thus, the end goal is to assist in managing non-communicable diseases and increasing survival chances at the end-of-life

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care stages. Psychology studies explain that art therapy liberates human expression. Accordingly, humans have used art as an expressive remedy to communicate thoughts in place of written words over centuries. In various capacities, art therapy covers broad creative activities as defined by the American Psychology Association. APA explains that art therapy uses creative activities; painting, sketching, sculpting and photography for psychotherapeutic interventions and treatment.

Psychology research reveals that art therapy allows individuals to express thoughts in literal senses. This element of art therapy is the expressive therapy of mental intervention used for persons diagnosed with mental conditions (Alter-Muri, 2017). In learning institutions, art therapy tends to meet the needs of learning students with mental conditions. Accordingly, educators continue to invest their time and expertise in establishing an all-inclusive environment for their students. Therefore, a significant component of the education system accommodates therapeutic services (Zubala et al., 2021). The rationale for the support of such a system is to meet the requirements of specialized education systems. Art therapy is effective when offered in learning institutions and environments compared to clinical settings. Importantly, students may fail to disclose their emotions when in private clinics. Instead, they may willingly share their emotions and thoughts when subjected to ordinary learning environments. Therapists gain an interactive platform for the student and their educators in the school environments. They form part of the support system, which constitutes the teachers, staff and other students. This aspect of therapy forms the non-isolative environment, which becomes beneficial to adolescents with mental challenges. Including art, therapy develops from the drive to understand students' emotional state and perception of academic achievements. It is important to understand that the overall school environment has a general impact on the student's emotional, personal, and behavioral problems. Therefore, incorporate a program that deals with these issues are vital to promoting academic excellence within institutional parameters.

Art therapy is a creative process that allows an individual to express their inner-self. The mental intervention program improves a patient's physical, mental and emotional welfare (Solvang, 2018). In various dynamics, it is a process that resolves personal issues while developing management potency related to behavior and emotions (Aguilar, 2017). Psychology studies reveal that art therapy reduces stress levels in adolescents while boosting self-esteem and awareness–professionals administering art therapy work with people with even less talent (Lazar et al., 2018). Therefore, an individual does not necessarily have to exhibit creative art potential to use the therapy. Instead, therapists tend to work with patients by diving into the underlying messages communicated by an individual (Haeyen et al., 2018). Adolescents tend to benefit from this form of intervention as they get absorbed in the process that supports a healing process. Art therapy mainly achieves different behavior elements from people. Therefore, it plays an influential role in healing and treatment (Killick & Greenwood, 2019). Psychology research also reveals that art therapy offers the chance for individual rehabilitation and psychotherapy. Extensively, the cognitive intervention tends to massage an inner-self. Additionally, art therapy offers an individual the chance to gain a deeper understanding of one. In this respect, a person experiencing mental challenges may secure an opportunity to understand their inner-self, making peace with their personality.

Methodology

A research study that employs the systematic review follows formulated questions. In this research, the formulated question guides understanding the relevance of studies in the matter

under investigation. Art therapy is a healthcare intervention program that benefits different patient groups (Kim et al., 2020). The lack of an understanding forms the imperative to use the methodology to compare studies. It also prompts the researcher in retrieving evidence with the explicit methodology. Accordingly, the systematic literature review will distinguish literature content from different databases to accommodate a rigorous quality of the necessary information. Different search terms also directed the study review to guarantee accuracy in defending opposing views of the study focus.

The sensitive nature of the study prompted the decision to use the systematic review approach. In many ways, this methodology approach tends to appraise and collate relevant empirical evidence. As a result, a researcher can obtain a complete interpretation of research results. Additionally, the method effectively identifies the research question using the PICOTS (Population, Intervention, Comparator, Outcome, Timing and Setting) framework. In the following study, the protocols helped to reduce any forms of bias and resources waste. As a result, the research followed a strict approach with high accuracy levels.

Results and Discussion

Mental health issues continue to raise concerns among healthcare providers. In learning institutions, children continue to face mental health complications affecting their ability to attain academic excellence (Roberts et al., 2021). The growth and developmental pattern change also create mental health complications for young people (Birnbaum et al., 2017). Additionally, some of the social environments also affect mental stability among different age groups. A growing concern develops on the adolescent groups exposed to different social settings. Many adolescents tend to succumb to social life pressure which affects their ability to reason and think. Consequentially, adolescents fail to maintain stable mental health patterns evidenced by their behavioral changes.

Art therapists understand the mental health challenges among different groups of young people. Therefore, they present the tailored treatment alternatives that aim to improve mood, behavior and way of expression (Chesin et al., 2017). In various capacities, art therapists rely on specific creativity, the expressive model, to understand the inner-self of an example patient. Though they understand the challenge of communication, these professionals struggle to learn and observe subjects through expressive ways (Palmer et al., 2018). This approach offers evidence that art tends to create a link between cognitive personality and the outside world (Malhi et al., 2021). Importantly, adolescents' challenges with mental stability use art to express their moods.

Therapists administering art therapy understand that adolescents face various mental health challenges. Thus, they engage in ineffective patient groups, which mainly start by communicating their feelings (Aguirre Velasco et al., 2020). The therapist tends to inquire about student feeling about the learning approach and their perception of themselves (McDonald et al., 2019). As a result, they develop a treatment plan with the student who comes in developing artworks. Therapists allow students to embark on their piece of work without interfering or passing judgment about their work. In these instances, the professional can read through their patient's thoughts from the representative artwork underway. As a result, the therapists pose questions about the artistic work. These falls mainly along the lines of the ease of drawing, painting or coloring. In some cases, the therapists question the mood or appeal of the artwork.

During these stages, the therapists predict the mental state of their patient or client to understand their thoughts and memory when working. In this regard, therapists maximize on common

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principles of cognitive learning and communication (Fenner, 2021). There is the firm belief that self-expression in artistic creation generates therapeutic value for individuals seeking deeper healing. Predominantly, belief and self-expression help clients understand their personalities (Quinlan-Davidson et al., 2021). Several elements of this thinking develop from connecting to color, texture and various art media, which are central to the therapeutic process. The American Art Therapy Association explains that therapists are practitioners trained to interpret various artistic tools (Rowe et al., 2017). They use a categorical tool to connect with a person's thoughts, feeling and psychological disposition. Importantly, these professionals relate with their clients in the psychotherapy process using visual art as the specifics. In some cases, they have to combine the therapies with other intervention programs to derive the desired outcome at a patient level.

The literature review section explains that art therapy has a permanent role in treating psychological disorders. Research studies reveal that art therapy forms part of other creative therapy types. It is among common interventions such as dance, drama, expressive, and music therapy to offer a healing opportunity for the patient population (Kim et al., 2021). The technique used in art therapy tends to encourage people to utilize creative art by exploring self-expression possibilities. These approaches guarantee building on personal insight while fostering means to adapt to new coping skills. In this respect, it is evident that art therapy influences the appreciation of creative works to help patients (adolescents to explore emotions, develop a self-sense of awareness and manage stress (Potash et al., 2017). In other cases, it is proven to boost self-esteem and building on social skills. The diverse research material presented informs that art therapy treat mental disorders and relieve a patient of psychological distress. Patients that choose art therapy are subjected to additional psychotherapy combinations such as cognitive-behavioural therapy (CBT) for effective functioning. This combination of therapies helps treat conditions such as anxiety, depression, emotional distress, and psychological issues.

Research obtained from the American Art Therapy Association informs on the efficacy of art therapy. In various ways, researchers observe that it has a positive effect on general mental health regardless of the artistic experience. Therapists engaging patients with mental complications can use any form of creative arts. They may include drawing, colorful painting and even collage. The strategies apply to different patient groups regardless of their age. Thus, art therapy has a general benefit to the community at large while influencing the impact of mental and physical health. Mental health is of pivotal interest in the study that has observed its efficacy when dealing with different people. The AATA association also explains that a specific clientele group (adolescents) can benefit from creative expression through art therapy. These young people may be victims of domestic abuse, anxiety, depression and even some relationship complication. Thus, a subjection to creative expression helps relieve their frustration to change their behavior and perception of life. The research presented offers significant learning points and a deeper understanding of art therapy. In various ways, the literature material presented indicates that art therapy covers a broad patient population. This element of the mental health intervention is beneficial and has high efficacy standards. The certification of therapists is important to expand on the delivery of the treatment services. The lack of certification for such professionals affects the treatment alternatives. Importantly, in the future, learning institutions should accommodate changing learner demands, especially in the special education category. Researchers should plan to evaluate the extreme effects of art therapy on mental health diagnosis, treatment alternatives, and integration into learning environments in future studies.

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Shruti Mittal – wrote the paper, concept.
Dr. Mamata Mahapatra – finally approved, edited.
Dr. Shadab Ahamad Ansari – edited, approved and reviewed the manuscript.

Author Details

Shruti Mittal – PhD Scholar, Amity University, Amity Institute of Psychology and Allied Sciences (AIPS), Noida, India; Scopus Author ID: 57823052200; e-mail: mittalshruti36@gmail.com
Dr. Mamata Mahapatra – Professor, Amity University, Amity Institute of Psychology and Allied Sciences (AIPS), Noida, India; Scopus Author ID: 57822807200; e-mail: mmahapatra@amity.edu
Dr. Shadab Ahamad Ansari – Associate Professor Psychology, Galgotias University, Greater Noida, India; Scopus Author ID: 57561214200, ORCID: https://orcid.org/0000-0002-1831-9912; e-mail: shadab0002003@gmail.com, shadab.ansari@galgotiasuniversity.edu.in

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The Relationship between Teacher Evaluation of Children's Musical Abilities and Executive Functions Indicators in Children Attending Music Classes

Alexandra G. Dolgikh[1,2], Larisa F. Bayanova[2], Arina N. Shatskaya[2], Anastasia A. Yakushina[1,2]✉
[1] Lomonosov Moscow State University, Moscow, Russian Federation
[2] Institute of Psychology of the Russian Academy of Education, Moscow, Russian Federation

✉ Anastasia.ya.au@yandex.ru

Abstract: Introduction. The purpose of this work was to investigate the correlation between teacher assessment of children's musical abilities and the development of their executive functions. Additionally, as part of the study, an initial approbation was conducted of a questionnaire for assessing the children's musical abilities. The novelty of this research lies, firstly, in the development and practical evaluation of a new tool for assessing children's musical abilities, based on a concept of B. M. Teplov, and secondly, in the demonstration that not only music lessons affect the developmental indicators of executive functions in children, but also some of the executive functions also contribute to children's musical abilities. **Methods**. The study involved 61 children, aged 5 to 6 years, who had attended music classes several times a week at children's art schools in Moscow and Krasnodar. During the evaluation, such indicators of executive functions as cognitive flexibility, working memory and inhibition were studied in the course of several meetings with children. 50 teachers took part in the assessment of the development level of children's musical abilities. They filled out a specially designed questionnaire aimed to identify the level of development of the following parameters of children's musical abilities: pitch perception, sense of rhythm, modal perception and emotional responsiveness. **Results.** As a result, a positive link was established between visual working memory and the assessment of pitch perception in children in music classes. Moreover, as a result of the regression analysis, it was shown that the indicator of children's visual working memory contributes to the assessment of such parameters of musical abilities as pitch perception ($R^2 = 0.241$, $p=0.008$) and emotional responsiveness ($R^2 = 0.149$, $p = 0.043$). **Discussion.** Therefore, the study demonstrates a link between musical abilities and executive functions in children, as well as a contribution of executive functions to the evaluation of their musical abilities, which justifies the value of systematic musical lessons in preschool age.

Keywords: executive functions, preschool age, music lessons, musical abilities, children, inhibition, cognitive flexibility, working memory, music, art schools

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Highlights:

- Musical abilities such as pitch perception, sense of rhythm and emotional responsiveness are positively correlated with such indicators of executive functions as visual working memory and inhibition in children aged 5–6 years.
- Such a component of executive functions as visual working memory contributes to the assessment of children's musical abilities such as pitch perception and emotional responsiveness.
- The established link between musical abilities and executive functions in preschool children indicates the possibility of introducing to musical classes specially designed programs aimed to develop children's executive functions.

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Introduction

Research of musical abilities

Music is a cultural universal, and all people have the potential to develop musical abilities and skills. However, the evaluation of musical abilities have remained problematic for many years. Many authors have developed methods for assessing musical abilities (Correia et al., 2021; Bentley, 1966; Gordon, 1989; Teplov, 1947), which has led to a large number of approaches to understanding what «musical abilities» are and a variety of testing procedures for this phenomenon (Colwell & Abrahams, 1991; Woodford, 1996; Hallam, 2010; Hallam & Papageorgi, 2016). The lack of a unified theoretical concept for musical abilities was not only reflected in a multitude of testing procedures, but also caused extensive criticism of existing tests, for example, their emphasis on auditory perception and the duration of practice (Howe et al., 1995; Woodford, 1996; Demorest, 1995; Hallam, 2010; Ollen, 2006; Mosing et al., 2014). Moreover, critics claim that the existing tests cannot reflect the true nature of musical abilities and their development, since they ignore a number of important abilities, for example, musical communication, music perception, motivation (Murphy, 1999).

The approach currently used to assess musical abilities considers them a social construct that bears different meanings in different cultures, social groups and even individuals (Hallam & Prince, 2003; Butkovic et al., 2015). Understanding musical abilities as a construct, specific to a population of a country, its musicians and music teachers, allows us to take into account cultural characteristics, as well as current social changes. This enables us to cover many facets of the concept of musical abilities in such a way as to reflect the real experience of practicing music (Levitin, 2012; Kragness et al., 2021).

For example, in a study by Haroutounian (2000) which involved 244 music teachers from the USA, it was shown that such indicators as sustained interest and self-discipline scored higher as predictors of musical abilities and giftedness than musical skills in the strict sense. However, among the skills, the highest average score was obtained for pitch and rhythm accuracy, rhythmicity and

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technical fluency. With additional clarifications, the experts stressed the importance of music perception, creative interpretation, performance and motivation. O'Neill (2002) investigated beliefs about musical abilities by evaluating children's personal beliefs about this construct. During the interview, 172 children from the United Kingdom aged 6 to 11 were asked about their beliefs about their own musical abilities. The results showed that the beliefs about one's musical abilities are largely based on their personal experience of practicing music: children who did not play any instruments demonstrated a more rigid view of musical abilities, leaving little room for change. In contrast, children with musical experience had more flexible ideas. Furthermore, motivational factors and enthusiasm are important components of musical abilities (Hallam, 2010; Hallam & Prince, 2003). The pleasure derived from music, as well as the internal motivation that develops through musical experience, are often described as important prerequisites for musical activity and intensive practice necessary for musical skills development (Sloboda et al., 1994).

Within the Russian psychology of musical abilities, the most developed and authoritative concept is the one by B. M. Teplov (1947). According to it, when assessing musical abilities, the following components must be taken into account: modal perception (the ability to perceive pitch movement, the direction and the expressive qualities of the melody), pitch perception (the ability to reproduce sounds and melodies by ear) and sense of rhythm (the ability to feel the rhythm and repeat it) (Teplov, 1947). Moreover, this concept suggests that all musical abilities are interconnected and develop through children's musical activity. In this regard, when evaluating musical abilities, it is important not to think in terms of presence or absence of a particular ability, but rather about the interrelation of the abilities.

Executive functions and music lessons in preschool age

Executive functions are the general cognitive abilities necessary for purposeful behavior, adaptation and problem solving (Miyake et al., 2000; Morosanova et al., 2021). They include several components such as inhibition, cognitive flexibility, and working memory (Miyake et al., 2000; Miyake & Friedman, 2012). Many authors state that executive functions are important predictors of academic success, social success and quality of life (Shanmugan & Satterthwaite, 2016; Diamond, 2013; Denham & Brown, 2010). In this connection, there is a great potential in developing educational strategies for their development, starting from childhood (Bukhalenkova et al., 2020).

One of the possible ways to develop executive functions in children of preschool and primary school age are music lessons (Diamond & Lee, 2011). Meanwhile, it is noted that various types of musical activities (in particular, playing an instrument, participating in an orchestra, choral singing) can increase the indicators of executive functions of preschoolers and younger schoolchildren (Bugos & DeMarie, 2017; Holochwost et al., 2017; Degé et al., 2011; Jaschke et al., 2018; Roden et al., 2014; Frischen et al., 2021). Several empirical studies have investigated the relationship between instrumental music lessons and executive functions in children (Degé et al., 2011; Joret et al., 2017; Zuk et al., 2014; Chen et al. 2021; Fasano et al., 2019). The results of these studies indicate a positive link between music learning and such indicators of executive functions in children as inhibition (Joret et al., 2017; Fasano et al., 2019), working memory (Chen et al. 2021), cognitive flexibility (Dege et al., 2011; Zuk et al., 2014), information processing speed (Zuk et al., 2014) and planning (Dege et al., 2011; Chen et al. 2021).

At the same time, it is worth mentioning that playing a musical instrument requires a high level of various components of executive functions, such as inhibition, selective attention and

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cognitive flexibility (Degé & Frischen, 2022; Okada & Slevc, 2018; Holochwost et al., 2017). For example, inhibition skills are required when the key or rhythm changes, and the musician needs to suppress the intention to stay in the previous key or rhythm (Degé & Frischen, 2022). In addition, the musician must read the notation and translate it into sounds, all while listening to the melody and analyzing it for errors, speed and volume, which also certainly requires a sufficient level of development of executive functions (Slevc et al., 2016).

Thus, despite a large number of studies demonstrating the relationship between music lessons and executive functions, it remains unclear whether music classes contribute to the development of executive functions or whether children with more developed executive functions are more likely to attend them (Schellenberg, 2006; Bayanova & Hamatvaleeva, 2022).

Due to the ambiguous results of studies on the influence of executive functions on children's musical abilities, and the lack of modern diagnostic tools for evaluating children's musical abilities, we decided to develop a questionnaire for music teachers and to assess the correlation between executive functions indicators and the results of this questionnaire.

Methods

Sample

61 children participated in the study: 17 boys and 44 girls (M age = 68.72 months, SD age = 6.73) who attended music classes in the institutions of additional education (children's music schools and art schools) in Moscow and Krasnodar. All the children participating in the study were in senior kindergarten groups. Children attended music classes at art schools over a period from 3 to 6 months, from 1 to 3 times a week. These lessons consisted of both practicing a musical instrument and mixed activities where children danced to music, studied in a group, and sang in a choir. 2 meetings lasting 20 to 25 minutes each were held with each child. The order of presentation of tasks in each meeting was the same for all children.

Tools

The level of development of executive functions was measured using a battery of tools that are subtests of the neuropsychological diagnostic complex NEPSY-II (Korkman et al., 2007):

1. The «Sentences Repetition» subtest is aimed at assessing auditory verbal working memory. This technique uses 17 sentences with a gradual complication of the stimulus material (sentences become longer and more complex in structure). For each sentence, the child is awarded 2 points if there are no errors, 1 point – for one or two errors, 0 points – for three or more errors or in case of a failure to repeat the sentence.
2. The «Memory for Designs» subtest is intended to assess visual working memory. With this technique, two aspects of visual memory are measured at once – memory for «images» and for the spatial arrangement of details. For each task, one point is awarded for each correctly selected card («details»), one for each correctly indicated place, according to the model («location»).
3. The «Dimensional Change Card Sort» subtest consists of several tasks for sorting cards by different attributes. This technique is aimed at determining the level of development of cognitive flexibility in a child.
4. The «Inhibition» subtest includes two tests: the first one is for naming geometric shapes, and the second one is for inhibition. The results of the child's performance (the number of mistakes made and the time spent on each take) allow to determine to what level the

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processes of switching and inhibition are developed.

Questionnaire for teachers

To evaluate the musical abilities of children attending music classes, a questionnaire «Assessment of children's musical abilities» was developed. When working on a questionnaire for teachers, we chose as a basis the concept of musical abilities of B. M. Teplov (Teplov, 1947), as it was described above. However, due to the need to take into account the actual life context and the importance of the motivational and emotional components of children's development, we have then included another component of musical abilities, which is more associated with enjoying music – emotional responsiveness, which is defined as the ability to emotionally engage in music and to awaken the imagination.

Thus, this questionnaire consists of 20 questions and requires teachers to assess musical abilities of children they are working with. Each of the 4 scales consists of five questions about relevant competencies of the child: the ability to reproduce a melody, perception of melodic motion, distinguishing registers by ear, identifying the rhythm of the melody, and the emotional response to the melody.

– The «Pitch Perception» scale includes the following questions: «The child is able to sing his favorite song with and without accompaniment, intoning the sounds purely»; «The child is able to identify the melodic motion – ascending, descending, repeated»;
– The scale «Modal Perception» consists of the following questions: «The child is able to identify the mode of a chord – major or minor»; «The child is able to determine the melodic motion of chords – ascending, descending, repeated»;
– The questions for the «Sense of Rhythm» scale are as follows: «The child is able to organize sounds into musical forms and ultimately into a whole composition»; «The child feels and understands the character of the rhythm (calm and slow, active and cheerful)»;
– The «Emotional Responsiveness» scale includes the following questions: «The child is able to feel the character of the music (cheerful, sad)»; «Music awakens the child's imagination, evoking a variety of ideas, associations, images».

The approbation of the methodology took place in several stages. At the first stage, the questionnaire was designed, consisting of 16 questions that constituted a single scale. Then a focus group of 7 teachers from 3 music schools was gathered. They were sent the primary version of the methodology. After the final version was approved by experts, the questionnaire was sent to music schoolteachers. In total, the study included 50 teachers, who taught children undergoing the assessment.

Results

Microsoft Excel 2016 and IBM SPSS Statistics 22 programs were used to process the empirical data. As a result of checking the distribution for normality, it was shown that the distribution over the sample is mixed (Kolmogorov – Smirnov criterion), therefore, nonparametric data processing methods were applied for further testing of the hypotheses.

From the analysis of descriptive statistics of the executive functions indicators, it was demonstrated that the indicators of preschool children attending additional music classes are within the norm relative to the indicators of children of the same age who were not attending music classes (Table 1).

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Table 1

Descriptive statistics for executive functions indicators in preschool children

Executive functions parameters	Average value	Minimum value	Maximum value
Cognitive flexibility	19.36	13	22
Visual working memory	85.66	53	114
Visual verbal working memory	19.52	8	28
Naming time	92.51	49	164
Inhibition time	124.69	80	180
Mistakes	12.87	3	51
Naming mistakes	4.22	0	25
Inhibition mistakes	8.64	2	31
Naming comb.	10.43	1	17
Inhibition comb.	10.18	3	16

Check of the consistency-reliability for the teachers' questionnaire scales

To check the consistency reliability for the scales of the questionnaire «Assessment of children's musical abilities», the Kronbach alpha coefficient ($\alpha = 0.880$) was calculated. A sufficiently high coefficient indicates that the scales of the methodology are consistent with each other.

As a result of the correlation analysis of the questionnaire scales (Spearman's Ro), it was shown that all scales of the methodology significantly and positively correlate with each other ($p < 0.01$). Similar results also demonstrate the link and consistency of the questionnaire scales with each other (Table 2).

Table 2

Results of the correlation analysis for the teachers' questionnaire scales

Indicators of the Russian Federation	Pitch perception	Modal perception	Sense rhythm	Emotional responsiveness
Pitch perception		.714**	.631**	.544**
Modal perception	.714**		.761**	.545**
Sense of rhythm	.631**	.761**		.738**
Emotional responsiveness	.544**	.545**	.738**	

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The relationship between teachers' assessments and the indicators of children's executive functions

To determine the level of correlation between teachers' assessments of children's musical abilities and executive functions and emotional development of preschoolers, a correlation analysis was carried out (Table 3).

Table 3

Results of the correlation analysis of the executive functions indicators and the teachers' assessement

Indicators of the Russian Federation	Pitch perception	Modal perception	Sense of rhythm	Emotional responsiveness
Cognitive flexibility	0.064	0.011	0.132	0.240
Visual working memory	0.421**	0.262	0.333*	0.342*
Visual verbal working memory	–0.050	–0.072	0.019	–0.056
Naming time	–0.323*	–0.280	–0.302*	–0.348*
Inhibition time	–0.363*	–0.264	–0.283	–0.234
Mistakes	–0.282	–0.241	–0.173	–0.337*
Naming mistakes	–0.106	–0.186	–0.092	–0.233
Inhibition mistakes	–0.304*	–0.219	–0.164	–0.302*
Naming comb.	0.096	0.066	–0.021	0.106
Inhibition comb.	0.207	0.069	–0.005	0.162

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Based on the correlation analysis, significant positive links were found between such indicators as visual working memory and pitch perception ($r = 0.421$; $p < 0.01$). That is, the more developed a child's visual working memory, the higher this child's teacher's evaluation of her or his ability to reproduce a melody and the ability to identify melodic motion. In addition, indicators of visual working memory are positively correlated with teachers' assessments on such indicators as a sense of rhythm ($r = 0.333$; $p < 0.05$) and emotional responsiveness ($r = 0.342$; $p < 0.05$).

Also, several indicators of the techniques for measuring inhbition demonstrated significant negative correlations with such indicators of children's musical abilities as pitch perception, sense of rhythm and emotional responsiveness. That is, the faster the children cope with tasks for inhibition, the higher the teachers evaluate their ability to reproduce the melody, to identify melodic motion, to identify the rhythm of the music, as well as their ability to respond emotionally to music.

To analyze, to what extent the developmental level of the executive functions of children in music classes contribute to the assessment of their musical abilities, a multiple regression analysis was carried out, where the criterion was musical abilities indicators, and the predictors were executive functions listed above.

Table 4

Results of the regression analysis for the contribution of the executive functions indicators to the indicators of the «Pitch Perception» variable

	Regression coefficient	R-square	F	Significance	Durbin-Watson Criterion
Constant	8.064				
Visual working memory	0.126	0.241	8.264	0.008	1.596

As a result of the regression analysis, it was shown that the indicator of children's visual working memory contributes by 24.1 % to the teachers' assessment of such a parameter as pitch perception (Table 4).

Table 5

Results of the regression analysis for the contribution of the executive functions indicators to the indicators of the Emotional Responsiveness variable

	Regression coefficient	R-square	F	Significance	Durbin-Watson Criterion
Constant	14.026				
Visual working memory	0.081	0.149	4.534	0.043	1.291

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As a result of the regression analysis, it was shown that such an indicator of children's executive functions as visual working memory contributes by 14.9 % to the teachers' assessment of such a parameter as emotional responsiveness (Table 5).

Thus, such an indicator of executive functions as visual working memory largely determines teachers' assessments of such indicators of musical abilities in preschoolers as pitch perception and emotional responsiveness.

Discussion

As a result of the conducted research, we have developed and tested a methodology of teacher evaluation of children's musical abilities.

Verification of the consistency-reliability of this questionnaire showed acceptable results, which indicates the uniformity of the scales and the possibility of its further implementation. At the same time, due to the lack of other diagnostic tools, at the moment we cannot verify the construct validity of this methodology.

Also, as a result of the study, a relationship was revealed between such a parameter of executive functions as visual working memory and such a parameter of teacher evaluation as pitch perception. In other words, children with a more developed ability to retain objects and their location in working memory are more able to recognize sounds of different heights and timbres. Moreover, the results demonstrated that the parameter «visual working memory» contributes more than 20 % to the ability to recognize sounds. In our opinion, these results may be linked to the fact that while learning to play a musical instrument, children primarily learn to read notation and take solfeggio classes, improving their musical hearing and literacy. While developing the ability to correlate notes and sounds, children are possibly also developing their visual working memory. This result is consistent with some studies that also show the effect of music lessons on visual working memory (Frischen et al., 2021; Bayanova et al., 2022). For example, in the work of Frischen and colleagues (2021), the children who participated in the study were taught to play musical instruments, which included learning and reading musical notation. It can be assumed that this specific activity contributes to the development of visual working memory in contrast to mixed musical activities, when children also sing, listen to music, dance to music, play rhythmic games, etc. (Frisen et al., 2021). Moreover, a study by Bayanova and colleagues showed that children who practice music also have a higher level of visual working memory than children who do not (Bayanova et al., 2022). However, in this study, such differences were not significant, which is explained by the fact that the children included in the musical group were not only practicing a musical instrument, but were also engaged in other music-related activities. In addition, this study was a pilot, and many factors that could influence the results were not controlled. Lastly, some authors note that visual working memory develops in children at a later age, which may also influence the contradictory results of the study by Bayanova and colleagues (Tikhomirova et al., 2020).

At the same time, it is important to emphasize that the results of this study do not agree with most studies on this topic. The latter demonstrate the influence of music lessons on the development of auditory verbal working memory to a greater extent than on visual working memory (Ho et al., 2003; Бойко и др., 2019; Chen et al. 2021). In our opinion, this may be due to the limitations of the study. One of these limitations is a small sample, which makes it impossible to sufficiently assess the diagnostic capabilities of the developed questionnaire and its potential

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to search for links between the children's executive functions and their teachers' assessment of their musical abilities. Also, the children who took part in this study had attended music classes for no more than 6 months, so their abilities may not have been formed sufficiently yet to produce noticeable differences in both musical abilities and executive functions. In addition, since it was a pilot study, it have not taken into account such factors as teacher-student relationships, teaching style, home music environment, and others.

Conclusion

Therefore, as a result of this research, a questionnaire was developed and tested to assess the musical abilities of children. This questionnaire is valuable for further study of the link between children's musical abilities and both their personal and cognitive development, as well as the specific features of music teaching in children's art schools. Moreover, the results of the study revealed a link between such a component of executive functions as visual working memory and children's musical abilities. Further study of how music lessons are connected to the development of executive functions is important, on the one hand, for designing programs aimed at working on executive functions of preschool children, and on the other hand, for improving children's musical skills through the development of their executive functions.

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A. G. Dolgikh made the conceptualization and methodology of the study, developed project administration and made the final approval of the version for publication.
L. F. Bayanova made the conceptualization and methodology, final approval of the version for publication.
A. N. Shatskaya – prepared the research, made the final approval of the version for publication.
A. A. Yakushina made the preparation and editing of the text, statistical analysis, and final approval of the version for publication.

Author Details

Alexandra Georgievna Dolgikh – Cand. Sci. (Psychology), Associate Professor, Head of the Laboratory of Psychology of Information Security of Adolescents, Psychological Institute of the Russian Academy of Education, Faculty of Psychology of the Lomonosov Moscow State University, Moscow, Russian Federation; ORCID: https://orcid.org/0000-0001-8845-1575, e-mail: ag.dolgikh@mail.ru

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Larisa Faritovna Bayanova – Dr. Sci (Psychology), Professor, Researcher of the Laboratory of Childhood Psychology and Digital Socialization, Psychological Institute of the Russian Academy of Education, Moscow, Russian Federation; Scopus Author ID: 35329260200, ORCID: https://orcid.org/0000–0002–7410–9127, e-mail: balan7@yandex.ru
Arina Nikolaevna Shatskaya – assistant at the Laboratory of Childhood Psychology and Digital Socialization, Psychological Institute of the Russian Academy of Education, Moscow, Russian Federation; ORCID: https://orcid.org/0000-0001-7283-8011, e-mail: arina.shatskaya@mail.ru
Anastasia Alexandrovna Yakushina – lecturer at the Department of Educational Psychology and Pedagogy, Faculty of Psychology, Lomonosov Moscow State University, Psychological Institute of the Russian Academy of Education, Moscow, Russian Federation; Scopus Author ID: 57226891040, ORCID: https://orcid.org/0000-0003-4968-336X, e-mail: Anastasia.ya.au@yandex.ru

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Structural and Functional Organization of Life Successfulness as a Meta-resource of the Personality of a Modern Higher School Teacherr

Natalya A. Semenova
The Krasnodar University of the Ministry of Internal Affairs of Russia, Krasnodar, Russian Federation
natalya_deeva@bk.ru

Abstract: Introduction. The relevance of the study is in connection with changes in the world, including the processes in the higher education system, when transformations take place considering the interests of the national economy, is substantiated. A new view on the problem of studying the personal resources of a higher school teacher is presented, where special attention is paid to the search for functional formations that allow the most efficient implementation of professional activities and maintaining the functioning of one's own personality at a productive level. For the first time, within the framework of the developed meta-resource concept, an understanding of the life successfulness is proposed. The problem of the need to study the structural and functional organization of the life successfulness of a higher school teacher in order to identify and study its features is posed. **Methods.** The study involved 164 teachers of educational institutions of higher education from different regions of Russia from 27 to 77 years old. The study was conducted using the author's self-assessment methodology «Life Success». The survey was conducted by posting on Google Forms. **Results.** The following results were obtained: praxis, existential experiences and subjective assessment of one's success in life are most pronounced; the integral qualities of success and moral experiences are expressed to a lesser extent; the average value of the subjective assessment of success in life is 7.23 on a ten-point scale; in the first place in importance for a successful life are the values of family and health; positive significant relationships were found between reflexive mechanisms and integral qualities of success in life. **Discussion.** The results made it possible to draw conclusions about the presence of strengths and problems of the meta-resource of the life successfulness of the respondents. Strengths include: a large number of interconnections between the components of life successfulness; the severity of praxis experiences, productive life disposition, reflexive-ontological mechanism of life successfulness; proximity of the real value hierarchy to the ideal of success; functional significance of instrumental qualities and focus on success. The identified problems can be «points of growth» for the most productive functioning of the meta-resource of life successfulness.

Keywords: meta-resource, personal resources, life successfulness, reflexive mechanisms, integrative qualities, experiences, values, teacher's personality, pedagogical activity, higher education

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Highlights:

- Life successfulness is a meta-resource of the personality of a modern teacher, and the features of its functioning determine the effectiveness of professional activity and life in general.
- The results of the study showed the presence of features of the organization of this meta-resource in the sample of teachers of higher education in comparison with the general sample.
- Features of the organization are in the severity and interrelationships of the structural components of life successfulness.

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Introduction

The relevance of the study of life successfulness of a teacher of higher education

Modern higher education is currently on the verge of major changes due to political, economic and sociocultural factors. The changes concern the transformation of the entire system of higher education, considering the interests of the national economy and the creation of a space of opportunities for students. This situation is especially significant for teachers as subjects of the educational process. In transitional moments, the personality of the teacher (university lecturer) becomes especially significant, because his personality transmits values and meanings to students, makes his personal contribution to their development and formation.

Psychological, pedagogical and psychological-pedagogical research highlights the issues associated with the radical transformation of the teacher's activity, due to various and sometimes mismatched reform processes in higher education.

This situation puts the teacher in the position of «incompetence» and, as a result, causes inconsistency in the functionality and personal qualities (Verbitsky, 2014). At the same time, the multi-role activity of a teacher of higher education requires the presence of developed meta-resources, which, from the standpoint of integrity, would allow one to regulate one's own system of resources in order to increase the efficiency of life.

The meta-resource of life successfulness, in this case, has one of the key values. The formation of the mechanisms of life success of a teacher, the value bases of his success, personal qualities and experiences that he demonstrates in the process of professional pedagogical activity, creates space for the formation of the personality of students.

The problem of researching the personal resources of a higher school teacher

Most research on the personality of a teacher concerns personality traits and the various options for integrating them.

Among domestic studies of the last decade devoted to this issue, at least three areas can be distinguished. Firstly, these are studies that reveal the most significant personal qualities of a teacher for the successful implementation of professional activities. Researchers have identified a very wide list of such qualities, which is very diverse and difficult to systematize; chronological dynamics can only be noted conditionally. Increased attention to the study of moral qualities is manifested in the first decade of the XXI century (honesty, justice, kindness (Ratner, 2007;

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Romanchuk, 2010)), subsequent studies are mostly related to professional abilities (practical training, experience, pedagogical flexibility, creativity (Borisenko et al., 2012)), emotional competence (Silantyeva, 2017), the ability to motivate and interest the audience (Tsvetkova et al., 2017), and in recent studies, the most significant qualities reflect the level of development of soft skills (tolerance, sociability, progressiveness, awareness and life wisdom) (Lukashenko & Ozhgikhina, 2019).

Secondly, it is the search for certain integrative formations that characterize the personality of the teacher: I-image, image and their correlation (Tsvetkova et al., 2017; Lukashenko & Ozhgikhina, 2019). Researchers point out that the image and self-image are quite contradictory.

Thirdly, this is a study of functional formations that would allow the teacher to most effectively carry out professional activities and maintain the functioning of his own personality at a productive level, in particular, to maintain psychological health (Demchenko et al., 2021). For example, scientists refer to such formations: readiness for self-change, lability of mental attitudes, self-development of personal qualities necessary in modern society («resource for success», self-confidence), active position, responsibility, creativity, productive life strategies, life potential and hardiness (Nikiforov et al., 2015; Skazko & Kostina, 2018). These integrative formations allow the teacher to move from the strategy of primitive functioning to higher-order strategies and creative self-expression in the profession (Plugina, 2008).

The third direction is the most productive in terms of searching and structuring the teacher's personal resources. These integrative formations implement the resource function to the fullest extent. The resource approach allows you to address the strengths of the personality, its constructive beginning. «Psychological resources can buffer vulnerability to negative psychological outcomes… and help to identify positive opportunities» (Bokhan et al., 2021, p. 274).

Foreign colleagues pay attention to teacher self-efficacy in their research (Matos et al., 2022; Milkhatun et al., 2020), ethical aspects of behavior (Jabbar, 2017) and personal characteristics (Siamian et al., 2012).

Life successfulness as a meta-resource of a teacher's personality

In this study, life successfulness of a person is considered as such a meta-resource. In our opinion, meta-resources occupy the highest level in the hierarchy of personal resources and represent integrative psychological formations that provide the most effective resolution of contradictions that arise in a person as a subject of social relations due to the transformation of the value-semantic sphere of a person in the process of self-regulation. One of these meta-resources is life successfulness.

The complexity and versatility of the phenomenon of life successfulness is revealed through the search for its essence in the cultural and historical context, scientific, practical and popular science psychology, philosophical and socio-philosophical knowledge. An analysis of the emergence of life successfulness as a phenomenon in a cultural, historical and philosophical context makes it possible to draw a conclusion about its formation in accordance with the historical stages of the development of society (Deeva, 2020).

In various areas of psychological science, one way or another, the problems associated with various aspects of the manifestation, formation and functioning of success were touched upon. For example, positive psychology provides the key to understanding success in life from the standpoint of a person's resource potential (Seligman, 2012), while the authenticity of success is related to its longevity and goals, which reveals its meta-resource function.

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The subject-activity paradigm in psychology outlines the problems of success and success of a person in the semantic field of categories and concepts related to the space of life and human meanings: life strategy, awareness, purposefulness, self-realization, etc. It is in this paradigm that success is correlated with the integral life of a person, which makes it possible to define the phenomenon of «life successfulness» and approach its understanding as a meta-resource of a person participating in the process of self-regulation. The relevance of the problem of success is increasing in the most modern studies of Russian psychology (Tulchinsky, 2016; Gelfond et al., 2020; Gafarova & Chernyaeva, 2015; Baturina & Chernyaeva, 2018; Baturin, 2018; Shabunova et al. 2019; Logvinova, 2016; Golovchanova, 2010; Dementy, 2004). Success as a process is an integrative psychological education (Baturina & Chernyaeva, 2018) associated with various personal resources that affect life productivity (Brian, 2005; Seligman, 2012; Erofeeva, 2021; Duckworth et al., 2007; Erofeeva & Nartova-Bochaver , 2020; Duckworth & Gross, 2014; Gordeeva et al., 2021; Kramarenko, 2008; Sidorov & Vasiliev, 2018; Dvoretskaya, Loshchakova, 2016; Rean et al., 2022). The characteristics inherent in success are a complex of integrative qualities of a person, where success in life acquires the status of a meta-resource that regulates their interconnections and functioning.

We rely on the principles of regulatory, resource and subjective approaches when building a meta-resource concept of life successfulness. A developed system of self-regulation has resource capabilities in the form of various psychological formations, mechanisms and processes that help a person to reveal his own potential, update his capabilities, achieve his goals and maintain a balance of integrity and openness to the world. Thus, the system of self-regulation, the system of psychological resources and subjectivity are inextricably linked (Morosanova, 2021; Leontiev, 2016). An important point is that success in various types of activities is ensured by the formation of an integral system of self-regulation, and any defect in the regulation process significantly limits the effectiveness in various types of activities (Konopkin, 2012). The system of success criteria makes it possible to specify the goal in the action program and compare the results obtained with the desired ones.

Life successfulness, as a meta-resource in the system of self-regulation of a personality, which has an acceptor function, on the one hand, reflects and presents, and on the other hand, determines the main value strategies of society and a person, is the starting point for the subjective choice of «life coordinates» of the individual. The essence of life successfulness as an integrative psychological education lies in the reflexive correlation of the anticipated and already achieved goals of subjective activity in accordance with the program of actions in the process of elections and decisions in the value-semantic and socio-cultural space. Life successfulness includes the relationship of mechanisms, properties and states: 1) as a set of special reflexive mechanisms functioning in the value-semantic space of the individual, aimed at understanding the relationship, social and existential significance of the goal and result of activity; 2) as an integral property of the personality, consisting of complexes of personal qualities, characterized by ways to achieve goals, motivational orientation and life disposition of the personality; 3) as an emotional experience that arises in the process of achieving the goal and evaluating the result, which accompanies the processes of understanding and evaluating one's own achievements (Deeva, 2022a, 2022b).

The problem of the research is to study the meta-resource of a person's life successfulness, which functions as a systemic education and contributes to an increase in the efficiency of the teacher's professional activities while maintaining the overall productivity of life.

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Purpose: to identify the features of the structural and functional organization of the meta-resource of life successfulness of a teacher of higher education.

Methods

Sample

The sample consisted of teachers of educational institutions of higher education from various regions of Russia (Krasnodar Territory, Rostov Region, Vologda Region, Khanty-Mansi Autonomous Okrug-Yugra, St. Petersburg, Moscow, Belgorod Region, Krasnoyarsk Territory, Primorsky Territory, Omsk Region, Kaliningrad Region) in the amount of 164 people ; of these, 54 men and 110 women aged 27 to 77 years. Teaching experience from 2 to 40 years.

Procedure and research methods

The study of the life successfulness meta-resource was carried out using the author's methodology «Life success», which was tested for reliability, constructive and convergent validity (Deeva, 2022a). When establishing convergent validity, the relationship of life successfulness with the scales of diagnostic questionnaires was confirmed, which characterize a positive motivational and psychological state, resource capabilities, subjectivity of the personality, which in general expresses the constructive beginning of the personality and a positively active attitude to life.

The methodology is a questionnaire aimed at studying the components of life successfulness and their relationships in accordance with a theoretical construct. The questionnaire has four parts aimed at studying the components life successfulness: reflexive mechanisms (reflexive-technological, reflexive-axiological, reflexive-ontological); integral qualities (instrumental qualities, focus on success, life disposition); emotional experiences (practical experiences, moral experiences, existential experiences); value orientations (correlation of real and desirable orientations of success in life, subjective assessment of one's own success in life). The questionnaire is hosted on the Google Forms platform.

Statistically significant differences were not found in terms of measured indicators between men and women, and no significant correlations with age and teaching experience were found, so the data are provided for the entire sample.

Results

The results obtained during the implementation of the questionnaire «Life success» allow us to talk about the features of severity, qualitative content and the relationship between the components of life successfulness in the sample under study.

Comparison of the average indicators obtained on a sample of teachers and on a mixed sample during the validation of the methodology (which included representatives of different professional affiliations) showed that the results on the indicators of the methodology, except for indicators of reflexive mechanisms, have significant differences (the Kolmogorov-Smirnov criterion was applied for independent samples) (Table 1).

To a greater extent, compared with the indicators of the general sample, teachers expressed praxic experiences, existential experiences and a subjective assessment of their success in life. All groups of integral qualities, as well as moral experiences, are expressed to a lesser extent. At the same time, the indicator of mismatch of values is expressed by teachers to a lesser extent. The

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severity of indicators characterizing the components of life successfulness relative to each other within the sample differs statistically significantly. The value of Friedman's criterion for reflexive mechanisms (reflexive-technological, reflexive-axiological, reflexive-ontological) is 17.862 (asympt. value 0.000); for integrative qualities (instrumental qualities, focus on success, life disposition) - 11.790 (asympt. value 0.003); for experiences (practical, moral and existential experiences) – 12.785 (asympt. value 0.003).

Table 1

Average values of life successfulness indicators in the sample

Indicators of life successfulness components	Sample of teachers (21–77 years old, N = 164)		General sample of respondents (18–77 years old, N = 705)		Indicators of the Kolmogorov-Smirnov criterion	
	M	St.	M	St.	Values	Asympt.
Reflexive-technological Mechanism	6.43	1.20	6.52	0.86	0.521	0.949
Reflexive-axiological mechanism	6.11	1.13	6.11	0.78	1.092	0.184
Reflective-ontological mechanism	6.57	1.24	6.63	0.80	1.127	0.158
Instrumental qualities	6.48	1.37	6.86	0.70	1.570	0.014
Success orientation	6.36	1.49	6.82	0.67	1.546	0.018
Life disposition	6.55	1.47	6.96	0.72	1.421	0.035
Praxic emotional experiences	7.46	6.08	6.10	0.71	5.410	0.00
Moral emotional experiences	5.95	1.41	6.66	0.79	5.410	0.00
Existential emotional experiences	6.05	1.56	5.78	0.79	5.410	0.00
Divergence of value orientations	1.88	1.54	2.82	1.62	3.371	0.00
Subjective assessment of life successfulness	7.23	1.64	6.40	1.54	2.279	0.00

With a more detailed analysis of the results, a percentage ratio of the severity of the levels of formation of reflexive mechanisms, integral qualities and experiences of life successfulness was obtained (Fig. 1).

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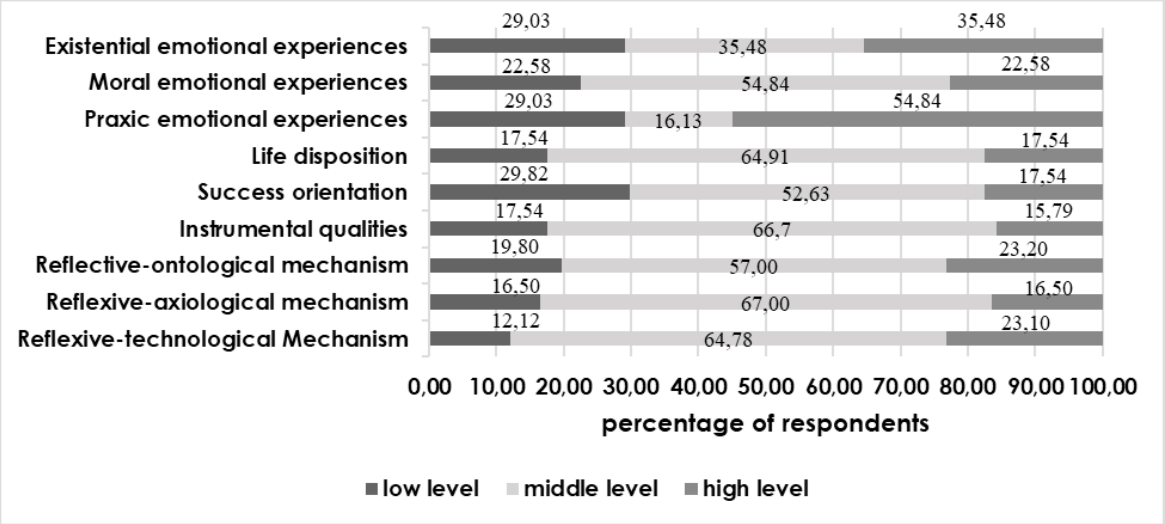
Figure 1

Percentage of the levels of severity of indicators of the components of life successfulness in the sample of teachers (in %)

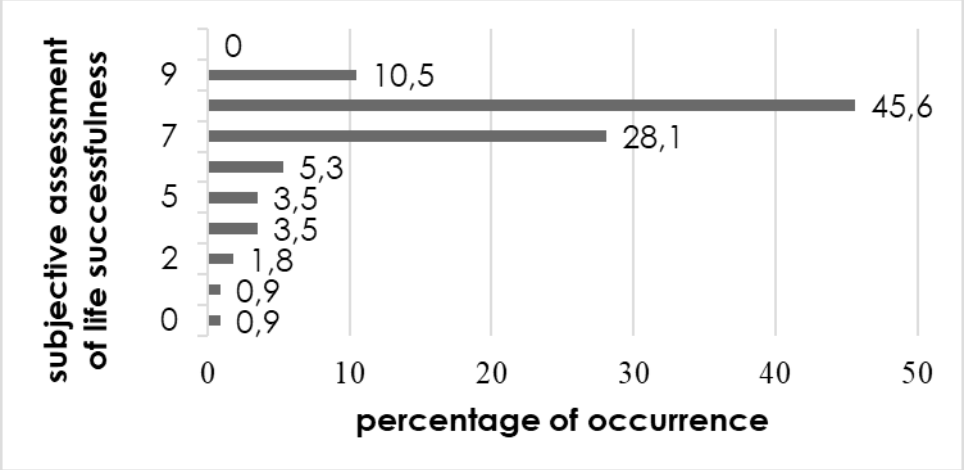


It can be seen from the diagram that all indicators have distributions over three levels. Basically, according to all indicators, the average level of design of the components prevails. There are indicators where the low level is most pronounced (practical experiences, existential experiences, focus on success), there is also an indicator with a clearly predominantly high level of manifestation - praxic experiences.

The average value of the subjective assessment of life successfulness is 7.23 on a ten-point scale. At the same time, the frequency distribution of responses is in the range from 0 to 9 (Fig. 2).

Figure 2

Frequency diagram of the subjective assessment of life successfulness in the study sample



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The largest percentage of respondents (45.6 %) rate their own life successfulness at 8 points. A significantly smaller percentage of respondents who rated their life successfulness from 0 to 6 points.

The results of the ranking of values showed that both in the case of an ideal successful person and in a real situation, the values of family and health come first (Table 2).

Table 2

Value ranks in the sample

Values	Ideal Values	Real values	Sign test (G), at p = 0.05
Family	4.90	4.00	28
Physical and spiritual health	5.77	5.13	30
Interesting job	6.00	6.13	42
Material well-being	6.17	6.10	34
Career	6.30	6.90	25
Social status. prestige	6.80	7.93	75
Love	7.00	5.77	89
Self-development	7.07	6.90	43
Education	7.13	8.40	26
Good relationship. friendship	7.30	6.60	31
Spiritual growth	7.50	7.73	48
Independence	7.57	7.17	35
Achieving a result	7.57	7.10	51
Information possession	7.77	8.73	81
Meaning of life	8.27	8.27	15

Divergence of value orientation 1.88.

Further, value hierarchies begin to differ: in real life, love is the most significant, in an ideal situation - interesting work. The least significant values for both real and ideal situations are: the possession of special information, the meaning of life. The application of the criterion of signs showed that significant differences in ranks are inherent in the values of love, social status, and possession of information. On average, the discrepancy between ideal and real values is relatively small and amounts to 1.88 points.

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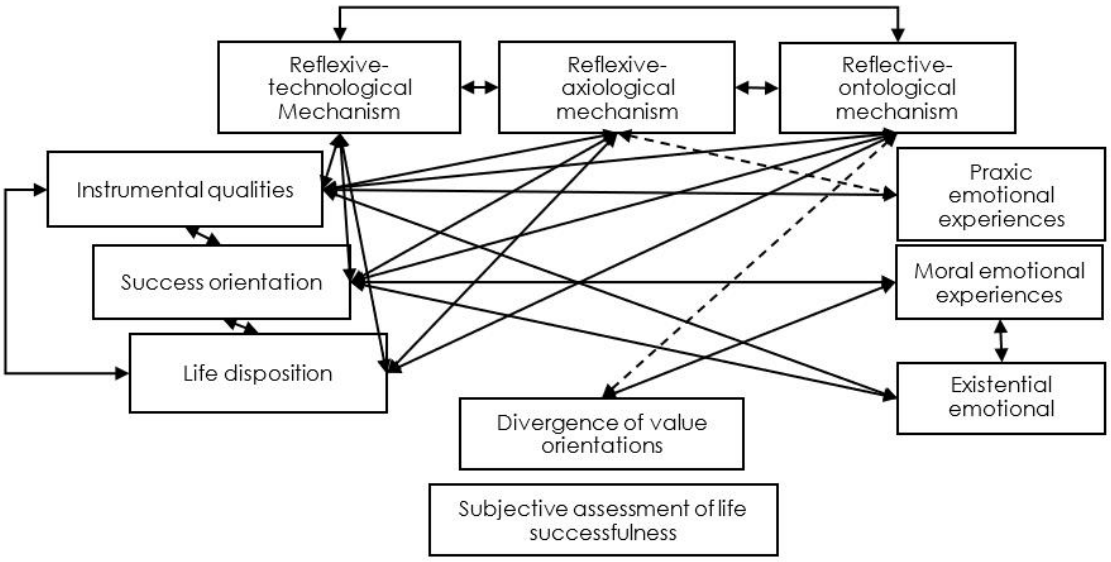
Figure 3

Correlations of indicators of the components of life successfulness in the study sample



At $p \leq 0.05$, where a bidirectional solid arrow indicates a positive significant relationship, a bidirectional dashed arrow indicates a negative significant relationship.

Discussion

The analysis of the obtained data made it possible to get an idea about the features of the structural and functional organization of the meta-resource of life successfulness among teachers of higher education.

In the sample of teachers, a number of indicators differ significantly from the general sample, which is logically manifested in the severity of the levels of each indicator. A greater degree of severity of praxic emotional experiences compared to the general sample, as well as within the sample compared to other experiences, which indicates their important (perhaps even leading) role in the fulfillment of the resource function of success in life. These emotional experiences are associated with the implementation of activities aimed at goals and results: satisfaction and enthusiasm for the process of activity, fatigue from activities, satisfaction with the result of activities and the more vivid emotions associated with this (interest, cheerfulness, delight, joy, etc.).

A significant difference in the direction of the greatest severity is also inherent in existential experiences, which include: the experience of fullness, meaningfulness and significance of one's life, peak existential experiences.

Moral feelings are expressed to a lesser extent in relation to the general sample and within the studied sample. Although the resource possibility of this type of emotional experiences is great, especially for the implementation of professional pedagogical activities. These experiences

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are indicators of the significance of the moral guidelines of the individual and contribute to the formation of the moral foundations of success in life. In situations associated with success, they manifest themselves in self-esteem, the significance of one's activity (profession), pride, love, altruism, patriotism, and duty.

The lower severity of all groups of integral qualities, compared with the general sample, indicates that their resource capabilities are used by teachers to a lesser extent. At the same time, the qualities that characterize the life disposition of the individual are most pronounced within the sample. They form a holistic attitude of the individual to success. This is manifested in the peculiarities of comprehension of reality, the creation and choice of life strategies based on existential values and meanings, life principles. These qualities include: optimism, realism, adherence to principles, resilience, inner freedom, self-confidence, active position, responsibility, conscience. Instrumental qualities determine the cognitive-behavioral and volitional capabilities of the individual in setting and achieving goals: the ability to formulate goals, the ability to predict the course of events, the ability to see what is happening from the outside, flexibility of thinking, developed imagination, flexibility of behavior, willpower, determination, perseverance, discipline. The development of qualities that characterize the orientation of the individual to success determines the ability of the individual to set value priorities, change value stereotypes, measure the value of one's own success with social norms, and find a balance between egoism and altruism. The combination of these qualities is represented by: the motivation to achieve success, the optimal propensity to take risks, the need for self-development, dedication to activities, leadership qualities, the ability to work in a team, and social interest.

The reflexive mechanisms of a person's life successfulness determine the ways of a person's reflexive work with their goals, values and meanings as interrelated contexts of life successfulness. An analysis of the severity of the reflexive mechanisms of life successfulness within the sample showed that the highest values are reflexive-ontological and reflexive-technological. The reflexive-technological mechanism is aimed at analyzing and predicting by the individual the most optimal ways to achieve the goal, comparing the goal and the result, showing flexibility in choosing the methods and means to achieve the goals. The reflexive-ontological mechanism consists in the reflexive processing and experiencing of life experience from the standpoint of the most universal life principles (rules, points of support), which are given in human existence and assimilated by the personality. The lower severity of the reflexive-axiological mechanism indicates that respondents may have difficulty understanding the significance of the goals and results of life. In particular, this is confirmed by a low assessment of the severity of statements related to the significance of professional activity for the individual and for society. Moreover, this trend is observed not only among teachers, but also among representatives of the general sample.

Respondents are characterized by a higher assessment of their own life successfulness, which is generally a positive thing, since, most likely, this is positively associated with self-attitude, self-presentation, etc. The majority of respondents (84.2 %) rated their life successfulness from 7 to 9

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points on a ten-point scale. However, it is alarming that the sample includes respondents (3.6 %) who rated their life successfulness from 0 to 2 points.

The results of ranking the proposed list of values that are most important for success showed a typical picture for the Russian sample in many respects (Deeva, 2022b). The most significant was the value of the family, the average rank of which significantly exceeds the rest. Significant differences in ranks in values indicate that respondents consider social status and possession of information to be the most significant values that determine success, while love does not quite fit into their ideal ideas about success in life.

The results of the correlation analysis allow us to speak about the presence of a large number of relationships between the components of life successfulness, which in general indicates the structural and functional harmony of this meta-resource. The reflexive mechanisms of life successfulness are interconnected (0.732 – 0.790, $p \leq 0.01$), which indicates the integrity of the reflexive mechanism of life success. This is expressed in the analysis of one's own goals, meanings, values in the context of life events; forecasting their capabilities, ways to achieve goals, evaluating them from the standpoint of society in situational and event contexts. Positive significant relationships unite all groups of integral qualities (0.872 – 0.910, $p \leq 0.01$), which characterize the subjectivity of the personality and allow the most effective implementation of the value-semantic foundations of life successfulness. At the same time, the functioning of the reflective mechanisms is interconnected with integral qualities.

Emotional experiences have much less significant relationships both with the components of life successfulness and among themselves. Praxic emotional experiences, against the background of their high severity in the study sample, are not associated with moral and existential ones, and show one positive relationship with instrumental qualities (0.863, $p \leq 0.01$) and one negative relationship with the reflexive-axiological mechanism (–0.299, $p \leq 0.01$). The inconsistency of this relationship is manifested in the fact that instrumental qualities are positively interconnected with the reflexive-axiological mechanism (0.645, $p \leq 0.01$). That is, praxic experiences as a resource contribute to the actualization of instrumental qualities, but at the same time inhibit the work of the reflexive-axiological mechanism: there is a certain failure in the functioning of life successfulness as a meta-resource.

Moral emotional experiences are interconnected with a focus on success (0.381, $p \leq 0.01$) and a mismatch between real and ideal values (0.371, $p \leq 0.01$). This relationship suggests that the manifestation of motivation to achieve success, risky behavior, leadership, social interest, etc. in the sample of teachers are accompanied by a sense of duty, altruism, etc. The strengthening of moral experiences leads to the activation of the value hierarchy, the reassessment of values, which leads to their greater mismatch. The existing mismatch of values can be expressed in an internal conflict and activate moral experiences. These connections carry a resource potential for the formation of a personality through a moral assessment of the coordinates of one's life successfulness.

Existential emotional experiences have significant relationships with moral experiences (0.883,

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$p \leq 0.01$), instrumental qualities (0.314, $p \leq 0.01$) and focus on success (0.440, $p \leq 0.01$), which indicates their existential significance and unlocks resource potential.

It should be noted that such an indicator as a subjective assessment of success in life does not have significant relationships with the components in the sample under study. This fact may indicate the lack of realism of this assessment, which, in turn, may interfere with the most productive functioning of the life successfulness meta-resource.

Conclusions

The results obtained in the study of the structural and functional organization of life success outlined the strengths and problematic aspects of the functioning of this meta-resource in the studied sample of higher school teachers.

The strengths are as follows.

The life successfulness meta-resource has a large number of interrelations between the components, which indicates its functionality, namely, the ability of respondents to show subjective activity, reflexively correlate life goals with results in the space of their own value-semantic field and socio-cultural conditions.

The most pronounced indicators in each component characterize specific resource opportunities for life successfulness, the actualization of which will contribute to the most efficient functioning of the meta-resource as a whole.

A slight discrepancy between the hierarchy of values in relation to reality and ideal success indicates a fairly harmonious value core of life successfulness, and a slight discrepancy in individual values, indicating the presence of internal contradictions, can be a source for self-development, rethinking the value hierarchy, building new options for life successfulness.

Such integral qualities as instrumental qualities and focus on success are interconnected with the largest number of indicators, which include emotional experiences as well, which indicates their greatest potential in the functioning of the life success meta-resource. Actualizing and forming these qualities, you can «start» the productive functioning of life successfulness.

The problems identified are as follows.

The lower severity of all groups of integral qualities indicates their insufficient actualization or formation and hinders the effectiveness of the functioning of life successfulness in general.

The presence in the sample of respondents who rated their life successfulness as less than two points on a ten-point scale, which indicates the presence of problems that may also affect the effectiveness of their professional activities.

The ambivalence of the relationship between praxic experiences and the reflexive-axiological mechanism, which is expressed in insufficient awareness of the significance of the activity performed.

A small number of significant relationships of experiences with the components of life successfulness, which indicates their incomplete involvement in the functioning of life success and a decrease in its subjective-sensory component - this is important when recognizing situations

of success, understanding the authenticity of goals and the significance of the activity performed.

Thus, the presented understanding of life successfulness as a meta-resource of the personality allowed us to approach the study of the personal resources of higher education teachers in the most holistic way. It is possible to improve the meta-resource of the life successfulness of higher school teachers in the sample under study, relying on strengths. Based on the proposed concept of life successfulness, it is possible to develop effective programs for psychological support and professional and personal development of teachers.

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Author Details

Natalya Alexandrovna Semenova – Cand. Sci. (Psychology), Associate professor, Associate Professor of the Department of Psychology and Pedagogy, The Krasnodar University of the Ministry of Internal Affairs of Russia, Krasnodar, Russian Federation; ResearcherID: U-7877-2017, SPIN-code: 2862-5230, ORCID ID: https://orcid.org/0000-0003-0687-0472, e-mail: natalya_deeva@bk.ru

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Conscious Self-Regulation and School Engagement as Resources for Exam Success: A Longitudinal Study

Tatiana G. Fomina[1]✉, Elena V. Filippova[2], Margarita L. Ovanesbekova[3], Varvara I. Morosanova[4]
[1, 2, 3, 4] Psychological Institute of the Russian Academy of Education, Moscow, Russian Federation
[4] Russian Academy of Education, Moscow, Russian Federation

✉ tanafomina@mail.ru

Abstract: **Introduction**. The current direction of modern research in the field of psychology of education is the study of psychological resources that can be considered as long-term predictors of learning success. Self-regulation and school engagement are traditionally considered as such resources. The study objectives included exploring the relationship of these resources among schoolchildren during their studies in the secondary school and clarifying whether the development of conscious self-regulation can predict examination success. Students participated in a 3-year longitudinal study during their schooling since 7th to 9th grade, a total of 81 participants (52 % – boys). **Methods**. "Self-regulation Profile of Learning Activity Questionnaire" by V. I. Morosanova (SRPLAQ-M); "Multidimensional Scale of School Engagement" adapted to the Russian sample (T. G. Fomina, V. I. Morosanova). The study collected data on the students' performance (an average of annual grades in the main academic subjects) and results of their major state exams in the 9th grade. **Results**. Statistical data analysis included the calculation of descriptive statistics, correlation analysis, and structural modeling. On its basis, a structural model was built, its correspondence to empirical data was assessed using the following agreement indices. The model demonstrates the specifics of longitudinal relationships between school engagement, conscious self-regulation, and the final exams results in the secondary school. It shows that the level of conscious self-regulation development, as measured in 7th grade students, is actually a long-term predictor of their academic performance and results of the major state exam in the 9th grade. School engagement turned out to be a less significant factor in the success of passing exams, and its influence is mediated by the level of conscious self-regulation development. **Discussion**. For the first time, the longitudinal study has revealed the specificity of relationship between conscious self-regulation and school engagement at different stages of education in the secondary school. The stated fact of the existence of long-term prognostic effects of the conscious self-regulation development on examination results is of undoubted scientific significance.

Keywords: conscious self-regulation, resource approach, school engagement, motivation, academic performance, learning activity, longitudinal research, examination success, age dynamics, structural modeling

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Highlights

- The formation of psychological resources contributing to the students' examination success is closely related to the development of conscious self-regulation of educational activities as the ability to independently and responsibly put forward educational and life goals and manage their achievement.
- Dynamics of development and features of the age-related changes in conscious self-regulation, school engagement, academic success in the education process in secondary school determine the specifics of their relationship.
- General level of the conscious self-regulation development is a long-term predictor of academic performance and a prognostic resource of the students' examination success in the secondary school.

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Introduction

Self-regulation and school engagement are traditionally regarded as significant predictors of academic performance. However, the study of their relationship and specifics of their joint determination of the various indicators of academic success has been actively developed only in recent years (Estévez et al., 2021; Fomina et al., 2020).

Since school engagement is a multidimensional construct extending its projections into various areas of educational activity, its manifestations are associated with a wide range of psychological phenomena (Fredricks et al., 2019). One of them is self-regulation. Research demonstrates the reciprocity of the relationship between engagement and self-regulation: on the one hand, engagement contributes to the development of self-organization skills, planning, self-control (Wang & Eccles, 2012b), while on the other hand, it has been shown that focusing on goals associated with achieving high results is more likely to lead for high levels of engagement (Bae & De Busk-Lane, 2019; Vasalampi et al., 2009). Numerous studies revealed the role of self-regulation as a predictor of various components of school engagement. For example, researchers identified a significant contribution of self-regulation to behavioral and cognitive engagement (Park & Kim, 2022). Self-regulation is essential for students to ensure the features of school engagement such as the ability to focus on relevant stimuli and maintain a high level of attention to the learning task (Rademacher, 2020). At the same time, researchers verified the hypotheses that school engagement contributes to actualization of the students' self-regulation (Stefansson et al., 2018; Morosanova et al., 2022).

However, many issues in this problem area require clarification, in particular what concerns the aspect of development and formation. Longitudinal studies make it possible to identify not only the dynamics of the phenomena under consideration, but also reliably establish causal relationships (Salmela-Aro et al., 2021). At present, researchers scrutinized some aspects of the

dynamics of school engagement: it has been shown that engagement of middle and high school students decreases, demonstrating meanwhile an uneven change in its individual components (Wang & Eccles, 2012a; Bakadorova et al., 2020; Engels et al., 2017). These studies also point that the trajectory of changes in school engagement can be influenced by contextual factors (peer status and popularity), the degree of aggression, self-competence (Moreira & Lee, 2020; Lemos et al., 2020; Engels et al., 2020). However, some issues still require consideration, e.g., to which extent the dynamics of engagement and self-regulation factors significant for academic results are reflected in their relationship.

Naturally, questions arise related to the psychological preparation for passing exams: what resources of the individual should be relied upon when building strategies for preparing for exams, how to help students cope with test anxiety and demonstrate their best knowledge during examination. Traditionally, among the factors influencing exam results, researchers consider cognitive characteristics: intelligence, working memory, information processing speed (Smirnov et al., 2007; Kornilova et al., 2018; Richardson et al., 2012; Rohde & Thompson, 2007; Fonteyne et al., 2017). In recent years, more and more attention has been paid to the personality factors of academic achievement, including motivational, characterological, temperamental characteristics, emotional stability and anxiety (Gordeeva et al., 2013; Eremina, 2010; Zaveryukha & Prokhorov, 2018; Prikhozhan, 2007; Strizhius, 2013; Chibisova, 2008; Chamorro-Premuzic & Furnham, 2014). There is now a growing body of research investigating various types of psychic self-regulation among the factors of academic achievement (Zimmerman & Schunk, 2011; Wolters & Hussain, 2014; Schunk & Greene, 2018; Baumeister, 2018).

In our opinion, formation of psychological competencies allowing students to successfully pass examinations is closely related to the development of conscious self-regulation of educational activities as the ability to independently and responsibly put forward educational and life goals and manage their achievement taking maximum advantage of the individual resources (Morosanova, 2014, 2022; Morosanova & Filippova, 2019).

The main objective of this study was to verify, on the basis of longitudinal data, the hypothesis of conscious self-regulation and school engagement as significant long-term predictors of the final examination results at school. This task required answering the particular research questions:

– Is there any specificity in the relationship between conscious self-regulation, school engagement, and academic performance of schoolchildren in the process of studying in the secondary school?
– Can the level of conscious self-regulation development be considered a long-term predictor of academic performance and a predictive resource of exam success?

Methods

In this work, we used the data obtained in a 3-year longitudinal study. The pupils were examined three times (with an interval of approximately one year) in the 7th, 8th, and 9th grades. The total sample included 81 people (52 % boys). The average age of the study participants in the 7th grade was 13.02 (standard deviation – 0.47), in the 8th grade – 13.91 (standard deviation – 0.45), in the 9th grade – 14.74 (standard deviation – 0.44).

Diagnostics of the conscious self-regulation development was carried out by means of V. I. Morosanova's "Self-regulation Profile of Learning Activity Questionnaire (SRPLAQ-M)" (Morosanova & Bondarenko, 2017). The technique allows assessing both the general level of

conscious self-regulation and its individual characteristics associated with the specifics of setting and achieving learning goals. To implement the study objectives, we used an indicator of the general level of conscious self-regulation.

School engagement was assessed using the "Multidimensional Scale of School Engagement Questionnaire" adapted to the Russian sample (Wang, 2019; Fomina & Morosanova, 2020). The method allows assessing the severity of four components of school engagement *vs* four components of school disengagement (behavioral, cognitive, emotional, social). In the context of the study objectives, an integral indicator of school engagement was used, calculated as the sum of scores for all components of engagement.

The study collected data on the effectiveness of schoolchildren's learning activities: academic achievement (the average value of annual marks in the main academic subjects) and the results of passing the major state exams at the end of the 9th grade. The overall indicator of the major exams result of a student was calculated as the sum of scores received for passing exams in the compulsory subjects (Russian language and Mathematics).

Statistical processing. Statistical analysis of the data was carried out using the statistical package SPSS 26.0 (SPSS Inc.) and AMOS 23 (calculation of descriptive statistics, correlation analysis, structural modeling).

Results

Correlation analysis

At the first stage of the data analysis, descriptive statistics were considered, as well as correlations between the variables under study, taking into account their repeated measurements (Table 1). The results obtained indicate significant relationships between the general level of conscious self-regulation measured in the 7th grade and all other variables – engagement and academic achievement, including later measurements (in the 8th and 9th grades). It should also be noted that, despite the level of significance, the correlation of academic achievement and self-regulation is higher than that of academic achievement and engagement. At the same time, engagement and self-regulation measured in the 9th grade do not show a significant relationship with exam success. This fact apparently indicates the multidirectional dynamics of the conscious self-regulation, engagement, and academic achievement at this stage of education.

Table 1

Means, standard deviations, and correlation analysis results

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
1. SR_7	28.73	9.91	1	0.64**	0.61**	0.52**	0.46**	0.38**	0.41**	0.48**	0.33**
2. SR_8	28.83	8.93		1	0.72**	0.57**	0.48**	0.16	0.25*	0.27*	0.28*
3. SR_9	28.53	9.96			1	0.47**	0.65**	0.11	0.17	0.31**	0.12
4. Engage_8	68.05	11.79				1	0.62**	0.22*	0.26*	0.34**	0.12

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
5. Engage_9	64.42	13.15					1	0.28*	0.32**	0.45**	0.12
6. Ach_7	4.00	0.68						1	0.86**	0.76**	0.70**
7. Ach_8	3.92	0.63							1	0.78**	0.70**
8. Ach_9	3.93	0.57								1	0.60**
9. Exm_9	43.48	8.51									1

*Note: ** p < 0.01, * p < 0.05; Mean* – mean value, *SD* – standard deviation, *SR* – self-regulation, *Engage* – school engagement, *Ach* – academic achievement, *Exm* – exam result.

On the whole, descriptive statistics suggest that conscious self-regulation is relatively stable, whereas school engagement is declining. These facts are confirmed by a number of studies (Fomina et al., 2021; Tsyganov & Bondarenko, 2022).

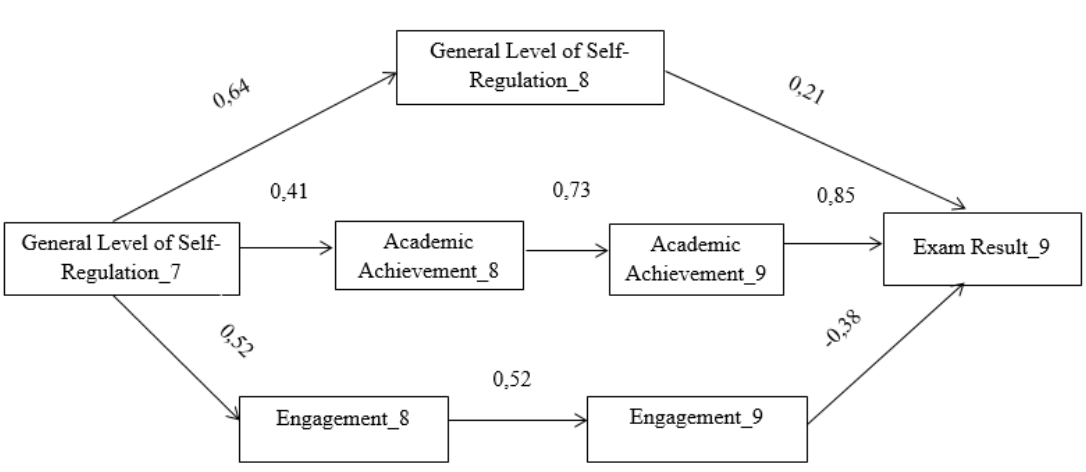
Structural modeling

Data analysis was performed by structural equation modeling (SEM) using the AMOS 23 computer program.

The following fit indices were used to assess the fit of the model to empirical data: GFI > 0.95; AGFI > 0.9; CFI > 0.95; RMSEA < 0.05, path analysis was used. Figure 1 shows the final model, characterized by acceptable fit indices: GFI = 0.970; AGFI = 0.905; CFI = 0.997; RMSEA = 0.037.

Figure 1

Structural model of the longitudinal relationship between conscious self-regulation, school engagement, and final exams result



The resulting model shows that pupils' academic achievement is a stable predictor of their success in the final examination, that is, children who consistently do well in the middle grades of the school demonstrate success in the future exams. At the same time, the general level of conscious self-regulation is a long-term predictor of academic performance: the data analysis revealed a significant effect of the conscious SR level on academic achievement in the 7th grade, and this effect is mediated by SR level in the 8th grade as well. In addition, self-regulation in the 7th grade affects academic achievement in the 9th grade through a mediator – academic achievement in the 8th grade. And although the general SR level in the 9th grade is not a significant predictor of exam results, nevertheless, it can be concluded that self-regulation is a long-term predictor of academic success in general.

The model also shows that general SR level in 7th grade influences the level of school engagement in 8th grade and, indirectly, – in 9th grade. However, school engagement itself is not related to the examination scores. Engagement in school life may be associated not so much with the will to achieve high academic success, but with the need to impress, interact more often with interesting people at school. Success in the final state examination requires engagement in a specific test preparation program with clearly defined conditions. In addition, activity within the framework of school curriculum, according to many students, in their minds is not directly related to their success in the exam. They consider additional classes, lessons with tutors, their own efforts out of school to be much more productive for obtaining high exam scores. In addition, in 7–9th grades adolescents experience a shift in the leading activity from their study to intimate-personal communication. It is possible that by the 9th grade schoolchildren do not yet have time to realize the personal significance of the major state exams. This form of examination appears as an incomprehensible goal set from the outside, so students are not engaged consciously and actively in the process of its implementation. However, it is worth noting the delayed impact of the general SR level on both exam success and school engagement. We can say that conscious work that students do by the 7th grade – activity in mastering school subjects – gives them a good base. This backlog allows them to live through a difficult adolescence period with the less loss in productivity.

We believe that when preparing schoolchildren for the major state examination, it is necessary to concentrate on the personal significance of the exam, to help the students understand why they should try to get a high score, how to choose subjects for examination, based on their long-term goals. The ability to make plans for the long term is associated with the need to realize oneself in the chosen profession, and this is formed a little later. Therefore, the teenagers still need help with planning in this period.

Discussion

For the first time the presented study has revealed, on the basis of longitudinal data, the specifics of the relationship between conscious self-regulation and school engagement of adolescents, and their resource role in relation to their academic performance and examination success.

The analysis made it possible to state the fact that school engagement has a clear downward trend in the middle grades of the school. Researchers confirm that declining school activity of students, especially adolescents, remains a serious problem that carries risks associated with serious social consequences (Lam et al., 2016; Perkmann et al., 2021). However, as evidenced by the data obtained, the conscious self-regulation of the learning activity serves as a significant resource

for the progress and engagement of students during this period. Thanks to it, students can compensate for the lack of engagement and motivation by overcoming natural limitations associated with the social situation of development and psychophysiological maturation (Bakracevic et al., 2010). Research demonstrated the effects convincingly proving the importance of goal setting, planning, and effective goal achievement for the school engagement of adolescents during this period (Caraway et al., 2003). Indeed, students with a high level of engagement develop more effective learning strategies, cope with learning difficulties more successfully, and are more likely to achieve their goals. Researchers come to the conclusion that relationships between self-regulation and school engagement are reciprocal and their directionality can be associated with both age and internal dynamics of the development of these phenomena (Fomina et al., 2021; Stefansson et al., 2018).

In this study, for the first time, it was established that the earlier development of conscious self-regulation contributes to higher productivity and efficiency of students (using the example of the situation of passing final exams). Children who were characterized by a higher development of regulatory competencies in the 7th grade, later coped with examination tests more successfully, demonstrating higher results. Empirical studies carried out within the framework of other methodological approaches to understanding self-regulation (executive functions, self-control, etc.) also show the effects of self-regulation on various types of activity and human behavior in subsequent periods of life: the level of achievement, interpersonal relationships, cognitive abilities, well-being (Robson et al., 2020).

It is also impossible to ignore the fact that, in general, there is a decrease in academic performance in the middle classes of the school. At the same time, children who consistently do well in the middle grades of school demonstrate success in the future exams. And those children who, for some reason, "let go" their studies or could not find sufficient motivators for themselves, can show a positive exam result only thanks to the resources of conscious self-regulation (Morosanova & Filippova, 2019). These results, in particular, are shown in the studies that consider differential aspects of the relationship between conscious self-regulation and academic success (Potanina & Morosanova, 2021).

Although some studies show significant correlations between academic achievement and engagement (Lei et al., 2018), our data show that engagement gains its resource role through the conscious self-regulation.

Conclusion

Thus, the study verified the hypothesis of conscious self-regulation and school engagement as significant long-term predictors of success in the final examination at school based on the longitudinal data and using structural modeling tools. It is demonstrated that dynamics of development and peculiarities of the age-related changes in conscious self-regulation, school engagement, and academic performance in the process of learning in the secondary school determine the specifics of their relationship. Conscious self-regulation, being a more stable resource for the productivity of educational activities, acts as a predictor of the examination success of students in the secondary school and influences the level of their school engagement. The results obtained indicate the directions of practical work with schoolchildren in terms of updating their psychological non-cognitive resources in the implementation of various forms of education activity.

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Author Contributions

T. G. Fomina prepared the theoretical review, developed the research design, collected, and processed the data and interpreted the results, prepared the text of the article.
E. V. Filippova prepared the theoretical review, collected, and processed the research data, participated in the interpretation of the research results.
M. L. Ovanesbekova participated in preparing of the theoretical review and interpretation of the results, designed the manuscript.
V. I. Morosanova supervised the project, developed the methodological concept and design of the study, participated in the interpretation of the results and preparation of the article.

Author Details

Tatyana Gennadievna Fomina – Cand. Sci. (Psychology), Leading Researcher, Department of Psychology of Self-regulation, Psychological Institute of the Russian Academy of Education, Moscow, Russian Federation; Scopus Author ID: 56528023600, ResearcherID: P-2785-2016, SPIN-code: 7480-4880, ORCID: https://orcid.org/0000-0001-5097-4733, e-mail: tanafomina@mail.ru
Elena Valerievna Filippova – Cand. Sci. (Psychology), Senior Researcher, Department of Psychology of Self-regulation, Psychological Institute of the Russian Academy of Education, Moscow, Russian Federation; Scopus Author ID: 57214711868, ResearcherID: Y-9831-2018, SPIN-code: 4491-1096, ORCID: http://orcid.org/0000-0003-3052-0421, e-mail: proftest@gmail.com
Margarita Leonidovna Ovanesbekova – Researcher, Department of Psychology of Self-regulation, Psychological Institute of the Russian Academy of Education, Moscow, Russian Federation; ORCID: https://orcid.org/0000-0003-4878-525X, SPIN-code: 9879-1045; e-mail: ovanesbekova@mail.ru
Varvara Ilyinichna Morosanova – Corresponding Member of the Russian Academy of Education, Dr. Sci. (Psychology), Professor, Head of the Department of Psychology of Self-regulation, Psychological

Institute of the Russian Academy of Education, Moscow, Russian Federation; Scopus Author ID: 6506351065, ResearcherID: J-5946-2016, SPIN-code: 4335-5542, ORCID: https://orcid.org/0000-0002-7694-1945, e-mail: morosanova@mail.ru

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Overview of the "Goal" Category in Psychology

Roman V. Vasyov
Moscow University for the Humanities, Moscow, Russian Federation
fin.roman285@gmail.com

Abstract: **Introduction**. The article presents an overview of the category "goal" from a psychological point of view, reveals the current state of goal research. The results of about 100 literary sources, including empirical studies of goals, are summarized. An attempt is being made to collect the definitions of the goal and generalize them into a single construct. The structure and properties of goals, the relationship between means and goals, the hierarchy of goals and sub-goals, the relationship between goals and plans, the processes of setting and achieving goals are shown. The novelty of the work lies in the refinement of the category "goal", taking into account the currently available scientific knowledge, the construction of the psychological phenomenon "goal" based on the key characteristics used in the literature, identified deficiencies in the study of goals. **Theoretical Basis**. The theoretical developments of psychology in this field are used in all spheres of activity – in education, in production, in sports, in the healthcare system and in everyday life. Attention is paid to the conflict of goals and the distribution of resources between several goals, the T.O.T.E. model, the Rubicon action phases model, the Apter reversal theory, the concept of psychological distance to the goal, the topic of purposeful behavior from cybernetic positions. **Results**. The author gives a historical digression concerning the goal category of the late XIX–XX centuries, also reflects the results of research of modern times. Based on the analysis, it is established that the category "goal" in the XX century is rapidly developing and becoming one of the links of the motivational sphere of a person. **Discussion**. The category "goal" in psychology is the object of research of various psychological schools and trends and is of key importance in predicting behavior, occupies one of the central places in personality psychology. At this stage of the development of psychological science, the issues of the dynamics of the system of goals in various ecological environments and over time are insufficiently studied, the nature of the links in the system of goals is disclosed in the form of hierarchical schemes, without taking into account the weights of the connections themselves.

Keywords: goal, motivation, goal setting, goal hierarchy, goal conflict, goal achievement, behavior, need, value, stimulus

Highlights:

- The analysis of the terminology of the category "goal" in psychological science, the main theoretical provisions and some empirical studies is carried out.

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▹ There is a significant variety of terms in the field of goal research; goals serve as a standard against which representations of current or expected states are compared.
▹ Diversity arises from considerations of properties and relationships between goals, the way goals are presented, operations designed to achieve goals, monitoring and modification of behavioral sequences to implement plans and strategies and control the achievement of goals, and decision-making processes related to goals setting, achievement, revision and preservation of goals.

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Introduction

Human goals have long attracted the attention of researchers: at the moment there is a significant amount of theoretical and empirical research concerning the setting and achievement of goals. In many works, the target personality system is compared with various motivational phenomena, many relationships are revealed: what kind of efforts and to what extent contribute to achieving the goals, commitment to goals and success in achieving them, depending on the difficulty of goals, types of motivation and productivity of goal formation in solving complex tasks.

The category "goal" has existed since the birth of psychological thought itself and combines a wide range of meanings, which we will try to outline in this review.

Theoretical Basis

Analysis of the main research and publications

In the age of Enlightenment, F. Herbart, a German scientist, a supporter of the scientific analysis of mental representations (images), emphasized the importance of representations for explaining human behavior. American philosopher and psychologist W. James (James, 1902) associated self-regulation with the strengthening of a weak tendency to perform desired behavior, or with the weakening of a strong tendency to perform undesirable behavior. Analysis of the will of W. James was based on the assumption that behavior could potentially be regulated by subjective goals, even if in certain situations and at certain times it might be difficult.

In 1896, a student of W. Wundt (Wundt) O. Kulpe (Külpe) founded the Würzburg Psychological School of Experimental Research of Thinking and will. In the work of the Würzburg School, goals were of particular importance in psychological theorizing and received sustained conceptual and empirical attention. Expressions relevant to the purpose appeared, the term "final state" or "object" was usually used. Psychologists of the "Würzburg School" (O. Kulpe, K. Buhler, N. Ah, K. Marbe, etc.) abandoned the associationist understanding of mental activity in general and thinking processes. Goals and goal-setting are inextricably linked with thinking, which is an active directed process, the process of determining relationships (Antsiferova et al., 1966). W. Wundt in 1920 wrote about volitional processes and the principle of goal heterogeneity (Patel & Mehta, 2014; Fahrenberg, 2020). This principle manifests itself in the consequences of actions that go beyond the originally intended goal and create new motives that may lead to unexpected results. Thus, goals multiply as a result of self-creation of goals, the target organization (chain of motives) is constantly growing. This principle is important for understanding motivational processes.

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The work of I. P. Pavlov "The Reflex of the goal" (Pavlov, 2001) is of great importance for the development of the direction of goal research. Goals, according to I. P. Pavlov, belong to the category of innate human properties, to the main activity of the nervous system. The goal reflex is defined as the desire to possess a certain irritating object, as an important factor of behavior, as a manifestation of the most important stimulus of life. The scientist connects the question of the origin of the goal reflex with the general instinct of life. I. P. Pavlov emphasized the importance of this reflex in active, purposeful behavior (Pavlov, 2001, 2011).

With the development of behaviorism, in the second decade of the twentieth century, when psychology sought to limit itself to observable behavior, goals (and other mental processes and internal mental events) began to be pushed out of the framework of scientific psychology. Over time, the goals returned to the focus of scientific research. The representative of behaviorism (neobehaviorism later) E. Tolman drew attention to the fact that behavior is inextricably linked with purposefulness. The scientist sought to explain the purposeful nature of behavior, based on the observed behavior, he defined "goal–object" as an object or situation to which (from which) the organism is moving (Tolman, 1949). E. Tolman helped to preserve the central place of goals in psychology, while combining behaviorism and goal constructions.

By the 30s of the XX century, the psychological literature reflected the design of the goal. The word "goal" became commonplace and was used as a scientific term to describe or explain psychological phenomena; subsequent theoretical research focused on the presentation of specific variants of target constructs and their application in the field of motivation psychology.

S. Mace, a British researcher who, perhaps less than others, was influenced by American behaviorism, was the first to draw attention to the influence of various types of goals on task performance (Phillips, 1991), and also conducted the first empirical studies of goal setting in 1935, from which he concluded that there was people (workers) have the will to work – that the fact of achieving a goal in itself can act as a motivator (Carson et al., 1994).

In the 1930s and 1940s, G. Allport (1937; Allport, 2002) postulates the idea of functional autonomy of motives. Functional autonomy is an acquired motivation system that differs from the original motivation of behavior. The subsequent motif is formed by superstructure over the original one and functionally differs from it. Thus, a part of human motives is functionally independent of the original motives that determine behavior. Functional autonomy makes an attempt to justify the presence in adults of a complex of actual motives that do not currently have a visible orientation to the future state (Craik et al., 1993).

N. Ah (Ach, 1935) suggested that the connection in a person's mind of an expected situation with a specific intended behavior creates what he called "certainty (clarity)", which automatically triggers the intended action when a specific situation arises. The power of "certainty" is not related to the importance of a person's attention or purpose. N. Ah' assumption that automatic processes can greatly contribute to the achievement of a person's goal is confirmed by recent findings that self-regulation strategies as implementation intentions (Gollwitzer & Oettingen, 2011) have a beneficial effect on the basis of automatic processes, as well as the discovery that the desire to achieve a goal can be activated (i.e. initiated). outside of a person's consciousness by subconsciously presenting signals related to the goal (for example, signals that relate to activities related to the goal) (Bargh, 1990).

K. Lewin (Lewin, 1926) claims that when an organism sets a certain goal, the tension system comes into play and remains until the goal is reached or until the organism "leaves the field".

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Twenty years later, K. Lewin and his colleagues (Lewin et al., 1944) studied conscious goals (levels of aspiration). They considered the levels of aspiration as a variable dependent on various motivational factors (primarily other levels). Goals attach importance to objects and events in the social and non-social environment of people. Since needs can be satisfied by various types of behavior that can replace each other in reducing the stress of needs, many different purposeful actions are suitable for meeting quasi-data related to the goal. Thus, K. Lewin's metaphor of the state of tension explains the flexibility of striving for a goal.

With the emergence of a new interdisciplinary field of cybernetics research in the 1940s, goal research became even more popular. In the late 1940s and early 1960s, works appeared on the topic of purposeful behavior from cybernetic positions ("Behavior, Purpose and Teleology" by N. Wiener and J. Bigelow (Rosenblueth et al., 1943)). Cybernetic models assumed the use of biological and mechanical systems based on feedback, taking into account the fact that the system has a goal (target state). The main meaning of these systems is to strive to achieve a certain goal, to maintain the final state. In cybernetic models, a person has ideas about standards of behavior (generalized states characteristic of each individual) used through self-adjustment and self-organization to regulate behavior.

D. McClelland (McClelland) and J. Atkinson (Atkinson) in 1953 postulated the existence of internal motives, such as the need for achievements, but it was argued that they are subconscious. In the following years, J. Atkinson (1957) and D. McClelland (1985) developed the problem of the need for achievement from the point of view of the motive of power (Locke & Latham, 2002; Maehr & Sjogren, 1971).

In 1956, B. Bloom published the "Taxonomy of Educational Goals", classifying educational goals, in particular, within the framework of cognitive psychology. Achieving educational goals from the cognitive field included performing tasks related to the recognition of knowledge and the development of intellectual skills and abilities (Bloom et al., 1956; Anderson & Krathwohl, 2001).

The theory of functional systems (1930–1955) by the Soviet physiologist P. K. Anokhin (Anokhin, 1955) contains a "result acceptor of action" representing a cognitive model of future results in the form of a network of neurons. The circulation of arousal through this network allows you to keep the goal of human behavior. In other words, the goal is synonymous with the acceptor of the result of the action.

Later theories interpret people as just and omniscient final judges of their actions. For example, the theory of expected value (Atkinson, 1957) assumes that people choose goals in a rational way, based on a comprehensive knowledge of the probability of achieving the goal and the expected value of the goal (Wigfield, 1994). In the model of solving general problems, A. Newell (Newell et al., 1958) discussed the relationship between means and goals, and the hierarchy of goals and sub-goals.

G. Miller, E. Galanter (Galanter) and K. Pribram (Miller et al., 1960) revealed the relationship between goals and plans, and in 1960 published a model of T.O.T.E. ("Test – Operate – Test – Exit") describing the relationship between the structures of perception and behavior in animals and a person. According to the model, the behavior program consists of hierarchically arranged stages of testing and action. Testing consists in comparing the current result of an action with the target values or the desired state (goal), the actual value is compared with the reference value. The "operation" stage is characterized by actions to implement the intended goal. The key value in the model belongs to the feedback loop, through which action plans are corrected at

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the testing stage. When the current state corresponds to the reference state (the intended goal), the process ends, the "exit" phase begins (Miller et al., 1960).

In the 70s, E. Locke began to investigate the influence of goals on human activity, at this time the famous theory of goal setting was created, his first article on this topic "On the theory of motivation of tasks and stimuli" was published in 1968 (Locke, 1968).

At the same time, R. Ryan (Ryan, 1970) argued that human behavior is primarily influenced by conscious goals, plans, intentions, tasks, and the like. R. Ryan called the totality of these phenomena explanatory concepts of the first level – they are the direct motivational causes of most human actions.

T. Gyesme developed the concept of psychological distance to the goal, using the time before reaching the goal, orientation to the future time, considered as a trait, and the expectation of achieving the goal (probability of achievement) (Gjesme, 1981).

In the mid-1980s, J. Heckhausen and P. Gollwitzer set out to analyze how people control their actions. Dividing the control of actions into different phases significantly improved the understanding of this process. In 1987, J. Heckhausen and P. Gollwitzer proposed the Rubicon model of action phases, which describes the course of action as a temporary, linear path starting with a person's desire and ending with an assessment of the achieved results of the action (Heckhausen & Gollwitzer, 1987). The procedure of actions includes a stage of discussion of expediency (goal selection), a phase of planning specific strategies to achieve this goal, a phase of putting these plans into effect (activity stage) and a stage of analyzing the results achieved (post-activity stage) (Keller et al., 2020). The Rubicon model was subsequently replaced by the theory of thinking about the phases of action, in which each of the four stages was proposed to be associated with a special thinking (Gollwitzer, 1990, 2012). Subsequent studies have shown that implementation intentions that depend on specific conditions, linking context and actions, qualify as a powerful tool of self-regulation when it comes to achieving one's goals, regardless of which area these goals relate to. Implementation intentions are concrete "if–then" plans that define a critical situation (a suitable opportunity to act in accordance with the goal) and link it to a targeted response. Such plans increase the indicators of achievement of goals (Gollwitzer, 1999, 2014; Gollwitzer & Sheeran, 2006).

Studies also show that the availability and type of social support (Chiaburu et al., 2010; Martin, 2010; Orehek & Forest, 2016), as well as the regulation of emotions are equal or even more important than cognitive abilities in predicting both intention and the emergence of new habits on the way to the goal (Lawton et al., 2009).

Goals are an important component of the theory of activity, because they are directly related to actions. Actions are subordinated to the idea of the result to be achieved, and are components of the structure of the activity. A higher-order goal tends to break up into several specific goals that generate a certain set of sequential actions. The same action in this case can relate to different activities, move from one activity to another. Similarly, the goal may have a number of motives. The expanded activity presupposes the achievement of a number of specific goals, and the general goal is the setting of specific goals. A conscious motive is a common goal (motive-goal) (Leontiev, 1975).

S. L. Rubinstein considers the object of satisfying a need as a goal; objects become objects of desires and possible goals of the subject's actions when he includes them in the practical awareness of his attitude to the need (Ilyin, 2011; Yurov, 2015).

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In Russian psychology, the scientific school of O. K. Tikhomirov (Babaeva et al., 2008) dealt with the issues of the correlation of goals, the formation of goals, the levels of goals and meanings within the framework of the study of thinking. O. K. Tikhomirov's goals contain anticipated results of actions and are conditioned by external conditions. Different goals are highlighted in the action (hierarchy of goals). An action can be evaluated both in its relation to the "ideal" goal to which it aspires, and in relation to a specific goal with which this action is directly related. The image of the future result is always associated with the subject's assessment of the significance of this result and its achievability after the implementation of the action. The goal is characterized by varying degrees of clarity (Tikhomirov, 1984).

M. G. Yaroshevsky believed that future goals give a purposeful character to thinking, ordering the course of thought, determine the future sequence of actions (Yaroshevsky, 1985).

Soviet and Russian psychologist V. V. Petukhov in 1987, when determining the phenomenon of thinking, used a teleological approach, the most important characteristic of which is the internal orientation of the subject to achieve the goal. In the psychological structure of the task, as an element of the thought process, the initiating element is a subjectively set goal. In the course of the thought process (as a process of solving a problem), there is a transformation of the present requirement into a subjective goal, the nomination of intermediate goals (if necessary), the nomination of goals that go beyond the conditions of the problem situation and the requirements set. The idea of the future result is a subjective goal, thus the act of accepting the task is at the same time an act of transforming the set requirement into specific goals of the subject's actions to solve the problem (Petukhov, 1987).

M. Apter's theory of reversal (Apter, 1989, 2006) asserts that there are alternative states of motivational systems available to an individual for interaction with his environment. The theory includes metamotivational constructions within the framework of bistability. Bistability refers to the ability to switch between two states: telic (goal-oriented) and parathelic (activity-oriented). Focusing of a higher order (telic) can lead to a revision of plans and to a transition from telic states to parathelic states.

In the 1990s, a number of foreign scientists define the goal (or aspirations) as one of the very significant variables in the study of personality and motivation of the future, they conduct cycles of empirical research and offer methods for measuring goals (Nevstrueva et al., 2016).

Results

Sphere of definitions of the "goal" category

According to E. Hilgard (Hilgard, 1953; Leary, 2002), the goal is the final state or condition to which motivated sequentially unfolding behavior is directed and through which this sequence is completed.

In the gestalt psychological theory of thinking, M. Wertheimer designates the goal as an obligatory element of the task necessary to trigger directed behavior (Wertheimer, 1959; Wertheimer, 1987).

The goal is the image of the future result (Leontiev, 1975), as a mental anticipation of the result of activity (Kondakov, 2003).

The goal is a conscious, expressed in words, anticipation of the future result of an action, an image of future results indirectly related to the motive (Tikhomirov, 1984).

Goals are desired states that represent the consequences of behavior that a person seeks to

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achieve (positive consequences) or attempts to avoid (negative consequences) (Winell, 1987).

According to A. Reber and A. Raymond, a goal is defined as an internally presented mental task set by an individual that guides his behavior and directs him (Reber & Allen, 2000).

J. Austin and J. Vancouver defined goals as internal representations of desired states (outcomes, events, or processes) (Austin & Vancouver, 1996).

Goal is a cognitive representation encompassing the relationship of means to achieve the goal and desired results (Kruglanski et al., 2002). Goals consist, therefore, of the means to achieve the goal and the desired result.

Goals are described as building blocks for various development tasks, and their achievement contributes to the formation of long-term models of successful development (Freund & Riediger, 2006).

The goal is understood as the ideal image of the future result obtained with the help of thinking, the achievement of which is conditioned by the motivation of the thinking subject, and for the purpose of which certain actions must be taken. The goal may be a certain spatial position, a distant event, the desired state of oneself or another system for the actor (Glazunov & Sidorov, 2017).

Goals as an innate potential of dissatisfaction. Setting goals creates a negative mismatch between the actual and desired state (Kaftan & Freund, 2018).

D. Dörner's goals are beacons indicating the direction of action (Dörner, 1997). Goals can be defined as an internal representation of desired outcomes (Austin & Vancouver, 1996).

Goals are incidents that have not yet happened to a person, but a person wants them to happen to him. Since they cannot happen by themselves, a person follows a set of rules or a plan to ensure that the goal is achieved (Balcetis & Dunning, 2010).

The presence of many different concepts to describe the goals of personality implies the creation of a generalizing construct. R. Emmons (Emmons, 2003) used the term "personal aspiration" as a generalizing term for the study of personality goals. To emphasize the specifics of the construct, R. Emmons focuses on the differences between personal aspirations and other concepts of the target personality system, highlights the boundaries of various personal target units.

On the other hand, with such a large number of definitions of goals, it becomes necessary to highlight their key characteristics. The goal construction has been variously defined in terms of cognition (Locke, 2000; Locke & Latham, 1990; Fishbach & Ferguson, 2007), behavior (Bargh et al., 2001; Elliot, 2005), affect (Pervin, 1983; Ferguson & Bargh, 2004), personality orientation (Vasiliev, 2016), Neuroscience (Berkman & Rock, 2014; Berkman, 2018).

L. Barsalou (1991) considered goals as an aid in the classification of behavioral categories related to solving problems of understanding, transformation and organization of reality.

Studies of individual differences in terms of motivational orientations have replaced the construction of a need (motive) with constructions describing a general orientation towards goals, such as personal projects, personal aspirations, life tasks or identity goals. Such personal aspirations (Emmons, 1996; Gollwitzer & Kirchhoff, 1998) are more limited in scope and can be characterized in terms of expectations of success and complexity, the level of abstraction and avoidance, the degree of conflict with each other.

D. Hamilton, L. Katz (Katz) and V. Leirer (Hamilton et al., 1980), found that study participants who had the goal of impression formation remembered research material better than participants who had the goal of memorization, and unconscious activation of the goal can lead to behavior

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associated with the goal. The unconscious activation of the goal leads to the achievement of the goal and the corresponding emotional reactions if the pursuit of the goal goes well or badly (Shah et al., 2002).

In modern theories of motivation, a person has flexible strategies for achieving goals. Attention is paid to various tasks that a person must perform when converting desires into actions. When choosing goals, people strive to conform to the ideal of an omniscient and just person. When realizing an already set goal, people are determined to achieve their goal, become biased (Gollwitzer, 1990, 2012).

In the literature on goals, there are studies focused on the process of achieving goals and the allocation of resources between several goals (Zeelenberg & Pieters, 2007; Schmidt et al., 2009; Locke et al., 1994). The work of L. Pervin (1991) was one of the first in which the idea of multiple achievement of goals and their parallel processing was outlined; it is assumed that people have basic goals that are key, and background goals that are inaccessible to working memory, but are largely part of the goal system (Austin & Vancouver, 1996).

In the 20th century, goals were increasingly used in many studies of motivation (Bargh et al., 2010). One direction of goal research focuses on the determinants and processes of goal setting, while the other direction focuses on the implementation of goals. With regard to goal setting, it was found that people who interpret their Self as an ideal that they internally want to achieve set goals for themselves, focusing on establishing and maintaining positive results, while people who interpret their Self as a state (due state) that they feel compelled to achieve, set goals of avoidance, focusing on getting rid of negative results (Higgins, 2006). Goals are defined as a factor that plays a key role in the transition from an existing state to a desired state or result (Spence, 2007; Cytrynbaum et al., 1979; Emmons, 1986).

Due to the obvious importance of goals and phenomena related to goals for human activity, in the second half of the XX century. there is a noticeable socio-psychological theorizing about goals. The concepts of goals are increasingly present in the field of cognition, personality and motivation. A number of studies focus on the structure and properties of goals, as well as the content and setting of goals (Louro et al., 2007; Schmidt et al., 2009). Studies concerning the hierarchy of goals indicate that goals at different levels affect other goals in the goal system (Cropanzano et al., 1992; Ortony et al., 1988). At the same time, goals will not always contribute to the achievement of other goals in the system of equivalent goals – you need to make a choice between them. This situation is referred to in the motivation literature as a conflict of goals (Zohner, 1963); the pursuit of mutually exclusive goals is destructive to a person's internal resources (Anderson et al., 2004).

Regulatory strategies for achieving conflicting goals have also been studied. One of the regulatory strategies for achieving the conflicting goals outlined by J. Kuhl (2001), which benefits in the successful achievement of goals and overcoming the conflict of goals, is the control of actions. Goal shielding (Shah et al., 2002; Goschke & Dreisbach, 2008) is a self-regulating strategy that can be used to protect the achievement of the main goal from alternative ones. Another study is devoted to the phenomenon showing that people may have difficulties in setting their priorities (priority goals), and, as a strategy to get out of the situation, partially sacrifice the energy (strength) of striving for each of these goals, without giving up any of them. This situation in the literature on goals is called "the search for satisfying alternatives" ("satisfying", Simon, 1967; Silvestrini et al., 2022).

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Discussion

The category "goal" has a long history and is a complex and multifaceted psychological phenomenon that requires further scientific study. The ambiguity of the definition of the goal in science, the dependence of the characteristics of the goal in research on the tasks is shown.

Two key factors for achieving a goal include a person's commitment and commitment to the goal, and perseverance, reflecting how much people continue to invest in specific goals.

Intentions to implement plans have a beneficial effect on achieving the goal through automatic processes. The desire to achieve the goal can be activated unconsciously due to the stimuli of the external environment.

A goal is a form of self–regulation of behavior used by people consciously or unconsciously to achieve certain future states of their physical Self or the world around them. By focusing people's attention, goals promote a response consistent with people's goals. Goals give a person the ability to regulate their reactions that go beyond biologically determined predispositions. By engaging in purposeful behavior, people take into account future events, behaving in such a way as to either facilitate or prevent their occurrence. The key importance is the mental image of the future possibility (the state of reality), which affects the behavior in the present.

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Author Details

Roman Vladimirovich Vasyov – Postgraduate student, General psychology Department, Moscow University for the Humanities, Moscow, Russian Federation; ORCID: https://orcid.org/0000-0002-6284-7878, e-mail: fin.roman285@gmail.com

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Theory of Mind in Persons with Permanent Hearing Disorders

Pavel N. Ermakov[1], **Vadim Yu. Gorelov**[2]✉
[1, 2] Southern Federal University, Rostov-on-Don, Russian Federation

✉ vgorelov@sfedu.ru

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;

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- 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

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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 I 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 theOthers' 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).

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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 mindin 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. Rumyantseva (Rumyantseva, 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.

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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://psytests.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

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Participants group	N	M	SD
Men	43	17,6	5,1
Women	27	15,1	3,9
Including:			
III hearing loss degree	15	18,4	3,1
IV hearing loss degree	37	16,7	5,3
Deafness	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. Rumyantseva (Rumyantseva, 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.

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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 ≤ 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 ≤ 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

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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.

Author Information

Pavel Nikolaevich Ermakov – Doctor of Biological Sciences, Professor, Academician of the Russian Academy of Education, Southern Federal University, Rostov-on-Don, Russian Federation; Scopus Author ID: 6602450914, SPIN-code: 7706-9441, ORCID: https://orcid.org/0000-0001-8395-2426, e-mail: paver@sfedu.ru

Vadim Yur'evich Gorelov– post-graduate student, Southern Federal University, Rostov-on-Don, Russian Federation; SPIN-code: 3796-8776, ORCID: https://orcid.org/0000-0002-5829-3470, e-mail: gorel86@mail.ru, vgorelov@sfedu.ru

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Presentation of the Personality Archetype in Semantic Structures

Viktor A. Skleynis
North-Eastern State University, Magadan, Russian Federation
kartiala@list.ru

Abstract: **Introduction**. This article is devoted to solving the problem of searching for semantic correlates of archetypal space. The author considers archetypal structures as systems of meanings having different levels of presentation and correlated with the three-layer model of the image structure of the world proposed by V. P. Serkin. The study is novel in that the conjugacy of the semantic space of Charles Osgood (evaluation, potency, activity) and the archetypal space of Carol Pearson are empirically studied for the first time. **Methods**. The study involved 320 respondents aged from 19 to 66 years. The definition of the leading personality archetype was carried out with the application of archetypal metaphorical mappings 12 Archetypes Plus, proposed by T. V. Kapustina. The respondents' ideas about themselves were studied using a personal semantic differential. **Results**. Comparison of intergroup indicators using the Kruskal–Wallis H test showed the intergroup differences in each factor of personal semantic differential (evaluation, potency, activity). Correlation analysis applying the Pearson coefficient showed the conjugacy of the axes of the archetypal space of Carol Pearson and the semantic space of Charles Osgood. Thus, the axis «self–knowledge - belonging» demonstrates the conjugacy with the «evaluation» and «potency» factors and the axis «stability – change» – with the «activity» factor. In addition, the «evaluation» factor demonstrates the correlation with the stages of the archetypal journey (preparation, journey, return). **Discussion**. The presence of the conjugacy of the factors of the semantic space of self-evaluation and the axes of the archetypal space allows us to consider the process of embodying archetypal structures in sign systems as a particular case of projecting the nuclear layer structures of the image of the world onto the semantic layer.

Keywords: psychosemantics, semantic structures, semantic space, archetype, archetype presentation, archetypal space, archetypal journey, world image, meaning systems, deep structures

Highlights:

- The axes of the archetypal space Carol Pearson demonstrate a correlation with the factors of the semantic space Charles Osgood: the ‘evaluation’ factor corresponds to the ‘self–knowledge – belonging’ scale, the ‘activity’ factor corresponds to the ‘stability – change’ scale; the ‘potency’ factor demonstrates conjugacy with both axes of the archetypal space.

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▹ The stages of D. Campbell's archetypal space demonstrate a correlation with the 'evaluation' factor.
▹ Since the semantic space within the framework of the three-layer model of the image structure of the world (V. P. Serkin) corresponds to the semantic layer, and archetypal structures correspond to the nuclear layer (V. A. Skleynis), the data on the correlation of archetypal and semantic spaces indicate the projection of archetypal structures on the underlying systems of meanings.

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Introduction

The concept of an archetype includes a wide range of phenomena studied by various fields of knowledge. Having arisen initially within the framework of philosophical science, this concept has become widespread in analytical psychology, where archetypes are considered as universal primary mental structures that attract psychic energy and influence the structuring of the perceived world and the psyche itself. Subsequently, the explication of the psychological definition denoting deep mental structures led to the emergence of many sociological and culturological models describing the expression of archetypal structures in cultural symbols and the interaction processes of intrapersonal and interpersonal forms of archetype existence (Kuz'min, 2015).

The socio-cultural direction of the study of archetypal structures can include approaches that consider the manifestation of the archetype in culture or models of social interaction. The sociological interpretation of the archetype concept presupposes its consideration as a stable recurring system of goals, values and meanings, born in collective experience based on the internal unity of social practices (Laza, 2012). Many authors, correlating the psychological and sociological aspects of the archetype, consider the processes of their interaction and mutual transition. For example, Sosteric (2021) interprets the process of dynamics of archetypal structures as a sequential transition from individual experience to social consciousness structures, and Malenko (2010) considers archetypes as imaginative determinants of the formation of the space of individual and collective scenarios of social interaction, organizing the field of initial natural meanings, as well as the possibilities of their interpretation in personal and social interaction spaces.

The culturological interpretation of the concept of «archetype» involves the consideration of cultural phenomena that are the result of the process of symbolization of deep mental structures and, at the same time, playing the role of the deep foundation of the socio-cultural space. Thus, Vdovushkina (2012), analyzing the elements of the archetypal content of culture, identifies three groups of archetypes that make up the semiopsychologemic subspace of culture. The first group of archetypes – axial – provides a connection between the spheres of understanding and preunderstanding, functioning as a balancing centrifugal and centripetal tendencies. Vector archetypes set the direction of cultural dynamics, providing the processes of generation and accumulation of new meanings. Finally, the third group of archetypes - the consolidating ones – perform the functions of the core of culture, ensuring the preservation of its stability.

The processes of interaction between the archetype and culture are considered by N. S. Vdovushkina as a mental projection into the external environment: the archetypal scheme absorbs the external world and interprets it, projecting the result of interpretation onto an external object. At the

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same time, the processes of perception of archetypal structures are described as a bifurcation transition, the attractors of which are the archetypes of culture.

In turn, the processes of the dynamics of the archetypal matrix itself are also considered as nonlinear and include the alternation of periodic, quasi-periodic and chaotic states. In our works (Skleynis, 2019, 2021), the dynamics of archetypal structures is also considered as a nonlinear dynamic process, but the process of their interaction affects various semantic formations, which include both intrapsychic and interpersonal structures.

Within the framework of the psychological direction of archetype research, the authors often attempted to construct an archetypal space, structuring archetypal images and describing their relationship. Thus, in the works of Jung (2016), the process of individuation is considered as a movement towards the self, understood as a sequential passage from outward structures to deep ones. The stages of this process are the disclosure of the Person, meeting with the Shadow, interaction with the Anima/Animus, and, finally, the acquisition of Selfhood (Korolenko, Dmitrieva, 2018).

Chetwynd (2017) structured the archetypal space by correlating archetypal images with the psychological functions identified by Carl Gustav Jung, which, in turn, are aligned with the four elements. So, the intelligence function corresponds to the element of Air and the figure of the Hero/Amazon. The sensation function correlates with both the mother and father figures and the Earth element. Intuition corresponds to the Witch/Trickster figures and the Water element. Finally, the sphere of emotions corresponds to the Fire element and the Young man/Princesses figures.

C. S. Pearson and H. Marr (Pearson & Marr, 2003; McPeek, 2008) localize archetypal images in a space represented by two axes. The first axis is represented by such poles as stability (control) and risk (mastery); the second axis is formed by the opposition of belonging/possession on the one hand and independence/self-realization on the other. Furthermore, the archetypes are also structured according to the stages axis, which includes three phases of the 'hero's journey' (Hillman, 2006; Campbell, 2018): preparation for the path, the path itself, and return.

In Russian psychology, the archetypal space is considered as a hierarchical system by most authors. At the same time, archetypal formations localized at the level of deep structures are reflected in semantic structures. Thus, Zarubko (2010), considering the archetype as an implicit model of interaction between universal actors, speaks about the hierarchical structure of the archetypal space, which is based on binary oppositions of abstract concepts, such as, for example, 'good–evil', 'nature–society', concretized in the form of universal figures that receive originality due to the scenario interactions.

Another example of a hierarchical model of archetypal space is the model of Perevozkina et al. (2013), which distinguishes three archetypal structures presentation levels, different in the degree of generalization. The level of undifferentiated consciousness includes a primary syncretic image. It differentiates at the mythological level into images categorized using semantic space, the factors of which are evaluation, sex, and age. At the level of the information space, these figures have the projections into particular spheres of life: intimate, interpersonal, professional, and family.

In our works (Skleynis, 2021), the process of manifestation of deep archetypal structures at the level of semantic space is considered as a special case of the functioning of the image of the world. It is understood as an integral system of meanings. Considering the structure of this

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system, Serkin (2019) identified 3 layers of the image of the world depending on the form of the presentation of values. *The nuclear layer* of the image of the world is a goal-motivational complex that includes the most generalized semantic structures. The content of *the perceptual layer* is represented by a set of perceptual features that form preconceptions that turn images into representations. Finally, *the semantic layer*, which is a set of relations to the currently perceived objects, ensures the interaction of outward and deep structures, combining the systems of relations projected on it by the nuclear layer on the one hand and the information coming from the perceptual layer on the other.

In our works (Skleynis, 2019), three groups of phenomena that make up the content of the 'archetype' concept are designated. The first group is the archetype as a basic tendency that exists at the level of deep structures and manifests itself at the underlying levels in the form of symbolic expression (Jung, 1997). The second group is a sum of sign–symbolic manifestations, covering a variety of forms of manifestation of the archetype in sign systems. Finally, the third group – the architectonic of the archetype – is a manifestation of the archetype in the ways of structuring intrapsychic or social space.

Considering the process of interaction of the layers of the image of the world within the three-layer model, Artemyeva (1999) noted that the nuclear layer is projected onto the semantic part of the relationship, influencing the meaning of the currently perceived objects. In our opinion, the manifestation of the archetype as a basic tendency in the underlying structures can be considered as a special case of projecting the structures of the nuclear layer onto the semantic one, since it represents the influence of deep structures on the processes of value formation.

Furthermore, based on the consideration of the manifestation mechanisms of archetypal structures as a special case of the dynamics of the structures of the image of the world, we compared the three–layer model of the image structure of the world with the model of the archetypal space of Perevozkina (2014). Thus, the level of undifferentiated consciousness, highlighted by Yu. M. Perevozkina, includes the original archetype, which is a basic tendency manifested at the underlying levels, and, accordingly, is correlated with the nuclear layer of the image of the world.

The mythological space is a set of coordinates of semantic categorization, investigated using the methods of semantic differential. It could equate the semantic layer of the image of the world, which is also studied using these techniques (Serkin, 2005). In addition, a number of authors speak about the manifestation of archetypal components at the semantic structures level. For example, Grekov (2016) describes the semantic content of the sub-identities of the Self-image represented by archetypal figures, and in the works of Dotsenko, Zarubko (2008) archetypes are considered as binary oppositions of generalized categories, concretized at the level of consciousness in the form of universal figures and categories with a lesser degree of generality. Finally, the level of the information space corresponds to the perceptual layer of the image of the world, since it includes a set of modal objects. Thus, a certain type of archetypal structures can be assigned to each layer of the image of the world (Table 1).

To solve the problem of complex description of archetypal structures as a multilevel system of meanings within the framework of a three–layer model of the structure of the image of the world, it is necessary to study the correlation of archetypal formations of the nuclear layer of the image of the world on the one hand and their manifestations at the level of the semantic layer on the other.

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Table 1

Comparison of the structures of the image of the world and the levels of archetypal structures presentation

Structures of the image of the world	Archetypal structures
Nuclear layer	The basic trend manifests itself at the level of underlying structures.
Semantic layer	Manifestations of the archetype in the subject's evaluation of related objects
Perceptual world	Manifestations of the archetype in modally presented phenomena. Example – cultural artifacts (architectonics by D. A. Leont'ev)

Methods

Within the framework of our research, theoretical (comparative analysis) and empirical (personal semantic differential, MAC «12 archetypes plus») methods were used. Statistical data processing was carried out using the Kraskell–Wallace test and a correlation analysis of arbitrary-sized contingency tables using the $\chi 2$ test .

To study the deep structures of the image of the world, the 12 Archetypes Plus Technique proposed by Kapustina (2018) was applied. This technique is a set of metaphorical associative cards corresponding to 12 personality archetypes identified by Mark and Pearson. In the future, the distribution of archetypes was carried out in accordance with the axes of C. Pearson's archetypal space (Fig. 1).

Since the basis for the creation of the methodology «12 archetypes plus" was the idea of the personality archetype (Kapustina, 2019), and considering the data indicating the correlation between 12 space archetypes by C. Pearson and personality traits (Skorobach, 2013), as a

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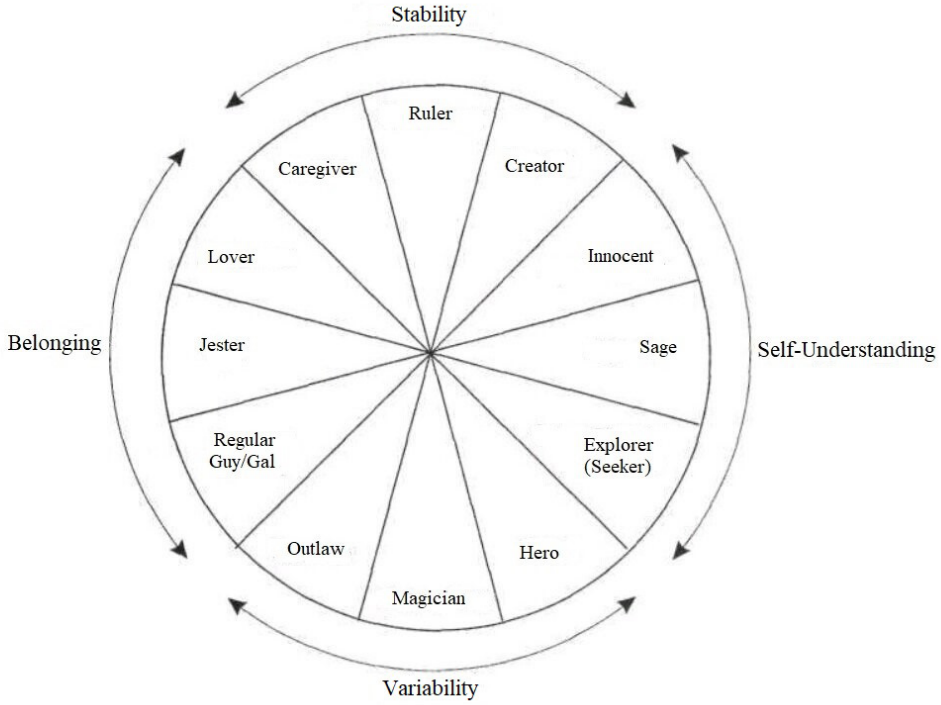
psychosemantic technique that complements the «12 archetypes plus" technique, we used the form of the personal semantic differential (the one adapted by V. M. Bekhterev National Medical Research Centre for Psychiatry and Neurology) (Fetiskin et al., 2002). This technique represents a set of bipolar scales. Using them, the subject describes their ideas about the personality. In the instructions, the subjects were asked to evaluate their ideas about themselves using a personal semantic differential.

Figure 1

Archetypal space (C. Pearson)



The processing of the personal semantic differential results was carried out by highlighting the factors of the semantic space of the EPA (Osgood, 1957). There are three factors in this space. *The evaluation factor* characterizes a subject's degree of satisfaction with their own behaviour, with the feeling of self-importance and the degree of self-acceptance. The value of *the potency factor* demonstrates the ideas of a subject about their degree of self-control and independence. *The activity factor*, which correlates with extraversion, indicates the degree of sociability, impulsiveness, and expression of emotional reactions in communication.

Results

Since there is no normal distribution, we used the non-parametric Kruskal-Wallis test to verify the hypothesis of intergroup differences in evaluation, potency, and activity among groups of subjects (Fig. 2).

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Figure 2

The result of comparing intergroup indicators according to the Kruskal-Wallis test

Hypothesis testing results

	Null hypothesis	Test	Significance	Result
1	The Evaluation distribution is the same for the Archetype categories	the Kruskal-Wallis test for independent samples	,000	Null hypothesis is rejected
2	The Potency distribution is the same for the Archetype categories	the Kruskal-Wallis test for independent samples	,021	Null hypothesis is rejected
3	The Activity distribution is the same for the Archetype categories	the Kruskal-Wallis test for independent samples	,000	Null hypothesis is rejected

Asymptotic significances are derived. Significance level at ,05.

Furthermore, we conducted the correlation analysis to determine the degree of conjugation of the semantic and archetypal spaces parameters. Each of the axes of the C. Pearson's archetypal space ('stability – variability', 'belonging – self-understanding') was tested for contingency with each of the EPA factors (evaluation, potency, activity) using Pearson's mutual contingency coefficient – χ^2. The results of the study are shown in Table 3.

Table 2

The contingency of the archetypal space axes and the EPA semantic space

Factor name	χ^2 test value	Getting into the significance zone
Self-Understanding – Belonging		
Evaluation	5,991	Yes ($p < 0,05$)
Potency	17,439	Yes ($p < 0,01$)
Activity	4,121	No ($p > 0,05$)
Stability – Variability		
Evaluation	4,667	No ($p > 0,05$)
Potency	7,389	Yes ($p < 0,05$)
Activity	6,186	Yes ($p < 0,05$)

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The data obtained indicate the presence of contingency of the axes of archetypal and semantic spaces. The evaluation factor correlates with the 'self-understanding – belonging' axis (the higher values are observed at the 'belonging' pole). The activity factor correlates with the variability axis (the higher values are at the 'variability' pole). The potency factor correlates with both axes of the archetypal space (the higher values are at the poles of 'self-understanding' and 'stability').

Similarly, we analyzed the contingency of the semantic space factors and the archetypal journey stages according to D. Campbell (Hillman, 2017; McPeek, 2008). According to the archetypal journey stages, the classification of archetypes involves the allocation of the family archetypes (hero, regular guy/gal, caregiver, innocent), the path archetypes (outlaw, lover, explorer (seeker), creator), and the return archetypes (magician, jester, sage, ruler).

Table 3

The contingency of the archetypal space axes and the archetypal journey stages

Factor name	χ^2 test value	Getting into the significance zone
The Family Archetypes – The Path Archetypes – The Return Archetypes		
Evaluation	20,484	Yes ($p < 0,01$)
Potency	7,413	No ($p > 0,05$)
Activity	1,799	No ($p > 0,05$)

Among the factors in semantic space, a high level of contingency is demonstrated by 'evaluation', while the largest number of subjects with a high value of this indicator has the leading archetype related to the 'path' stage.

Discussion

In interpreting the results obtained, we can distinguish the following patterns.

Higher values of the 'potency' factor are observed in subjects with a leading personality archetype devoted to the 'independence' archetype group (Seeker, Sage, Innocent).

The «activity" factor, which indicates general activity, impulsiveness, and extroversion, correlates with the 'stability – variability' axis. The axis groups archetypal figures according to their relationship to the transformation of the surrounding world and with the positions of the hero's journey.

The 'evaluation' factor, which manifests itself in the indicators of a subject's self-assessment, and the assessment of their attractiveness, correlates both with the 'self-understanding – belonging' axis of the archetypal space, and with the archetypal path stages. There is a correlation with the 'self-understanding – belonging' axis. In our opinion, higher values in groups of the subjects of the 'self-understanding' pole, can be due to their greater degree of autonomy and self-sufficiency. It is noteworthy that the indicators of this factor demonstrate the highest values in the subjects whose leading archetype correlates with the 'path' stage (Seeker, Outlaw, Lover, Creator). In our opinion, high values of the evaluation factor in the 'path' stage can be due to the specifics of this group of archetypes, referred to as the 'archetypes of metamorphoses'. They are associated with the active transformation of the archetypal model of the surrounding reality by a carrier.

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The 'strength' factor correlates with both axes of the archetypal space, while the relationship with the 'belonging – self-understanding' axis has the highest degree of expression ($p < 0.01$). High values of the 'potency' factor are interpreted as the development of the volitional sides of a personality, independence, and self-control. Consequently, high values of this factor correlate with the 'self-understanding' pole, also referred to as 'independence' (Pearson, 2003). In turn, the correlation of this factor with the 'stability – variability' axis can be explained by the characteristics of the archetypes devoted to the 'stability' pole (Caregiver, Ruler, Creator). These are associated with the strong expression of one's own identity and therefore with the need for internal stability.

Conclusion

The data obtained in the study, which indicate the relationship of archetypal and semantic spaces, prove the relevance of the characteristics of a personality archetype, on the one hand, and semantic structures, on the other.

Within the framework of the three-layer model of the image of the world structure proposed by V.P. Serkin, psychosemantic methods, in particular, the semantic differential, are considered as a tool for analyzing the semantic layer of the world image. At the same time, projective methods, which include metaphorical associative maps (Dmitrieva, Buravtsova, 2015), serve as one of the tools for studying the structures of the core layer. With that said, based on the thesis about the projection of the structures of the core layer onto the structures of the semantic layer, and data on the relationship between semantic and archetypal structures, the process of embodiment of deep archetypal structures can be considered as a special case of projecting the structures of the core layer of the world image onto the semantic layer in sign systems.

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Author Information

Viktor Aleksandrovich Skleynis – Cand. Sci. (Psychology), Associate Professor of the Department of Social and Human Sciences, Federal State Budgetary Educational Institution of Higher Education «North-Eastern State University», Magadan, Russian Federation; ResearcherID: ABH-3121-2020, SPIN-code: 4764-9822, ORCID: https://orcid.org/0000-0002-6653-4924, e-mail: kartiala@list.ru

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The Contribution of Various Spatial Modulations to the Management of Exogenous Attention: An N2pc Study

Eugene G. Rodionov
Southern Federal University, Rostov-on-Don, Russian Federation
ew.rodionov@gmail.com

Abstract: **Introduction**. The mechanisms of exogenous attention, having a high sensitivity to the physical characteristics of sensory signals, provide primary adaptation to the environment. We have suggested that non-local features of the visual scene may have different priorities in attracting exogenous attention. The process of exogenous orientation in the situation of pairwise competition of modulated textures was studied for the first time by isolating the N2pc component. As a result of the study, we established the peculiarities of attention distribution in pairs of spatial features modulated on textures, expanding the idea of the work of exogenous control mechanisms in the visual system. **Methods**. The study involved 32 people aged 18.2 ± 0.4 years with normal vision. The experiment consisted of three parts performed according to the same scheme: the task of the subject was to find the target stimulus (modulated texture) given in the instructions among the decoy (another modulated texture) and distractors. During the experiment, an EEG was recorded in order to analyze the N2pc component. **Results**. Based on the comparison of the N2pc component, it was found that contrast and orientation modulations attract exogenous attention to a greater extent than spatial frequency modulation. The theoretical significance of the results lies in the study of the fundamental mechanisms of exogenous control in the visual system. The results of studying this process can be applied in the development of graphical interfaces, brain–computer systems, as well as in solving a wide range of problems of engineering psychology related to the optimization of human-machine interaction. **Discussion**. Contrast and orientation modulations may have a higher priority for exogenous attention than spatial frequency modulation. In a situation of simultaneous presentation with the latter, contrast and orientation modulations can largely distract attention due to their greater salience. The lower latency of the N2pc component in response to orientation modulation suggests the priority of its processing in comparison with contrast and spatial frequency modulations.

Keywords: attention management, exogenous attention, visual filters, N2pc component, salience, spatial modulation, contrast, orientation, spatial frequency, visual search

Highlights:

- Spatial modulations of different dimensions attract exogenous attention to varying degrees.

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- Spatial frequency modulation contributes significantly less to visual attention management than contrast and orientation modulations.
- Orientation modulation is the highest priority in the competition for attention in comparison with contrast and spatial frequency modulations.

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Introduction

Attention processes allow the brain to overcome the limitations of its processing capabilities, enhancing important visual information and suppressing unnecessary. In order to interact adaptively with the world around us, it is useful to choose the information that is relevant to our goals and ignore what does not apply to them. However, some events should not remain without our attention, even if they are not directly related to current goals. The fundamental research question concerns the mechanisms that control which areas of the visual scene attention will be directed to. On the one hand, the focus of attention can be controlled by the properties of the stimulus, regardless of the goals of the observer. For example, a noticeable new object suddenly appearing in the field of view will attract our attention (Theeuwes, 1994). This control mode is known as exogenous control (or stimulus-driven, involuntary, ascending). Exogenous control mechanisms are sensitive to the physical characteristics of the signals of sensory systems. They provide primary adaptation to the environment, allowing you to navigate and react quickly to sudden events (Klein, 2009). This causes a few features characteristic of this type of orientation. Exogenous attention is fast, resistant to interference and does not require conscious control, and its effects manifest themselves within 100 ms after the attractor (Hopfinger & West, 2006). Exogenous control does not depend on top-down influences, but its effects can be quickly suppressed if the object taken into account does not correspond to the actual task (Theeuwes et al., 2000). On the other hand, the choice of an object for attention may depend on our goals, expectations, or external instructions. For example, the subject can pay attention to an object by following the instructions (Findlay, 1997). This control mode is known as endogenous (or purposeful, conscious, top-down).

It is believed that exogenous attention is attracted by so-called areas of interest, and there may be competition between them. These areas carry the bulk of the information being read, and the result of processing this information is recorded in memory in the form of representations of visual images (Rayner, 2009). With the discovery of D. Hubel functions of striar neurons of the central cortex (Hubel & Wiesel, 1962) fixed the idea that the competition for attention between different parts of the visual scene is based on a comparison of primary (basic) features – brightness gradients, colors, etc. However, striar neurons describe brightness gradients within their relatively small receptive fields, as a result of which the striar neuron model can explain the detection of only a limited number of modulations, for example brightness modulation. But what will be the output of the striar neuron model when contrast modulation is projected onto it, subjectively similar to brightness modulation? If the average brightness of low-contrast and

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high-contrast areas of the image is equal and does not differ from the average brightness of the image, the linear detector will give zero at the output, and the modulation will not be detected. However, an observer with normal vision effortlessly detects contrast modulation.

Another confirmation of the insufficiency of the probabilistic summation of the responses of striar neurons for the full perception of visual scenes is found in the reports of patients whose areas of the visual cortex are damaged by stroke. With local damage to the striar cortex, patients are diagnosed with a scotoma – a blind spot in the field of vision (Chandra et al., 2017), while damage to the extrastriar zones leads to various agnosies – subject, facial, opto-motor, etc., while maintaining the overall integrity of the field of vision (Tikhomirov et al., 2021). These facts suggested the presence of mechanisms in the visual system that group the responses of striar neurons in a special way in large areas of the visual field. These mechanisms are now known as second-order visual filters, the first ideas about which were formulated already in the late 80s (Babenko, 1989; Chubb & Sperling, 1989; Fogel & Sagi, 1989; Sutter et al., 1989). These concepts are based on the "filtration – rectification – filtration" scheme, which replaced the model of multiple detectors when explaining the results of experiments with modulated textures. It is important to note that this model in its original form was considered as universal for detecting both contrast modulations and spatial frequency and orientation. In the future, this gave rise to the problem of the specificity of second-order visual mechanisms and raised the question of which mechanism is responsible for distinguishing these types of modulation, given that the observer distinguishes them without additional effort (probably at the preattentive level) (Yavna et al., 2009; Babenko et al., 2020). Currently, there are several studies showing the relative independence of channels detecting various spatial modulations (Kingdom et al., 2003; Cruickshank & Schofield, 2005; Yavna, 2012; Babenko & Ermakov, 2015). In addition, in recent years, data have been obtained indicating that second-order filters can act as a "gate" of attention (Babenko & Yavna, 2018). Being at the exit of the preattentive stage of visual information processing, these structures can control attention from the bottom up, presumably marking the most informative areas. Since each of the presented modulations is simultaneously present in the visual scene, these areas of the visual scene can attract the observer's attention to varying degrees. We attempted to assess the priority of contrast, orientation, and spatial frequency modulations in attracting attention by analyzing the evoked N2pc component fixed in the visual search task. The purpose of the current work is to determine to what extent each of the modulations is a priority for exogenous attention. This task is implemented for the first time by allocating the N2pc component.

The N2pc component is a potential associated with an event that manifests itself contralateral to the place of the visual scene that the subject pays attention to: if the subjects pay attention to the left part of the visual field, N2pc appears in the right hemisphere of the brain, and vice versa. This component got its name in the article by S. Luck and S. Hillyard (Luck & Hillyard, 1994): the letter "N" denotes negative polarity, the digit "2" is the ordinal number of the component (the peak amplitude of N2pc reaches 180–300 ms after the presentation of the stimulus (Luck, 2011)) and "pc" (short for "posterior contralateral") indicates spatial localization, since negativity is formed in the parietal-occipital leads of the contralateral hemisphere. The N2pc component is actively used as a marker of attention recorded by EEG. The first works related to N2pc used the paradigm of parallel-sequential visual search for targets among distractors, in which it was found that although the amplitude of N2pc is the same in both cases, the length of the negative wave is significantly higher in samples with sequential search. This led researchers to the idea

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that the N2pc component reflects the process of filtering irrelevant information. However, it later turned out that N2pc occurs contralaterally to the presented stimulus even when there are no distractors in its half-field at all. To date, there is evidence according to which only one goal is sufficient for the manifestation of the N2pc component in any of the half-fields (Ilse et al., 2020).

This component can be considered within the framework of two large theories of attention control: the theory of ascending attention control (bottom-up attention, or exogenous attention) and the theory of descending attention control (top-down attention, or endogenous attention) (Gaspelin & Luck, 2019). The first assumes that salient stimuli attract attention automatically and independently of our knowledge and tasks, the second – that salient elements can be ignored if they do not correspond to the expected signs of the search goal or previous experience. Now, it is obvious that N2pc cannot be considered as a component reflecting exclusively bottom-up processes, since in this case the task assigned to the subject would not matter. However, within the framework of the classic experiment with N2pc, the target is manipulated while maintaining other equal conditions. Thus, although only the subject's task actually changes, and the general characteristics of the visual scene remain unchanged, we can observe a more powerful response of the N2pc component in response to a relevant stimulus than to an irrelevant one (Luck, 2006). Nor can N2pc be attributed to components reflecting exclusively top-down processes due to the large amount of experimental data confirming the influence of physical characteristics of stimuli on the component (Gaspelin & Luck, 2018; Bartolomeo & Malkinson, 2019; Han et al., 2022).

The totality of experimental data suggests that both ascending and descending processes contribute to the formation of N2pc. When two stimuli compete in different half-fields, N2pc is highly likely to be tied to a stimulus that has a high salience. However, this is only true for a situation in which both stimuli have the same relevance. The ascending processes of attention are reflected in the latent period of N2pc, practically without affecting its amplitude in visual search tasks (Bachman et al., 2020). The descending processes of attention modulate the amplitude and duration of N2pc, organizing the process of visual search (Goller et al., 2020).

Methods

The study involved 32 people (25 women and 7 men) with normal or corrected to normal vision, the average age was 18.2 ± 0.4 years.

The study consisted of three parts, the procedure for presenting incentives for each of which was similar. The subject was instructed to report the location of the desired stimulus (target) as soon as possible, presented simultaneously with distracting images (decoy and distractors). The target stimulus and the decoy were always represented by a pair of circles with a diameter of 5.25 angular degrees filled with a texture created by summing randomly arranged vertical Gabor micropatterns with an average wavelength of about 2 mm (λ = 8 pixels). The attractor stimuli (target image and decoy) were modulated by contrast, orientation, or spatial frequency. Distractor stimuli were circles without textures, similar to modulated ones in size and average brightness. Each part of the study was represented by a pair of modulated textures presented simultaneously (contrast modulation – spatial frequency modulation, contrast modulation – orientation modulation, orientation modulation – spatial frequency modulation) and divided into two series (Table 1).

At the beginning of each series, the subject was shown a graphic instruction, on which the target image was depicted on the left, and on the right – a decoy and a distractor. An example of the instruction is shown in Figure 1. The subject was tasked to report the location of the target

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stimulus as quickly as possible using the "left" and "right" keys. The sequence of successive parts and series of the experiment was randomized. Instructions and incentives were presented on a Philips 240V monitor, with a resolution of 1920 by 1080 pixels at a frame rate of 60 Hz (IPS, diagonal 23"). The subject's head was fixed in the frontal-chin rest at 60 cm from the screen. The procedure for presenting instructions, stimuli, and recording responses was written in Python 3 using the PsychoPy library.

Table 1

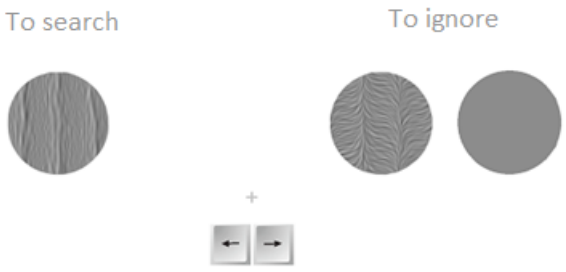
Experiment design

	Series 1 (100 trials)		Series 2 (100 trials)	
	Aim	Decoy	Aim	Decoy
MC – MSF	MC	MSF	MSF	MC
MC – MO	MC	MO	MO	MC
MO – MSF	MO	MSF	MSF	MO

Note: The Aim is a texture, the determination of the location of which is the task of the subject; *the Decoy* is a distracting texture presented simultaneously with the Aim; *MC* is a texture modulated by contrast; *MSF* is a texture modulated by spatial frequency; *MO* is a texture modulated by orientation.

Figure 1

Example slide instructions



Here the Aim is a texture modulated by spatial frequency (MF), the Decoy is a texture modulated by orientation.

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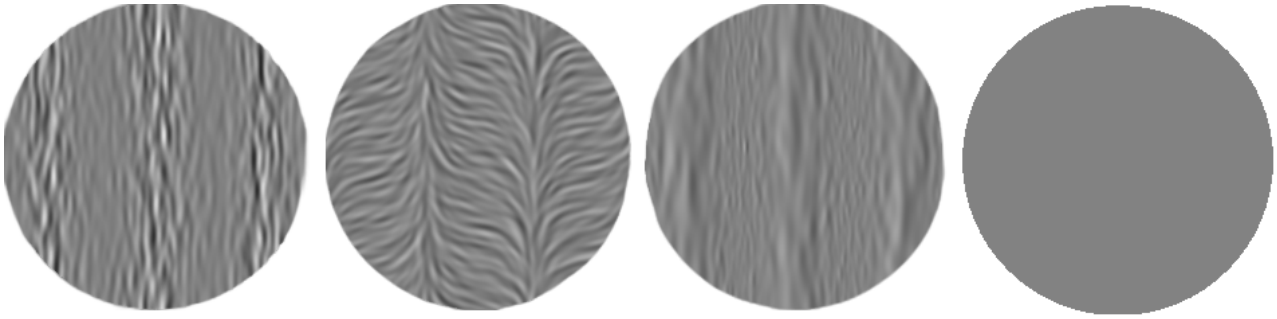
Each series consisted of 100 presentations. Each presentation began with a demonstration of a fixing point that lit up on the screen for 1000–2000 ms. Then 12 stimulus images were presented for 500 ms: 6 on the left and right. The stimulus images were placed at random positions within two windows on the left and right sides of the screen (Figure 3). One of the stimulus images was always the target texture, another was the distracting texture (decoy); each texture could be presented from the left and right with equal probability. The rest of the images were presented by distractors. Subjectively, the target texture and the decoy looked like circles with vertical stripes, the distractors looked like homogeneous gray circles identical to each other. Examples of incentives are shown in Figure 2. Each subsequent presentation was launched immediately after the response of the subject using the "left", "right" and "space" keys (no response). For each presentation, the response of the subject and the time spent were recorded. Each episode ended with an instruction to rest for 40 seconds, after which a new instruction was presented, in which the texture that was the target in the previous series became the decoy, and the target, respectively, became the texture that acted as the decoy. Thus, both series were performed similarly to each other, differing only in the instructions.

Figure 2

Images used as stimuli



From left to right: contrast modulation (MC), orientation modulation (MO), spatial frequency modulation (MSF), distractor.

EEG recording was carried out monopolarly (Fz was used as an indifferent electrode) using the NV-40 digital amplifier of Neurobotics LLC in the parietal-occipital leads PO7/PO8 at a sampling frequency of 1000 Hz. The frequency band of the amplifier was limited to 30 Hz from above, 0.5 Hz from below. Synchronization of the graphics and EEG output was carried out using a light flux sensor through an analog synchronization channel of the amplifier. The post–stimulus epochs of the EEG were averaged separately for each subject, the target–decoy pair and the side from which the target stimulus was presented. The epochs associated with the erroneously determined position of the target stimulus were removed from the analysis, as well as epochs in which the response of the subject was delayed by more than 1 second.

For each subject, the average d–wave curve for each "target-decoy" pair was calculated, representing the millisecond difference in VP for counter- and ipsilateral presentations of the target stimulus. Individual difference curves were averaged, confidence intervals ($\alpha = 0.05$) were

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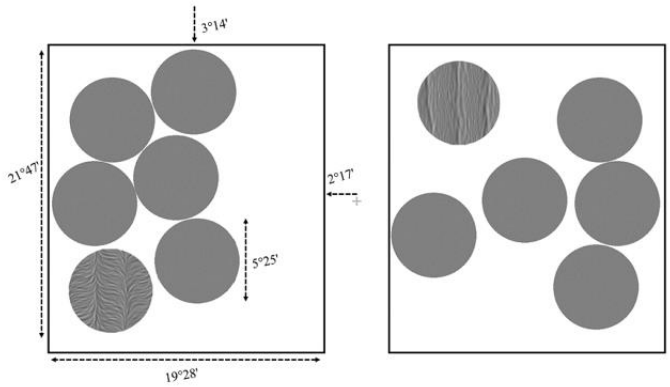
constructed for the results of averaging. Then, for each target–decoy pair, the average power of the N2pc component was calculated, expressed in the sum of all statistically significant negative values of the d-wave ($p < 0.05$).

Figure 3

Sizes of incentives and demonstration windows in angular degrees



The frames and dotted lines are shown for clarity. The stimulus content corresponds to the part of the study "MO (orientation modulation) – MSF (spatial frequency modulation)" (see Table 1). The Aim, Decoy and distractors are in random positions within the demonstration windows.

Results

Figure 4 shows the difference waves of the SSP mismatch for contra- and ipsilateral targets in the leads P07/PO8 in the time interval of 155–300 ms with the upper and lower bounds of the student confidence interval ($\alpha = 0.05$). The left shows the N2pc component in response to the MC as a goal, and the MO as a decoy, the graph on the right reflects the N2pc in response to the opposite situation.

N2pc in response to the condition "MC – target, MO – decoy" is registered at the level of statistical significance ($p < 0.05$) from 191 to 275 ms, reaching its peak (–0.69 ± 0.27 mv) at 243 ms.

In the inverse problem, when orientation modulation was the target, and the decoy was represented by a texture modulated by contrast (the condition "MO – target, MC – decoy"), the N2pc component was recorded at the level of statistical significance ($p < 0.05$) at two time intervals: from 164 to 188 ms with a peak (–0.44 ± 0.24 mv) at 175 ms, and from 219 to 272 ms with a peak (–0.72 ± 0.18 mv) at 253 ms.

The total power of the N2pc component in the condition "MC – target, MO – decoy" was –55.08 ± 11.44 mv, for the inverse problem ("MO – target, MC – decoy") the power was –55.70 ± 13.51 mv. There were no statistically significant differences in the power index of the N2pc component for this pair of modulated textures.

Let's turn to the next pair of modulated textures. Figure 5 shows graphs of N2pc registered in leads P07/PO8 in the time interval of 155–300 ms with the upper and lower bounds of the student confidence interval ($\alpha = 0.05$). On the left, the N2pc component is presented in response to the MC as a target paired with a decoy in the form of a texture modulated by spatial frequency. The graph on the right reflects N2pc in response to the reverse situation.

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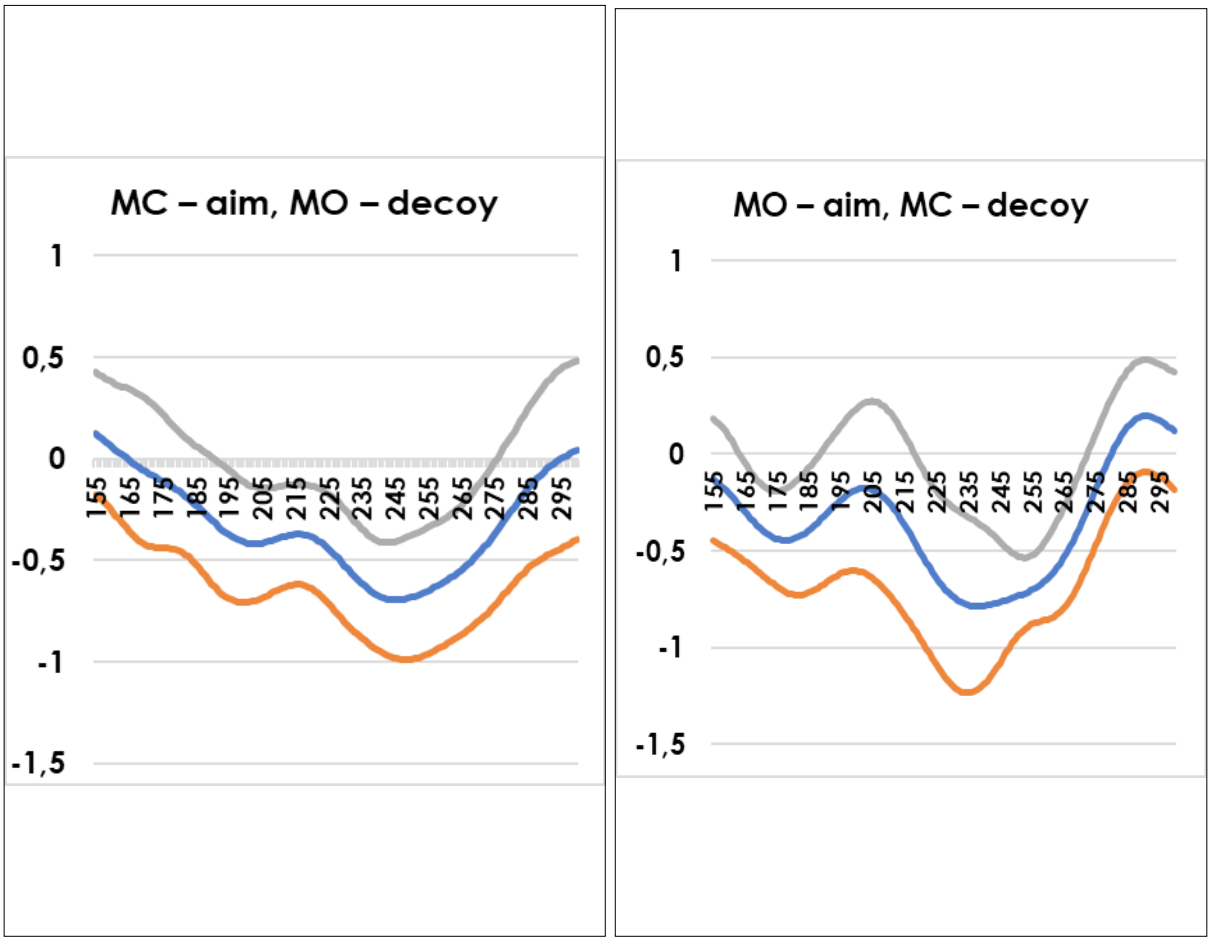
Figure 4

N2pc in Po7/Po8 on a contrast modulated target (left) and an orientation modulated target (right)



The red and gray lines indicate, respectively, the lower and upper limits of the confidence interval for the d-wave. On the abscissa axis – time in ms, on the ordinate axis – the potential difference in mv.

N2pc in response to the condition "MC – target, MO – decoy" is registered at the level of statistical significance ($p < 0.05$) from 193 to 256 ms, reaching its peak (–0.60 ± 0.34 mv) at 244 ms. The average power of the N2pc component in significant areas of the d-wave was –42.25 ± 11.90 mv.

In the inverse problem (the condition "MO – target, MC – decoy"), there was no significant increase in negativity in the contralateral leads.

Consider the last pair of modulated textures. Figure 6 shows graphs of N2pc registered in leads P07/PO8 in the time interval of 155–300 ms with the upper and lower bounds of the student confidence interval ($\alpha = 0.05$). On the left is the N2pc component in response to the MO as a target paired with a decor in the form of a texture modulated by spatial frequency. The graph on the right reflects N2pc in response to the reverse situation.

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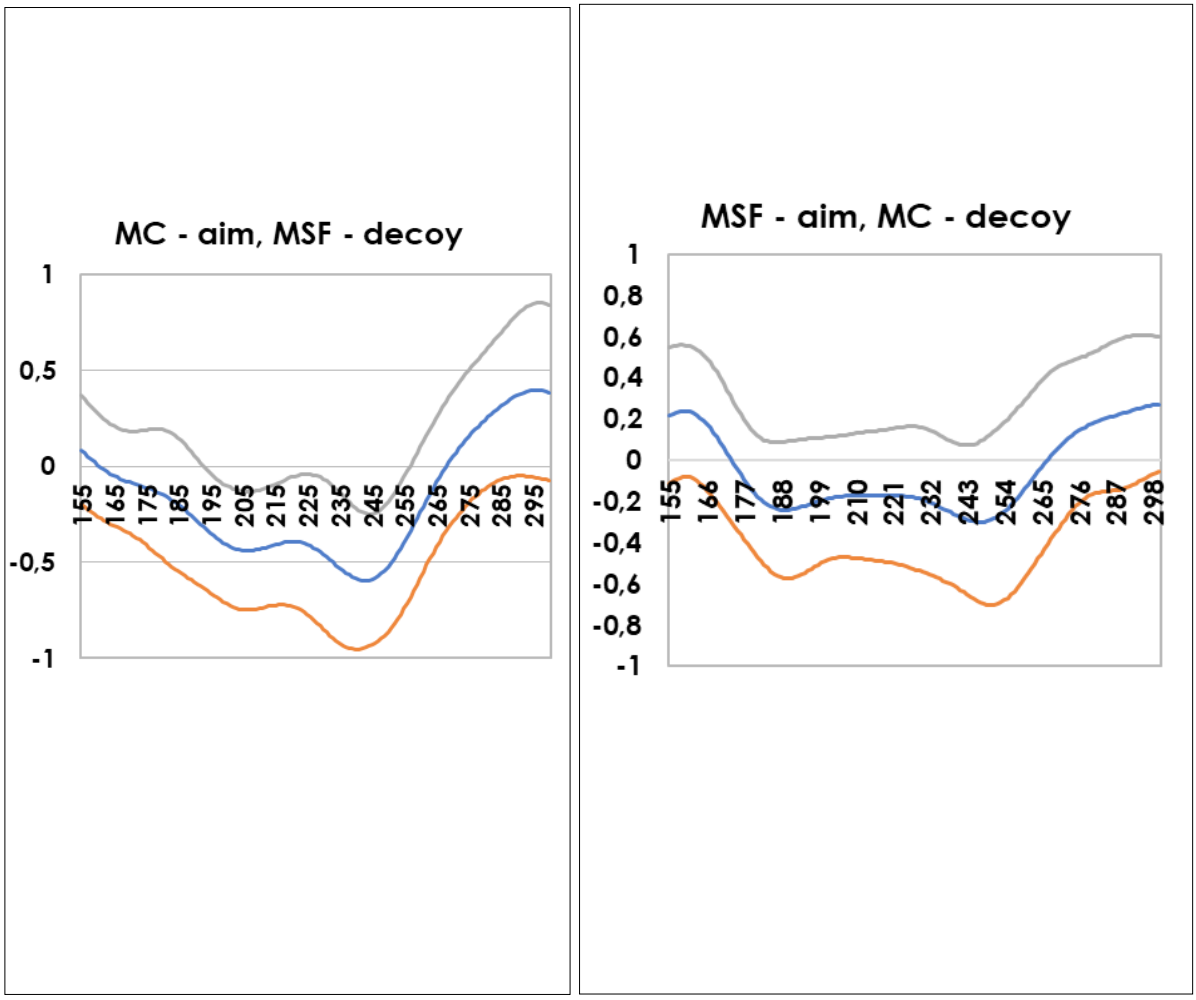
Figure 5

Difference waves in Po7/Po8 leads to a target modulated by contrast (left) and a target modulated by spatial frequency (right)



The red and gray lines indicate, respectively, the lower and upper limits of the confidence interval for the d-wave. On the abscissa axis – time in ms, on the ordinate axis – the potential difference in mv.

N2pc in response to the condition "MO – target, MSF – decoy" is recorded at the level of statistical significance ($p < 0.05$) at two time intervals: from 174 to 201 ms with a peak (–0.35 ± 0.25 mv) at 191 ms, and from 268 to 280 ms with a peak (–0.30 ± 0.25 mv) at 275 ms. The average power of the N2pc component for this condition was –22.27 ± 5.75 mv.

In the inverse problem (the condition "MSF – target, MO – decoy"), no statistically significant N2pc component was found in response to the target texture.

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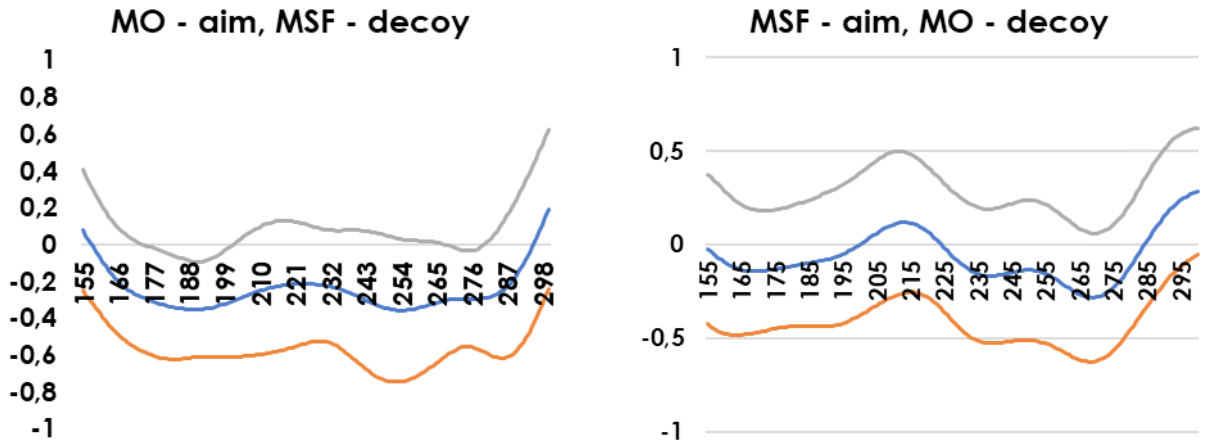
Figure 6

Difference waves in Po7/Po8 leads to a target modulated by orientation (left) and a target modulated by spatial frequency (right)



The red and gray lines indicate, respectively, the lower and upper limits of the confidence interval for the d-wave. On the abscissa axis – time in ms, on the ordinate axis – the potential difference in mv.

Discussion

The design of our study suggests equal relevance of stimuli acting as visual search goals: in each part of our experiment, the subject performed the same task, and the procedure for presenting stimuli was organized according to the same algorithm. In our opinion, there is no reason to assume that the subjects could experience influences that encourage them to subjectively distinguish some textures from others. The only factor modulating endogenous attention in our experiment was the instruction that meets the basic methodological requirements for experiments with N2pc registration (Luck, 2006).

We found that in the "contrast modulation – orientation modulation" pair, N2pc has a shorter latency period when the target of visual search is an orientation-modulated texture. This corresponds to the result obtained in the pair "orientation modulation – spatial frequency modulation". In this problem, the N2pc component also manifested early enough in response to an orientation-modulated texture as a target, with a peak (–0.35 ± 0.25 mv) at 191 ms. According to the conclusions formulated in a number of studies, the latent period of the N2pc component is associated with the physical characteristics of the visual scene: the salient stimulus is able to quickly attract the observer's attention even before the endogenous control mechanisms are activated, which is reflected in the early occurrence of the N2pc component (Bachman et al., 2020;

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Mudrik & Deouell, 2022). Based on this, we can assume that orientation modulation is more noticeable both against the background of contrast modulation and against the background of spatial frequency modulation.

We found no manifestations of the N2pc component in response to spatial frequency modulation as a target. There was no statistically significant increase in negativity between contra- and ipsilateral leads either in the task when spatial frequency modulation was presented in conjunction with contrast modulation as a decoy, or in the task in which orientation modulation was the decoy. However, the absence of the N2pc component in itself is not an indicator of the absence of attention bias, since stimuli presented as distractions can reduce the N2pc component, leaving the target stimulus detectable (Zivony et al., 2018). We tend to interpret the result obtained by us as evidence of the upward influences of the textures-decoys, manifested due to their greater (relative to the texture modulated by spatial frequency) salience. In the inverse problems, when the spatial frequency modulation was the decoy, and the contrast and orientation modulations, respectively, were the goals, the N2pc component was registered at the significance level $p < 0.05$.

Conclusion

Based on the results obtained, we can draw the following conclusions:

1. Textures modulated by contrast and orientation attract attention significantly more than textures modulated by spatial frequency.

2. Textures modulated by contrast and orientation are probably detected due to exogenous control mechanisms. A direct confirmation of this hypothesis is the relatively low latency of the N2pc component.

The results obtained will significantly expand the understanding of the mechanisms of image formation and can be used in solving applied problems in the field of information technology and education.

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Author Details

Eugene Gennadievich Rodionov – Assistant, Southern Federal University, Rostov-on-Don, Russian Federation; Scopus Author ID: 57219781878, ORCID: https://orcid.org/0000-0003-2875-4640, e-mail: ew.rodionov@gmail.com

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Software Possibilities of Using the Eye-tracking Method in Visual Perception Research

Kseniya A. Skuratova[1]✉, **Evgeny Yu. Shelepin**[2], **Konstantin Yu. Shelepin**[3]
[1, 2, 3] Pavlov Institute of Physiology, Saint Petersburg, Russian Federation
[2, 3] Neuroiconica Assistive LLC, Saint Petersburg, Russian Federation

✉ kseskuratova@gmail.com

Annotation: Introduction. Eye movements objectively reflect perceptual, cognitive and emotional processes during visual perception. Studies aimed at analyzing human oculomotor activity require the use of special equipment (an infrared video oculograph or eye tracker), as well as software for creating, conducting and analyzing experiments. **Methods.** A qualitative analysis of the results of eye-tracking studies makes it possible to visualize the order of attention (using gaze movement maps), as well as the proportion of attention (using heat maps) to stimulus elements. With the help of quantitative analysis, it is possible to statistically test hypotheses about the distribution of attention, as well as to assess the cognitive load both over the entire stimulus and by highlighting individual areas of interest (the so-called Areas of Interest mechanism, which allows calculating statistics in individual parts of the stimulus). Quantitative parameters are used to classify errors and as a predictive metric for target recognition. Quantitative parameters of fixations and saccades are used to assess professional experience, as well as to diagnose disorders of mental development and emotional disorders. **Results and discussion**. Software with advanced capabilities for qualitative and quantitative analysis allows for a comprehensive assessment of both the mental processes of a person and the visual features of the presented stimulus. An in-depth analysis of oculomotor activity metrics is primarily relevant for research in the field of cognitive psychology, but can also be useful in other scientific and applied areas: psychopathology, pedagogy, ergonomics, medicine, and neuromarketing. The mechanisms of processing «raw data» and algorithms for determining the types of eye movements, identifying saccades and fixations are shown using the IVT algorithm as an example. Examples of research in applied fields are given. The novelty of the article lies in the fact that eye tracking is considered as a tool for studying cognitive processes and analyzing a person's gaze on a spatio-temporal basis. It is an integration of qualitative and quantitative analysis using specialized software.

Keywords: visual perception, research methods, video oculography, eye tracking, oculomotor activity, eye movements, psychophysiology, fixations, saccades, areas of interest

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Highlights:

- Eye-tracking is used in the social and humanitarian sciences to objectify the processes of visual perception.
- Algorithms based on the speed of eye movements and algorithms based on the spatial position of eye movements are used to separate fixations from saccades.
- When analyzing eye movements, both qualitative and quantitative results can be obtained.
- Qualitative results of eye-tracking studies include: eye movement maps, heat maps, fog maps, bee swarms.
- The quantitative results of eye-tracking studies include parameters related to the number and duration of fixations, as well as the amplitude of saccades.

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Introduction

The processes of visual perception are largely unconscious and inaccessible to introspection. For example, subjects report only some of their eye movements or even eye movements they did not make. For this reason, their study requires special research methods. Eye tracking provides an opportunity to explore mental processes in settings where verbal reports or introspective judgments cannot be obtained (e.g., studies on infants and toddlers) or their validity is questioned.

Eye movements are closely related to perceptual, cognitive and even emotional processes, so eye tracking can be used as an effective, objective and relatively simple method of learning when perceiving complex visual scenes, performing cognitive tasks, interacting with interfaces, perceiving social scenes and much more.

Some of the main scientific and applied areas of application of eye tracking:

1. *Cognitive psychology.* Eye tracking is a highly sensitive method of probing attention by reducing interference from motor or verbal responses, and is therefore often used in visual search paradigms (Blakley et al., 2022). Analysis of oculomotor activity patterns provides evidence that Raven's matrix solving strategies are directly related to individual differences in intelligence (Vigneau et al., 2006). Since eye movements precede and facilitate conscious retrieval of information from memory, eye tracking is also popular in memory research (Hannula et al., 2010).
2. *Psychopathology.* Since eye movements are quite stereotyped and reproducible, even relatively minor deviations in oculomotor patterns can be informative markers for identifying the risk of many mental disorders, such as attention deficit hyperactivity disorder (Maron et al., 2021), schizophrenia (Hashimoto, 2021), obsessive- compulsive disorder (Kim et al., 2021).
3. *Pedagogy.* The subject of eye-tracking research in education is related to various aspects of human cognitive development. For example, eye movements are objective indicators of impaired development of reading skills in children, so they can play a significant role in

their diagnosis (Zashchirinskaya et al., 2019). The close relationship between the study of geometry and spatial reasoning makes eye-tracking a suitable method for investigating the perceptual processing of geometric shapes (Strohmaier et al., 2020). Eye tracking is also used to track student engagement (Kaakinen, 2021).

4. *Neuromarketing*. One of the main application areas using the eyetracking method. The registration of eye movements allows us to explore the visual attention of consumers and provides information about the level of visibility and attractiveness of advertising or product packaging elements (Motoki et al., 2021).
5. *Ergonomics*. Increased cognitive load can negatively affect the performance of professionals in high-risk industries (such as aviation) and increase the likelihood of dangerous situations. A potential benefit of using eye-tracking to measure cognitive load is that it can capture fluctuations in cognitive load that occur over short time intervals (Ahlstrom & Friedman-Berg, 2006).
6. *Medicine*. Tracking eye movements can help not only to objectively consider the features of the cognitive processes that underlie the interpretation of diagnostic images, but also make a significant contribution to the process of medical education. Allowing students to observe the scanning paths performed by experts is more effective than verbal description of the visual diagnostic method (Fox & Faulkner-Jones, 2017).

For a long time, only foreign solutions were presented on the Russian market of software for recording and analyzing eye movements. After analyzing their functionality, as well as the needs of researchers, we developed the Neuroburo software, which provides synchronous recording of eye movements, ECG (electrocardiograms), EMG (electromyograms), EDA (electrodermal activity), EEG (electroencephalography) and responses of the subjects, as well as a wide range of qualitative and quantitative methods of analysis.

Methods

Algorithms for detecting commits

Specialized software designed for research with eye movement registration uses various algorithms for detecting fixations and separating them from saccades.

The input data for the algorithm is a sequence of the form [time stamp, coordinate along the horizontal axis, coordinate along the vertical axis], where the spatial coordinates of the gaze positions correspond to each time stamp. Timestamps follow with a frequency based on the sampling rate and for the Gazepoint series eyetrackers are 60 and 150 Hz and correspond to the resulting CNT / TIME / TIME_TICK value. Spatial coordinates correspond to the gaze direction point (POG, point-of-gaze), calculated on the eye tracker using the LPOGX, LPOGY/RPOGX, RPOGY/BPOGX, BPOGY values, on the monitor screen, and are given as coordinates, where (0,0) – top left, (0.5,0.5) the center of the screen, and (1.0,1.0) the bottom right.

There are two groups of algorithms: algorithms based on the speed of eye movements and algorithms based on the spatial position of eye movements (Komogortsev et al., 2010).

Rate-based commit detection algorithms include:

- I-VT (classification based on saccade velocity threshold);
- I-HMM (classification based on the hidden Markov model);
- I-KF (classification based on the Kalman filter).

Spatial data-based fixation detection algorithms include:

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– I-MST (minimum spanning tree classification);
– I-DT (classification based on the spatial dispersion of gaze points).
–

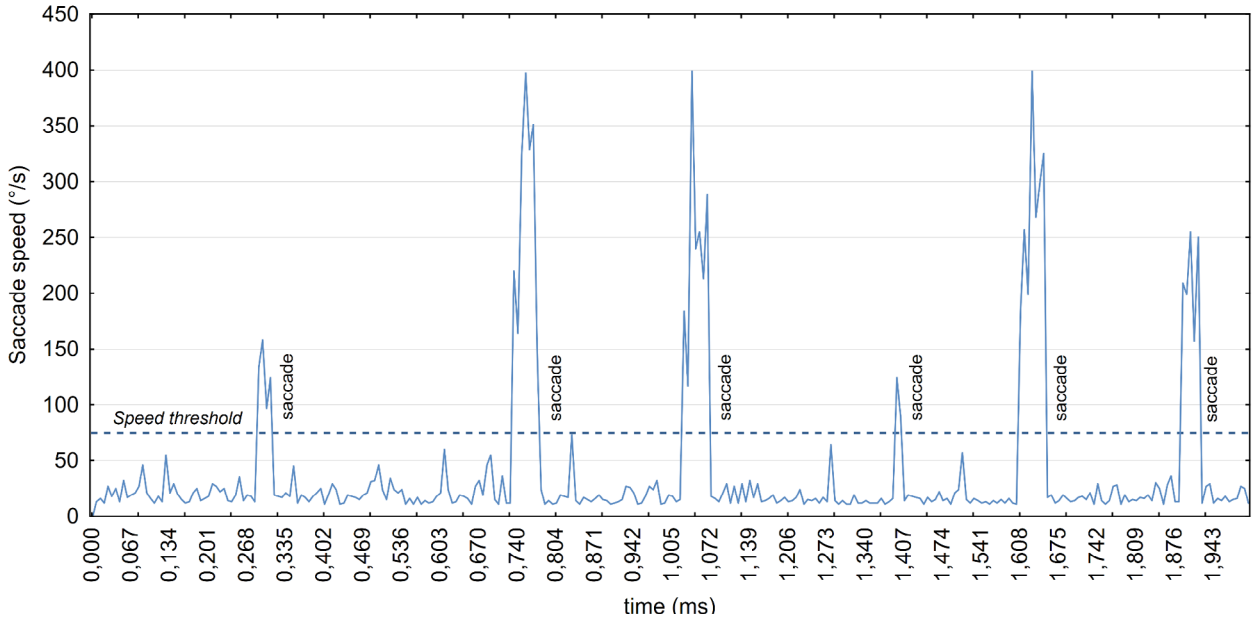
Fixation detection based on the determination of the saccade speed threshold

At present, Neurobureau software uses an algorithm of the I-VT (the Velocity-Threshold Identification) family, which consists in classifying eye movements based on the determination of the saccade velocity threshold:

1. For each distance between the current point and the next point, a speed is calculated.
2. Each point is then classified as either a fixation point or a saccade point based on the velocity threshold: if the point's velocity is below the threshold, it becomes a fixation point, otherwise it becomes a saccade point.
3. The process then aggregates successive commit points into a commit group.
4. Finally, I-VT translates each fixation group into an <x, y, t, d> representation using the centroid of the points as x and y, the time of the first point as t, and the duration of the points as d (Salvucci & Goldberg, 2000).

Figure 1

Classification based on saccade velocity threshold



Thus, for the I-VT algorithm to work, it is necessary to set the saccade velocity threshold (Fig. 1). The recommended value for this parameter is 70 °/s (Komogortsev et al., 2010).

To improve the accuracy of fixation detection in the «Neurobureau» software, the I-VT algorithm was supplemented with the following functions: gap filling, data source selection, noise suppression, merging of adjacent fixations, removal of short fixations. These functions will be discussed in more detail below.

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The gap filling feature helps fill in data where it is missing: for example, if the subject blinked or looked at an area off the monitor. «Neurobureau» allows you to select the maximum duration of the gap that must be filled. The recommended value for this parameter is 75 ms (Komogortsev et al., 2010).

For detection of fixations, it is possible to select the source of data obtained both from one individual eye (for example, right or left), and averaged data. When choosing the left eye, the source of coordinate data is LPOGX, LPOGY. When choosing the right eye, the data source for coordinates is RPOGX, RPOGY. When averaging is selected, the coordinate data source is BPOGX, BPOGY / (LPOGX+RPOGX) : 2, (LPOGY + RPOGY) : 2.

The I-VT algorithm implemented in the «Neurobureau» software includes the possibility of using the noise reduction function based on the mean or median. This function is a special case of a low pass filter, better known in signal processing terms as an unweighted moving average filter (Oppenheim, 1997). To use the noise reduction function, you must set the "window size" parameter: the higher it is, the smoother the output data will be. It should be taken into account that an increase in the numerical values of the "window size" parameter leads to an increase in the duration of saccades and a decrease in the duration of fixations. The advantage of using median-based denoising, compared to moving average, is that fewer «false» gaze coordinates are created.

If the fixations are close together both in time and space, there is a high chance that they are actually parts of the same long fix. To correct such errors, you can use the function of merging adjacent commits (Komogortsev et al., 2010). «Neuroburo» allows you to set the maximum time and maximum angle between two fixation parts, after which they will be considered as separate fixations. The value of the parameter «maximum time between fixations» should not exceed the blink duration (Ingre et al., 2006). The recommended value is 75 ms (Komogortsev et al., 2010). For the "maximum angle between fixations" parameter, the recommended value is 0.5° (Kliegl et al., 2004; Komogortsev et al., 2010; Over et al., 2007).

Even after using the function of combining adjacent fixations, fixations of very short duration can still remain, the analysis of which is not meaningful in the study of oculomotor behavior, since the eye and brain take some time to process information about what it sees (Munn et al., 2008). The solution to this situation is to use the *function to remove short fixations*, for which you need to set the minimum duration of fixation. The recommended value for this parameter is 60 ms (Komogortsev et al., 2010), which corresponds to the shortest fixations during reading (Over et al., 2007).

Results and its discussion

This section will describe the functionality implemented by us in the Neuroburo software.

Mode «Creating an experiment»

This mode is designed to create an experiment design and includes the functions of selecting, adding and editing the name of the experiment, description of the experiment, necessary information about the subject, psychophysiological sensors that will be used in the experiment, as well as stimulus material.

The «Experiment» mode

The «Experiment» mode is intended for conducting an experiment, as well as for setting up and testing equipment.

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Mode «Experiment Analysis»

This mode is designed to analyze the results of the experiment, as well as export the obtained data for further statistical processing.

The «Experiment Analysis» mode provides such types of visualization and analysis of eye movements as: eye movement, heat map, areas of interest, bee swarm, combined analytics.

In the «Experiment Analysis» mode, it is possible to change the following parameters for eye movement registration data: *speed scale; speed threshold; minimum duration of fixation; association of fixations (by time; by time and angle); maximum time between fixations; maximum angle between fixations; noise reduction (average; median); filling gaps.*

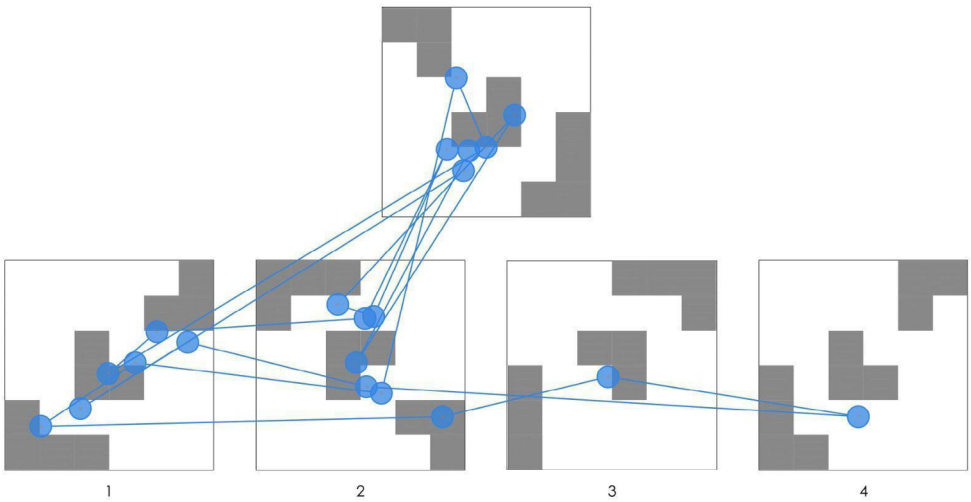
Next, consider the visualization and analysis methods available in the «Experiment Analysis» mode.

Analytics «Movement of the eye». The commit sequence map is based on spatial data (where the commit occurred) and temporal data (when the commit occurred and how long it lasted). The sequence of fixations and its schematic representation depends on where the subjects look and how much time they spend on it, and gives a deeper understanding of the mechanism of attention. The order of attention is a commonly used parameter in oculomotor activity studies because it reflects a person's interest and allows you to highlight the most significant objects on the screen or in the environment that stand out visually (for example, by color or brightness) or are emotionally or socially significant. Also, this type of analytics helps to evaluate the pattern of image analysis or problem solving.

Figure 2 shows an example of a visualization obtained using the Eye Movement analytics.

Figure 2

Visualization obtained using the Eye Movement analytics



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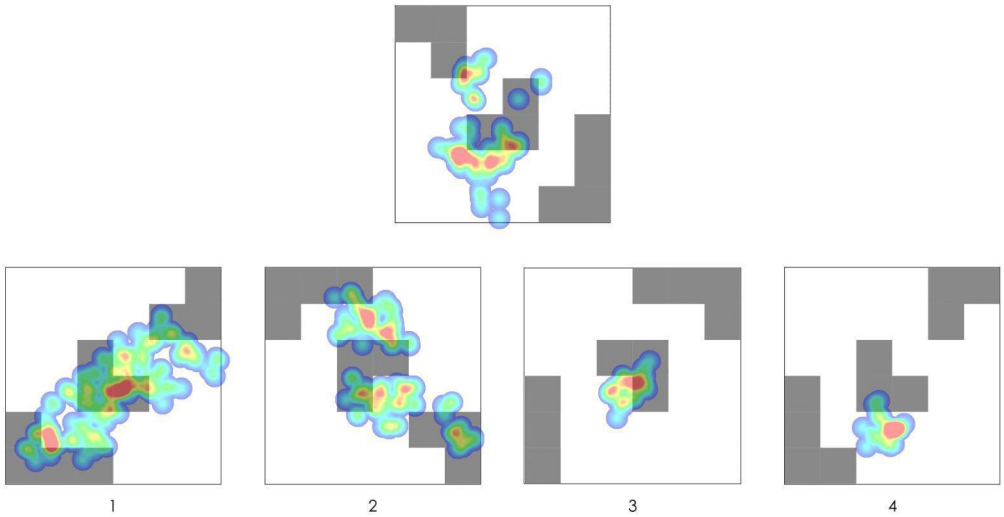
Analytics «Heat map». A heat map is a static or dynamic union of all points of view of the subject, showing the distribution of visual attention and displayed by overlaying a color gradient on the presented image. Using an easy-to-understand color scheme, heat maps are an excellent way to visualize which stimulus items received the most attention: warmer red areas correspond to more gaze points (and thus the most interest), cooler yellows and then, green areas correspond to fewer viewpoints (and thus a lower proportion of attention). The colorless areas correspond to elements that did not receive the attention of the subjects.

The «Experiment Analysis» mode allows you to select an algorithm for constructing a heat map (you can select such functions as: constant, linear, exponential).

An example of a visualization obtained using the Heat Map analytics is shown in Figure 3.

Figure 3

Visualization obtained using the Heatmap analytics



Analytics «Areas of interest». An area of interest (AOI, short for Area of Interest) is a tool for selecting areas of a presented image or video and extracting metrics specific to those areas.

The Areas of Interest analytics allows you to select any shape to highlight (rectangle, circle, ellipse, freeform, polygon).

Using the Regions of Interest analytics, the following eye movement parameters can be calculated and optionally exported in CSV (Comma-Separated Values) or XLS (Excel) format:

1. *Time to first fixation on the region of interest*. Bright (Bojko, 2006), large (Schreij et al., 2008) or out-of-context elements (de Graef et al., 1990) attract attention faster. Based on this, location, color, contrast, brightness and size are called *ascending* factors, as they cause involuntary switching of attention to oneself (Orquin et al., 2020). This type of attention is

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called *exogenous*, or *ascending*. *Endogenous*, or *downward* attention, provides an arbitrary switching of attention to a certain element of the stimulus. For example, the time to the first fixation on a target trait is related to the specialist's professional experience (Kundel et al., 2008). In addition to the time to the first fixation, «Neurobureau» also calculates the number of fixations before the first fixation on the area of interest.

2. *The total fixation time on the region of interest*. This parameter can be used to compare the amount of attention given to different areas of interest (Poole & Ball, 2005).
3. *Duration of the first fixation*. One of the most popular parameters in psycholinguistics, it reflects the process of lexical activation and depends on the grammatical characteristics of the word (Clifton et al., 2007).
4. *The number of returns to the region of interest*. Re-fixations on a previously scanned area are necessary to remove information ambiguity and other processing difficulties (Spivey & Tanenhaus, 1998).
5. *Average fixation time*. Longer fixations indicate that subjects spend more cognitive resources on analyzing and interpreting the content of the area of interest (Sharafi et al., 2015). For visual search tasks, fixation duration can be used to classify errors and as a predictive metric for target recognition (Williams & Drew, 2019). Fixation duration indicates the time needed to plan the next saccade (Liversedge et al., 2012). Anxiety has also been found to reduce the duration of fixations (Wilson, 2012).
6. *The ratio of the number of subjects who looked at the area of interest to the total number of subjects*. This parameter is used as an indicator of the visibility of an interface element, advertising or product packaging (Jacob & Karn, 2003). In reading studies, this parameter can be used to calculate the «percentage of gaps», i.e. the percentage of words on which the reader did not fixate (Inhoff & Radach, 1998).
7. *The total number of commits*. The number of fixations per area of interest is related to the information value and complexity of information processing (Henderson et al., 2009). A higher number of fixations for the entire stimulus indicates a less efficient search for relevant information (Goldberg & Kotval, 1999).
8. *Average amplitude of saccades*. The smaller the saccade amplitude, the higher the cognitive load (Poole & Ball, 2005). When reading, the amplitude of saccades is limited to 7–9 letters (approximately 2°), while it depends on the reading skill: it is much smaller in children and dyslexics (Rayner, 1998). When reading aloud, the amplitude of saccades decreases to 1.5 angular degrees (Rayner & Pollatsek, 1989). Problems with understanding the text also lead to a decrease in the amplitude of saccades. For visual search tasks, the amplitude of saccades averages 3 angular degrees, and when perceiving visual scenes, it increases to 4–5 angular degrees (Rayner, 2009).
9. *The number of saccades*. This parameter reflects the process of comparing or integrating several elements of the stimulus (Eckstein et al., 2017). In addition, the number of saccades increases with increasing cognitive load (Hébraud et al., 2004). Work experience also affects the number of saccades: experts perform fewer saccades than beginners (Dong et al., 2018).
10. *The total length of the scan path*. The longer scanning path suggests that the subject paid more attention to switching between different areas of interest and explored the stimulus more in general, which indicates a less effective visual search (Goldberg et al., 2002). The length of the scanning path decreases as the professional skill improves (Skuratova et al., 2021).

11. *Average and peak speed of saccades*. The peak saccade velocity, in contrast to the average velocity, does not depend on the saccade duration, because it is not associated with it a priori by a mathematical function (Di Stasi et al., 2011). According to the cognitive-energy performance model of Sanders (Sanders, 1983), peak saccade velocity varies with changes in the resources required to complete a task (App & Debus, 1998), decreasing as task complexity increases, as well as cognitive fatigue (Di Stasi et al., 2011).

A display of the ratio of the area of interest to the total area of the stimulus is also available.

Analytics «Bee Swarm». Analytics is designed to display the movement of the gaze of the subject without pre-processing.

Combined analytics. This mode is designed to combine several methods of visualization and analysis of results. You can combine any type of analytics.

Data export. The «Data Export» function is designed to save the original signal received from the eye tracker, EDA sensor, ECG sensor, EMG sensor and electroencephalograph, as well as data on mouse clicks and keyboard buttons for further processing in third-party software. Export is possible in the following formats: for electroencephalography, edf+ format, for other devices, csv and xlsx formats. It is possible to export data containing synchronization marks, which indicate the time of entry and exit from the region of interest. A multi-export function is available, which allows you to save all the results obtained in one experiment with the click of a button.

Conclusion

The software presented in the article allows you to conduct experiments to study the processes of visual perception. It is also possible to combine various sensors of the psychophysiological state. In the future, the expansion of the functionality of creating an experiment to support behavioral and cognitive experiments, by creating a functionality for logical control of the presentation of stimuli (selection of answers, repetition of tasks, etc.).

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Author Contributions

K. A. Skuratova provided the description of fixation detection algorithms and preparation of illustrations.
E. Yu. Shelepin provided the description of the functionality of the software.
K. Yu. Shelepin provided the description of the quantitative parameters of oculomotor activity.

Author Details

Kseniya Andreevna Skuratova – Juniour Researcher, Pavlov Institute of Physiology, Saint Petersburg, Russian Federation; Scopus Author ID: 7216979736, ResearcherID: ABA-2446-2021, SPIN-code: 5940-0930, ORCID: https://orcid.org/0000-0001-8371-4348, e-mail: kseskuratova@gmail.com
Evgeny Yurievich Shelepin – Juniour Researcher, Pavlov Institute of Physiology, «Neuroiconica Assistive» LLC, Saint Petersburg, Russian Federation; Scopus Author ID: 7200940465, ResearcherID: AAA-9227-2021, SPIN-code: 5938-7368, ORCID: https://orcid.org/0000-0002-3124-5540, e-mail: sey2@yandex.ru
Konstantin Yurievich Shelepin – Cand. Sci. (Medicine), researcher, Pavlov Institute of Physiology, «Neuroiconica Assistive» LLC, Saint Petersburg, Russian Federation ORCID: https://orcid.org/0000-0002-1728-3794, e-mail: neiroiconica@ya.ru

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Comparison of the Mechanisms of Phonemic Awareness and Internal Pronunciation of Phonemes and Syllables: EEG and fMRI Study

Andrey O. Shevchenko[1]✉, **Aleksandr V. Vartanov**[2]
[1, 2] Lomonosov Moscow State University, Moscow, Russian Federation

✉ andreyshevchenkomsu@gmail.com

Abstract: **Introduction**. The existing speech production schemes do not fully reflect the interaction of speech perception systems and one's own internal speech. The study is aimed at comparing the connection between internal pronunciation and phonemic perception using psychophysiological methods. **Methods**. Twenty-five people took part in the EEG study. The subjects were offered auditory stimuli, and then it was necessary to internally pronounce the given phonemes or syllables with the same intonation and pronunciation as in external speech. Functional analysis of variance was used to process the results. An fMRI study was also conducted, and 30 healthy right-handed subjects took part in it. The respondents were also offered auditory stimuli, and the background, listening to the material, and listening with subsequent internal pronouncing of a given stimulus was recorded. The results were processed using a program for statistical parametric mapping and then analyzed by group statistics applying a one-sample Student t-test. **Results**. During the EEG investigation, intervals of significant differences in the structure of the evoked potential of internal pronunciation and phonemic perception were found. During the fMRI study, we obtained data that indicate both the process of phonemic perception and intentional internal pronunciation. **Discussion**. Differences in brain structures activity during internal pronunciation and perception were analyzed. Based on the data obtained by us and theoretical analysis results, a scheme of phonemic perception and internal pronunciation was proposed. This scheme represents not only the interaction of the processes of perception and speech generation but also shows the influence of articulations on the internal speech process.

Keywords: speech fMRI, speech EEG, evoked potentials, internal speech, localization, neurolinguistics, subvocalisation, phoneme, syllable, phonemic perception

Highlights:

- Phonemic perception activates conventional brain zones that are associated with speech production.
- There are differences in internal pronunciation at the level of the accompanying speech zones, in particular the cerebellum when pronouncing phonemes and syllables.

▸ Based on the work conducted, a scheme of phonemic perception and pronunciation was proposed.

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Introduction

Internal speech entails a multimodal intersection of images. One of the key elements of internal speech is internal pronunciation, which is most similar to external speech. Highlighting only the phonemic side of internal speech, we are trying to move to the level of internal pronunciation. So, according to a number of authors, the generation (production) of speech is a process with a specific hierarchy. It includes the following stages: the idea or motive of a speech utterance (motive framed in semantics), lexical selection, grammatical and syntactic construction of a phrase, and articulation of the necessary words (Gorelov & Sedov, 2001; Levelt et al., 1999; Dell, 1986; Oppenheim & Dell, 2008, 2010). Levelt's model consists of stages that have their own characteristic unit. Transitions are made from the conceptual stage to the lexical choice of a word and then to its grammatical and phonological coding. Levelt et al. (1999) claim that there is a process of collecting words through syllabification. As soon as the word is divided into syllables, the stage of syllabic phonetic coding takes place. The syllables received at the last stage turn into instructions for articulatory movements. The authors write that the already collected articulation characteristics of the most frequent syllables are stored in memory, which makes it possible not to build these syllables every time, but to extract them from memory. Levelt's model has self–control in speech production (Levelt et al., 1999), consisting of two systems: external – acoustic control and internal - control of internal representations (Levelt et al., 1999). Internal control is performed at the phonological level, not the phonetic one (Indefrey & Levelt, 2004). Another model, the Della model, includes 4 levels: semantic, syntactic, morphemic and phonological. Each level has its own rules for selecting the necessary elements for speech production (Dell, 1986). This model has a network structure and each node represents separate units of speech and interacts with other nodes at all levels. The network proposed for phonological coding consists of nodes for morphemes, syllables, syllabic components, phonemes and signs (articulatory characteristics of sounds). The network has a hierarchy of these nodes. Phonological representations in the model consist of labelled nodes denoting syllabic components. These components often are single phonemes.

Oppenheim & Dell (2010) investigated errors of phonemic similarity and lexical bias in two forms of internal speech with different degrees of articulation and concluded that articulation changes internal speech. The authors state that there is only a phonological level in internal speech, which can be influenced by articulation. Thus, the selected phonemes are able to reflect a different amount of activation beyond the phoneme level (Oppenheim & Dell, 2010). Scott et al. (2013) conducted experiments to prove the assumption that a more active participation of articulation should cause a corollary discharge of greater force. A corollary discharge is a motor command

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similar to a motor action command but not directly leading to action. The behavioural feature of the corollary discharge is perceptual capture – delay in perception. As a result of the study, it was proved that active involvement of the speech apparatus causes a harder corollary discharge. In addition, perceptual capture is not a simple matter of phonemic priming, and internal speech contains the information below the phoneme level. Analyzing the internal pronunciation, one can conclude that there is a clear connection between the articulatory act and internal pronunciation, while internal pronunciation is possible even without the inclusion of an explicit articulatory act because there are different levels of articulatory activation inside the internal pronunciation. Based on this, phonemic perception becomes a process related to the retention of the auditory image and its identification. Phonemic perception also involves detection – it is a reaction to an external or internal stimulus, and articulatory and phonetic accompaniment is secondary concerning the speed of recognition of the stimulus within the system of speech organization. Motor internal pronunciation has the most similar appearance to external speech. Since the tempo and intensity are preserved in the internal plan, this is represented by the internal auditory image of the spoken units. It can be assumed that the level of articulatory activation is higher. Thus, the effective construction of the BCI (brain–computer interface) is more possible precisely on articulation pronunciation (presentation of articulation) due to a bigger motor component (Sarmiento et al., 2014).

The purpose of our study is to compare the relationship between internal pronunciation and phonemic perception using psychophysiological methods.

Methods

The EEG examination procedure

The study involved 25 subjects: fifteen girls and ten boys aged 17 to 28 years. All the subjects had no history of traumatic brain injuries and mental illnesses and were right-handed. The following experiment was conducted. The launch of internal pronunciation took place based on an auditory stimulus (phonemes and syllables). The following incentives were presented:

– 7 phonemes (A – [a], B –[b], F – [f], G – [g], M – [m], R – [r], U – [u]),
– 10 syllables (BA, FA, GA, MA, RA, BU, RU, MU, FU, GU).

The stimuli were presented randomly. The beginning of pronouncing was set by a special stimulus, informing the spoken phoneme. After the appearance of the setting stimulus, a pause of 500 ms was created. After it, a fixing cross and a sound signal appeared on the screen, which was the starting command of internal pronouncing. During the command to pronounce, the subjects were asked to repeat a phoneme or syllable inwardly with the same duration and intonation as in external speech.

BrainSys (BrainWin) was used as a program for recording and viewing EEG and preliminary purification of evoked potentials. The electrical activity of the brain was recorded monopolarly, using a 19-channel electroencephalograph Neuro-KM (Statokin Company, Russia). The electrodes were arranged according to the international system of 10-20% with two mostoids. The Presentation program (version 18.0 of Neurobehavioral Systems, Inc.) was used to present the stimuli.

The analysis of the obtained data was carried out using the statistical programming language R (version 3.6.3) (R Core Team, 2019) as part of the integrated *RStudio* development environment (version 1.2.5003) (RStudioTeam, 2019). As part of this work, *data.table* packages were used for efficient work with data. The primary method used in the analysis is functional dispersion. This

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method has the same interpretation and applies as the 'classical' analysis of variance – its main difference is that it evaluates the difference not of averages but of curves. For this reason, functional variance analysis was perfectly suited for evoked potentials (the evoked potential is a curve) and was adapted to detect significant differences in the *ERP* package (Benjamini & Hochberg, 1995).

fMRI examination procedure

The study involved 30 healthy right-handed people (9 men and 21 women aged 20 to 30 years, average age = of 24 years). All participants had no neurological or mental abnormalities, which was confirmed by a preliminary survey. All participants signed an informed consent after explaining the protocol of the experiment. Before the start of each stage, the subjects listened to standardized instruction. The strings were as follows: simple listening to the stimulus material, listening with subsequent repetition, and background strings were also recorded, during which the subject lay quietly in the tomograph. The duration of each episode was 2 minutes (the experiment took about 10 minutes in total). The continuance of each stimulus was 1500 ms, then after a pause (500 ms), an audible signal followed, which indicated the beginning of pronunciation. The stimuli were delivered in a female voice. To study the features of internal pronunciation, a series containing following:

– 7 phonemes (A – [a], B –[b], F – [f], G – [g], M – [m], R – [r], U – [u]),
– 10 syllables (BA, FA, GA, MA, RA, BU, RU, MU, FU, GU).

The presentation was made through special headphones. All stages were held in one session. Throughout the experiment, the subjects' eyes were closed.

Obtaining fMRI images

Functional MRI was performed on a Siemens MagnetomSkyra 3T MRI Machine (Siemens Medical Systems, Erlangen, Germany) to obtain a BOLD contrast (dependent on blood oxygenation). T1-weighted structural scanning was performed for each subject (TR = 2200 ms, TE = 2.48, msflipangle = 6, matrix = 256 × 256, 230 mmfieldofview, slices = 176, slice thickness = 1 mm). For functional scans, we used T2*-weighted, gradient-echo EPI sequence (TR = 3000 ms, TE = 30 ms, tilt angle = 90°, matrix = 128 × 128, field of view 260 mm, slices = 41, slice thickness = 3 mm). The movement of the head was minimized with the help of a specially selected headrest.

Image processing and data analysis were performed using the software package for statistical parametric mapping SPM12 (The Wellcome Centre for Human Neuroimaging, UCL Queen Square Institute of Neurology, London, UK). Next, the group statistics were analyzed by applying the one-sample Student's t-test. Then the t-statistics were converted to the normal standard deviation (z). The voxelwise activation threshold corresponded to pFWEuncorr. < 0.001.

Results

The results of the EEG study, the allocation of evoked potentials for pronunciation

Checking the interaction effect of the EEG lead channel variable and the stage variable showed significant differences for phonemes ($p = 0.02$) and syllables ($p = 0.005$, respectively). As for the localization of differences, the most significant differences at the $p < 0.05$ level are found on channels C3 and F3, and F7. It confirms our results obtained earlier on a smaller sample (Vartanov et al., 2021). They are characterized by a positive wave in the region of 120-170 ms and a negative wave (at C3 and F3) in the interval of 200-280 ms.

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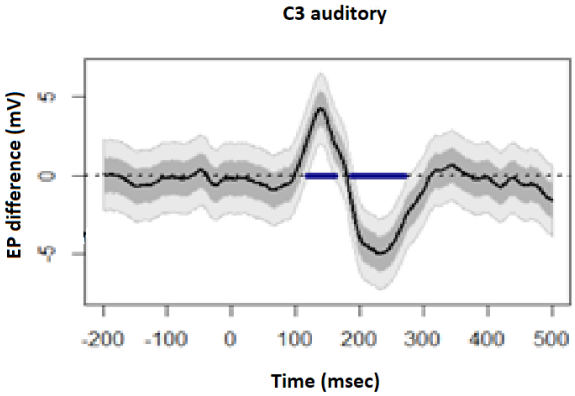
Figure 1

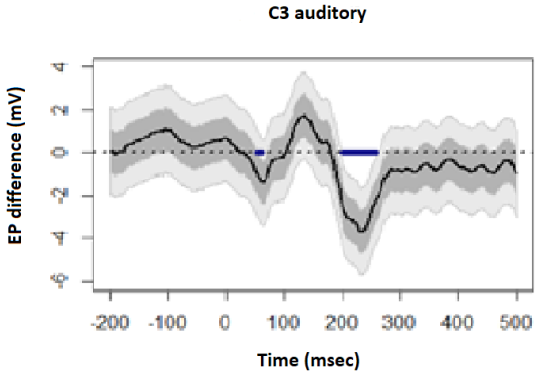
Differences between evoked potentials (pronouncing phonemes minus phonemic perception)



The moments of significant differences are marked in blue.

Figure 2

Differences between evoked potentials (pronouncing syllables minus phonemic perception)



The moments of significant differences are marked in blue.

When comparing the phonemic perception of stimuli with their pronunciation, there are significant differences at the $p < 0.001$ level, while, if you look at the syllables on average, the channels C3 and F3 are again the most pronounced. If we analyze the components of the EP, then the negative wave with a latency of 200 ms is more pronounced.

Functional MRI examination of phonemic perception and internal pronunciation

As a result of the analysis, structures significantly related to phonemic perception and intentional pronunciation were identified. The coordinates of the detected voxels are presented in the MNI format. The voxelwise activation threshold corresponded to pFWEuncorr. < 0.001, the

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most significant structures with $p < 0.05$ are highlighted in grey. Thus, in comparison of motor internal pronunciation with phonemic perception, the cerebellum plays a significant role in series with motor pronouncing syllables inwardly (Table 1). At the same time, the T- and Z-values are markers of the contribution to the description of the model, relative to which Table 1 is filtered. BA is the number of the cytoarchitectonic field according to Brodman.

Table 1

Comparison of the mechanisms of pronouncing phonemes and syllables with their phonemic perception

L / R	Structure	BA	Cluster	T	Z	P (FWE)	X {mm}	Y {mm}	Z {mm}
Internal pronunciation of syllables compared to phonemic perception									
L	Cerebellum	–	1	6.362920	4.993979	0.00000030	–24	–52	–46
L	Cerebellum exterior	–	1	6.337997	4.980898	0.00000032	–14	–56	–46
L	Cerebellum	–	575	6.362920	4.993979	0.00000030	–24	–52	–46
L	Subcallosal area	BA25	44	5.823698	4.701207	0.00000129	–2	14	–4
R	MP Temporal Pole	BA38	6	4.443623	3.848925	0.00005932	44	12	–40
R	SecVisual	BA18	19	4.339899	3.778314	0.00007895	20	–70	–1
R	Subcallosal area	BA25	4	4.289875	3.743913	0.00009059	2	14	–4
L	SecVisual	BA18	6	4.204751	3.684852	0.00011442	–18	–80	–4
R	Inferior occipital gyrus (SecVisual)	BA18	11	4.197034	3.679465	0.00011686	30	–92	2
R	Cerebellum exterior	–	3	4.156387	3.651	0.00013061	16	–82	–46
R	Superior frontal gyrus	BA6	1	3.92514	3.486165	0.000245	18	–6	77
R	Inferior occipital gyrus	BA18	3	3.918942	3.481679	0.00024914	34	–92	–1

L	Fusiform gyrus	BA37	10	3.862814	3.44089	0.00028990	–36	–58	–7
R	Cerebellum exterior	–	22	3.861920	3.440238	0.00029060	22	–82	–46
R	Fusiform gyrus	BA37	1	3.858072	3.43743	0.00029363	54	–68	–1
R	Medial frontal cortex (orbFrontal)	BA11	4	3.851278	3.43247	0.00029906	12	34	–13
L	Precentral gyrus	BA6	2	3.790266	3.387731	0.00035237	–36	–14	68
L	Medial frontal cortex (orbFrontal)	BA11	6	3.77112	3.37362	0.00037093	–8	30	–16
R	Cerebellum exterior	–	1	3.714886	3.331975	0.00043116	22	–60	–49
R	Inferioir occipital gyrus (VisualAssoc)	BA19	3	3.711242	3.329267	0.00043538	52	–66	5
R	Inferior occipital gyrus	BA18	1	3.679365	3.305516	0.00047401	32	–84	–7
L	Orbital part of the inferior frontal gyrus	BA47	2	3.663915	3.293972	0.00049391	–42	30	–4
R	Cerebellum exterior	–	4	3.634835	3.27218	0.00053361	4	–74	–43
R	Lingual gyrus	BA19	1	3.604819	3.249604	0.00057783	16	–42	–10
R	Cerebellum exterior	–	1	3.572326	3.225069	0.00062971	18	–70	–46
L	Brain Stem (pyramid area)	–	1	3.545394	3.204658	0.00067612	–10	–40	–43

R	Cerebellum exterior	–	2	3.542027	3.202101	0.00068215	24	–64	–49
R	Medial frontal cortex	BA11	1	3.541181	3.201458	0.00068367	12	38	–13
R	Fusiform gyrus	BA37	1	3.539396	3.200102	0.0006869	42	–56	–13
L	Lateral ventricle (Arg-Retrolimb)	BA30	2	3.536704	3.198057	0.00069178	–26	–56	11
R	Cerebellum exterior	–	1	3.530372	3.193243	0.00070342	42	–72	–34
R	Cerebellum white matter	–	3	3.511992	3.179248	0.00073829	14	–42	–37
R	Occipital Pole	BA18	2	3.498797	3.169181	0.00076435	14	–100	11
L	Cerebral white matter (y lateral ventricle)	–	1	3.493938	3.16547	0.00077416	–24	–38	26
R	Superior occipital gyrus	BA18	2	3.492151	3.164105	0.00077780	22	–82	14
R	Cerebellum exterioir	–	1	3.451802	3.133195	0.00086457	16	–68	–43
L	Lingual gyrus (Visual-Associated)	BA19	1	3.444823	3.127833	0.00088050	–22	–62	–7
L	Cerebellum exterior	–	1	3.444173	3.127333	0.0008826	–16	–74	–43
L	Cerebellum exterior	–	1	3.422555	3.110694	0.00093324	–12	–68	–22
Internal pronunciation of phonemes compared to phonemic perception									
L	Supramarginal gyrus	BA40	15	4.748875	3.870373	0.00005433	–52	–34	32
L	Precuneus (Dorsal)	BA31	3	4.15238	3.508109	0.00022565	–18	–54	38

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L	Fusiform gyrus	BA37	7	4.126642	3.491703	0.00023996	–26	–54	–10
L	Superior parietal lobule (VisMotor)	BA7	3	3.973716	3.392849	0.00034585	–32	–48	65
L	Cuneus (visual associative)	BA19	2	3.948858	3.376556	0.000367	–6	–86	35

Based on the obtained coordinates, the images were made with color-highlighted zones of activation of intentional internal pronunciation in comparison with phonemic awareness (Fig. 3, Fig. 4). The gradient of changing dynamics is reflected on the right side of the images.

Figure 3

Internal pronunciation of syllables compared with phonemic awareness

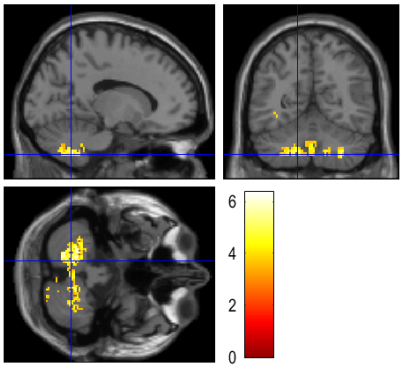
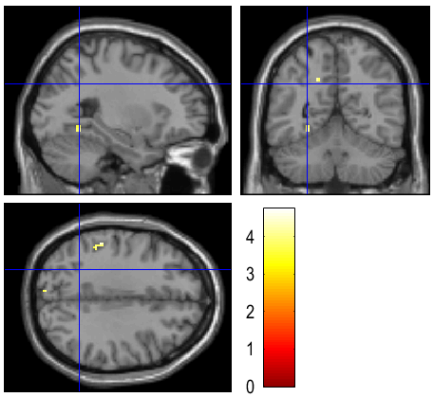


Figure 4

Internal pronunciation of phonemes compared with phonemic awareness



Phonemic awareness was also compared with the background. The most expressed structures were the BA22 zone in the left and right hemispheres (Table 2).

Table 2

Comparison of phonemic awareness mechanisms with the background

L / R	Structure	BA	Clus-ter	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
Phonemic awareness compared with the background									
R	STG (Superior temporal gyrus)	BA22	8	7.058488	5.34254	0.00000005	50	–38	11
L	STG (Superior temporal gyrus)	BA22	4	6.715026	5.17432	0.00000011	–36	–38	8
R	Cerebellum	–	1587	6.015718	4.807855	0.00000076	18	–36	–34
L	Posterior insula	BA13	61	5.648526	4.601521	0.0000021	–28	–22	17
R	Thalamus	–	44	5.30348	4.39823	0.00000546	12	–22	5
R	Agranular retrolimbic area	BA30	115	5.283346	4.386076	0.00000577	16	–40	2
L	Calcarine cortex	BA17	20	5.253253	4.367849	0.00000627	–18	–74	5
R	Insula	BA13	62	5.206018	4.339092	0.00000715	30	–12	20
L	Cerebellum	–	21	5.178558	4.32229	0.00000772	–2	–58	–10
L	Calcarine cortex	BA17	56	5.108249	4.278987	0.00000939	–12	–86	14
R	Calcarine cortex	BA1	55	5.085045	4.264607	0.00001001	22	–36	44

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L / R	Structure	BA	Clus-ter	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
R	Lateral ventricle	–	22	5.026877	4.228361	0.00001177	16	–34	17
L	Lateral ventricle		14	5.013901	4.220236	0.00001220	–22	–36	17
R	Inferior temporal gyrus	BA20	46	4.986055	4.202754	0.00001318	38	–10	–28
R	Superior temporal gyrus	BA41	9	4.965448	4.189775	0.00001396	44	–24	–1
R	Lateral orbital gyrus	BA47	46	4.905086	4.151549	0.00001651	40	36	–4
R	Posteriorc ingulate gyrus	BA23	10	4.887183	4.140153	0.00001735	10	–14	29
L	Thalamus	–	78	4.730111	4.038985	0.00002684	–26	–24	2
R	Hippo-campus	–	13	4.700709	4.019812	0.00002912	30	–24	–16
R	Posterior cingulate gyrus	BA31	13	4.651894	3.987812	0.00003334	4	–42	41
R	Calcarine cortex	BA17	25	4.587883	3.945534	0.00003981	4	–76	11

L / R	Structure	BA	Clus-ter	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
R	Fusiform gyrus	BA37	17	4.556784	3.924864	0.00004339	28	–32	–22
R	Lingual gyrus	BA18	25	4.501969	3.888222	0.00005049	14	–68	2
L	Amygdala	–	44	4.478426	3.872402	0.00005388	–28	–4	–19
L	Cuneus	BA18	5	4.359511	3.79174	0.0000748	–4	–76	32
L	Superior temporal gyrus	BA22	2	4.357996	3.790704	0.00007511	–50	6	–13
R	Middle frontal gyrus	BA9	14	4.347326	3.783403	0.00007735	38	22	26
L	Lateral ventricle	–	7	4.336168	3.775757	0.00007976	–8	–24	23
L	Visual assoc	BA19	9	4.335631	3.775389	0.00007988	–30	–70	–4
R	Visual assoc	BA19	6	4.317257	3.762772	0.00008402	34	–70	–7

L / R	Structure	BA	Cluster	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
R	Thalamus	–	5	4.312673	3.75962	0.00008509	2	–22	8
R	Precentral gyrus (PrimVisual)	BA4	3	4.269074	3.729542	0.00009591	30	–20	38
R	Anterior orbital gyrus (Orbital Frontal)	BA11	4	4.255989	3.720481	0.00009942	24	40	–10
R	Postcentral gyrus (PrimSensory)	BA1	10	4.244459	3.712484	0.00010262	38	–28	41
L	Precentral gyrus medial segment	BA24	6	4.238666	3.708462	0.00010426	–20	–20	41
R	Precentral Gyrus (PreMot+-SuppMot)	BA6	13	4.211751	3.689733	0.00011224	28	–20	59
R	Precentral gyrus medial segment	BA24	8	4.18588	3.671668	0.00012049	18	–14	38

L / R	Structure	BA	Cluster	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
R	Calcarine cortex (Sec-Visual)	BA18	17	4.176546	3.665136	0.00012360	18	–84	17
R	Thalamus	–	2	4.148016	3.645119	0.00013363	6	–26	–13
R	Parahipp	BA36	10	4.147383	3.644674	0.00013387	16	–38	–10
R	Precuneus (VisMotor)	BA7	11	4.143725	3.642102	0.00013521	12	–68	47
R	Thalamus	–	8	4.028056	3.560136	0.00018533	4	–18	5
L	Postcentral gyurs (PrimSensory)	BA1	5	4.022578	3.556223	0.00018811	–62	–16	20
L	Cerebellum	–	13	3.98835	3.531713	0.00020644	–34	–68	–31
R	Cerebellum	–	4	3.944522	3.500171	0.00023248	24	–62	–49

L / R	Structure	BA	Cluster	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
L	Occipital fusiform gyrus (VisualAssoc)	BA19	2	3.944196	3.499936	0.00023268	–26	–76	–4
L	Anterior cingulate gyrus	BA24	1	3.940487	3.497258	0.00023503	–14	–4	41
L	Agranular retrolimbic area	BA30	2	3.93505	3.493331	0.00023852	–22	–52	11
R	Cerebellum	–	2	3.918813	3.481586	0.00024923	32	–58	–43
R	Middle frontal gyrus (Front-EyeFields)	BA8	19	3.913408	3.47767	0.0002529	42	8	53
R	Brain Stem	–	3	3.909098	3.474547	0.00025586	6	–26	–7
R	Angular Gyrus	BA39	1	3.892334	3.462379	0.00026771	46	–64	23
R	Temporal pole	BA38	5	3.874402	3.449335	0.00028098	54	2	–31
R	Precentral gyrus (PreMot+-SuppMot)	BA6	7	3.866411	3.443513	0.00028710	30	4	41
L	Cerebellum	–	4	3.849235	3.430977	0.0003007	–28	–76	–25

L / R	Structure	BA	Cluster	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
R	Anterior frontal gyrus (Orbital Frontal)	BA11	1	3.835686	3.42107	0.00031188	20	46	–7
L	Insula	BA13	2	3.827527	3.415095	0.00031880	–34	–4	2
R	Anterior prefrontal cortex	BA10	3	3.817274	3.407578	0.00032771	26	50	–1
R	Globus pallidum	–	5	3.809014	3.401515	0.00033507	24	–6	–7
L	Supra-marginal gyrus	BA40	1	3.801684	3.39613	0.00034173	–30	–32	32
R	Posterior cingulate cortex	BA31	7	3.792591	3.389443	0.00035017	0	–36	41
L	Middle occipital gyrus (Visual-Assoc)	BA19	2	3.772275	3.374472	0.00036979	–36	–68	11
R	Inferior temporal gyrus (Prim-Sensory)	BA1	1	3.764789	3.368946	0.00037728	46	–16	–25
L	Cerebellum	–	5	3.759167	3.364793	0.00038301	–44	–60	–40

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L / R	Structure	BA	Cluster	T	Z	P (FWE)	X {mm}	y {mm}	z {mm}
R	Cerebellum	–	4	3.758329	3.364174	0.00038387	50	–56	38
L	Calcarine cortex	BA17	6	3.74434	3.353825	0.00039851	–2	–74	11
L	Frontal operculum (Broca-Operc)	BA44	1	3.739974	3.350591	0.00040320	–42	12	14

Discussion

As follows from the study results, considering the analysis of evoked potentials on temporal electrodes (Fig. 1, Fig. 2) as a basis, it can be assumed that the main difference between internal pronunciation and perception is the earlier components of the evoked potential (100–200 ms). This may indicate both the process of launching the command to pronounce (which should not have occurred with passive perception) and the effect of waiting for the starting stimulus (this is best seen in the series with syllables). The absence of identified differences in late components is actually an indicator of the similarity of the response process in both phonemic awareness and internal pronunciation. That is, apparently, a similar internal auditory representation arises when perceiving a phonemic stimulus.

Analyzing the obtained fMRI data, it is possible to identify a number of general patterns in phonemic listening and internal pronunciation. Thus, the Wernicke's area (BA22L, and its homologous BA22R) is activated during both phonemic awareness and internal pronunciation. Several authors claim the existence of two different systems for the perception and production of speech. For example, when the Broca's area is damaged, speech production may be affected, but speech perception and understanding remain intact. In case of injury in the Wernicke's area, the opposite may occur, which tells us about the difference in systems for these two processes (Morais & Kolinsky, 1994). However, we assume that these systems are more than likely interconnected.

In a series of comparisons of the mechanisms of pronunciation of phonemes and syllables with their phonemic awareness (Table 1), activation of the BA37L zone was found. It is known that this zone is associated with pronunciation to a visual stimulus, and there is an assumption that this zone is responsible for phonemic awareness (Devlin et al., 2003). This may be relevant for studies with visual stimulus display (Ardila et al., 2015; Flowers et al., 2004). There is also a hypothesis

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about the role of this zone in the rhythmic construction of speech process (Booth et al., 2002a, 2002b), which confirms the different role of tempo in motor pronunciation in comparison with phonemic awareness.

The pronunciation of syllables to oneself includes the BA6L zone, associated with motor speech planning and phonological planning (Shuster & Lemieux, 2005; Fox et al., 2000), which is also clearly seen in our study. Furthermore, in the study by Shuster & Lemieux (2005), activation of this zone was presented during the pronunciation of monosyllabic words. Another activated zone during pronunciation of syllables is BA47L; it is associated with semantic coding, as well as with the processes of recalling and memory retrieval (Robinson et al., 2015; Demb et al., 1995; De Carli et al., 2007). This suggests that the activation of this zone during the syllable pronunciation is associated with the extraction of sound images in the syllable from memory. In the series with the pronunciation of syllables, the activity of the BA30L zone was revealed. This zone (Posterior cingulated BA30L) is associated with semantic coding (Patel et al., 2006). However, the data obtained in the course of research bring this into question, since the experimental model of the study did not assume the presence of semantic coding. Perhaps this zone can also be associated with phonological coding and with memory processes that are launched to search for a word with the same syllable and the similar meaning.

One of the most interesting results obtained in this study was the discovery of a difference in cerebellar activation at the moment of pronunciation of phonemes and syllables. It appears that the cerebellum contains a model of "reverse dynamics" (according to Ziegler, 2016). In support of this version, we can note that the cerebellum is involved in learning new patterns, evaluation, and compensatory response to auditory and somatosensory errors. For this reason, some researchers consider the cerebellum an auxiliary component in speech production models. It is known that after cerebellum injury, motor ataxia is possible, leading to impaired sound pronunciation (Ziegler, 2016). Indefrey & Levelt (2004) reported that areas involved in articulatory planning are more likely to be activated with external pronunciation than with internal pronunciation. At the same time, the areas involved in the syllable formation process should be activated regardless of external or internal pronunciation. Indefrey & Levelt (2004) mention that the bilateral motor and sensory areas, the right dorsal motor area, the right supplementary motor area (SMA), the left and right medial cerebellum, the bilateral thalamus, and the midbrain are most likely involved in the planning and execution of articulatory movements. Furthermore, the left ventral precentral gyrus, the bilateral middle anterior temporal gyri, the left fusiform gyrus, the left thalamus, and the right medial cerebellum were observed more frequently in external articulation tasks than in internal pronunciation tasks. However, in our study, activation of the right and left areas of the cerebellum was recorded in the pronunciation of syllables and phonemes during internal speech. Moreover, the cerebellum was activated in listening tasks compared to the background. That is, we can conclude that the auxiliary role of the cerebellum manifests itself not only at the level of external speech, but also at the level of internal speech. The role is differentiated at the level of

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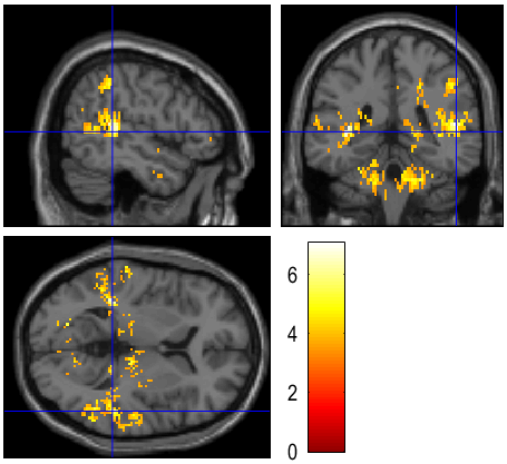
phonemic units (phonemes, syllables, etc.): the more complex the unit, the more the role of the cerebellum is expressed.

In the pronunciation of phonemes, in comparison with listening, the BA40L zone was active, associated with phonological operations and semantic processing (McDermott et al., 2003; Chou et al., 2006). It is of great interest that this zone was generally active both during motor pronunciation of phonemes and during phonemic awareness (although there was a difference in the spatial localization of the maximum of differences). Therefore, we can assume that in this zone there are subzones responsible for various aspects of phonological operations. In addition, the demonstrated fact may testify that the conscious and unconscious representation of phonemes relies on different, but close areas of the brain (Morais & Kolinsky, 1994). Phonemic awareness is presumably related to the process of detection and is directly related to the production of speech. Taking this into consideration, one can state that there is a close relationship between the structures responsible for phonemic listening and internal pronunciation, but the present differences should not be overlooked. Traditionally, the zones BA44, BA22, BA17, and BA39 are associated with perception, speech production, and reading. These zones were also presented in our study in phonemic awareness compared with the background (Fig. 5).

Figure 5

Phonemic awareness compared with the background



In addition, the BA24L zone, which was active during phonemic awareness, should be viewed a little closer. Researchers associate this zone with the naming of objects process (Garn et al., 2009; Kiyosawa et al., 1996), and with semantic and phonological fluency (Whitney et al., 2009). It is necessary to pay attention to the BA38R zone, which showed activation in a series of phonemic awareness. In a study by Nakamura et al. (2001), this zone was active in the course of recognition of familiar voices. There is a possibility that the activation of this zone in our study was caused

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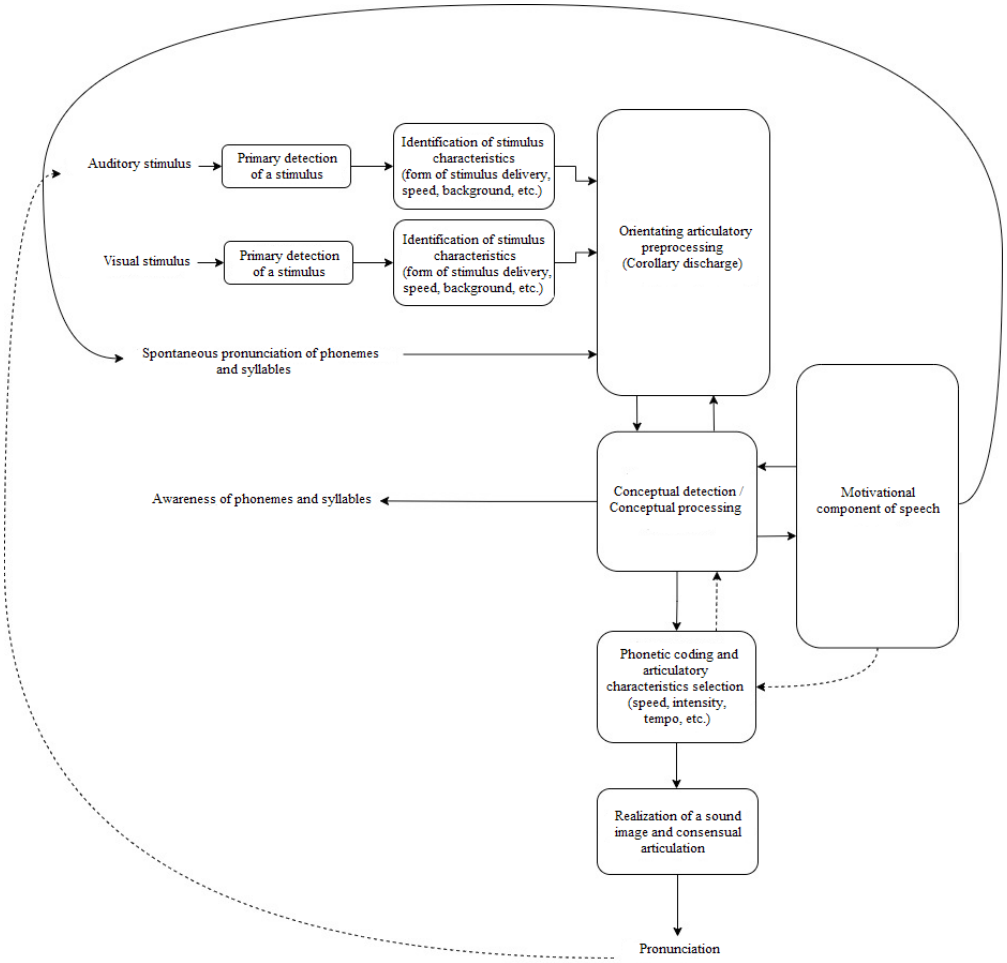
by the display of auditory stimuli. Phonemic listening involves the internal representation of an auditory stimulus through the activation of conventional areas associated with speech. Listening to speech, even phonemic, stimuli is associated with the processes of detection and repetition, but the rhythmic component may differ. Also, in the process of communication, the systems of production and perception of speech constantly interact. These two systems not only work in harmony, but also interact in a special way at different levels of processing. These facts should be considered when searching for common in neural networks of perception and speech production (Indefrey & Levelt, 2004).

Based on the results obtained and the theoretical analysis performed, it is possible to present the following scheme of phonemic awareness and pronunciation, inspired by the Levelt model (Fig. 6).

Figure 6

The scheme of phonemic awareness and pronunciation



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In contrast to the Levelt scheme (Indefrey & Levelt, 2004), we consider the plan only at the level of phonemic units. In this case, we believe that the motivational component of speech is an important condition even for a phonemic plan. The reason is that at this level, the assessment and planning of a potential result take place. The detection of phonemes and syllables perceived based on visual or auditory input is encoded differently in perception, as shown in our other studies (Vartanov et al., 2021), which is also consistent with the Levelt model. The stage of orientating articulatory preprocessing carries out the process of disintegrating a phoneme into components (subphonemic quanta) or commands for motor action (kinakemes) and launches a corollary discharge to certain areas of the brain. It is what distinguishes our model from the Levelt model. At the stage of conceptual detection, a compilation of separate perceptual features is carried out in a single image of a phonemic unit. It also includes what V. Levelt described as a "conceptualizer" (Levelt et al., 1999). This image is influenced by a form of stimulus delivery, its tonal characteristics, and the motivation a person has at the time of receiving the stimulus. At the stage of phonetic coding, a program is formed for articulatory actions related to the future auditory image that should result from pronunciation. There characteristics for the pronunciation of phonemes or syllables are laid, with consideration of the influence of the motivational component and the image formed at the level of conceptual detection. For example, a speaker's voice can set intonation in a speaking task based on an auditory stimulus. In addition, at this stage, the received program is compared with the image that was formed in the conceptual detection buffer to check accuracy. In case of an error, the program of motor actions is corrected. When the command to pronounce the received image is delivered to the block of primary detection of a stimulus in order to correct the integral image. During mental pronunciation (when external speech is inhibited), the signal from the level of phonetic coding goes back to the conceptual detection unit. It ensures the process of the emergence of a sound image of a phoneme or syllable in the absence of an external stimulus.

Conclusion

1. The triggering of the pronunciation command in comparison with phonemic listening has been confirmed to be reflected in the early components of the evoked potential. However, no differences were found in the late components (from 300 to 500 ms) of the amplitude, which can be explained in terms of the corollary discharge.
2. Phonemic awareness is associated with internal pronunciation. With phonemic awareness, the activation of conventional zones occurs, which are also associated with the production of speech.
3. There are differences in motor pronunciation at the level of concomitant speech zones, in particular, the cerebellum, when pronouncing phonemes and syllables. This is also found in awareness in comparison with the background. One of the possible explanations is the emulation of existing functional cortical connections by this zone. These results complement the Levelt model. We believe that the expression of articulation (muscle) commands is also reflected at the level of concomitant speech zones.

4. Activation of the BA38R zone Indicates the influence of intonational characteristics (in particular, the parameters of the speaker's voice) on phonemic pronunciation and awareness. This largely confirms the idea of the influence of the starting stimulus on the speech process.
5. Based on the results obtained and the theoretical review performed, a scheme (Fig. 6) of phonemic awareness and pronunciation was proposed, inspired by the Levelt model.

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Author Details

Andrey Olegovych Shevchenko – Graduate student, Lomonosov Moscow State University, Moscow, Russian Federation; Researcher ID: GLQ-7645-2022, SPIN-code: 9970-3878, ORCID ID: https://orcid.org/0000-0002-9118-2617, e-mail: andreyshevchenkomsu@gmail.com

Alexander Valentinovich Vartanov – Cand. Sci. (Psychology), Associate Professor, Senior Research Fellow, Lomonosov Moscow State University, Moscow, Russian Federation; Scopus Author ID: 6603018783, Researcher ID: D-9907-2012, ORCID ID: https://orcid.org/0000-0001-8844-9643, e-mail: a_v_vartanov@mail.ru

Conflict of Interest Information

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Dynamics of Attitudes towards Tolerance Formation in the Family of Various Social Groups Representatives

Liubov I. Ryumshina[1]✉, Elena V. Zinchenko[2], Anastasia A. Chernova[3], Julia V. Berdyanskaya[4], Olga V. Batychko[5]
[1, 2, 3, 4, 5] Southern Federal University, Rostov-on-Don, Russian Federation

✉ ryumshina@sfedu.ru

Abstract: **Introduction**. Tolerance, as the basis of a personality that develops constructive relationships with other people, in modern conditions is associated with the development of civil society, political and social events. Therefore, much attention is paid to the development of tolerance in educational institutions. There are practically no works aimed at studying the significance of its formation in the family, which plays a decisive role in the development of various personality traits of the child. The article analyzes the tolerance formation attitudes in the family among respondents of various groups for the first time over a long period of time. **Methods**. Object of study: tolerance as a psychological phenomenon. The study used the World Values Survey (WVS) database with the participation of Russia since the end of the 20th century until 2017. The total sample consisted of 10344 people. Statistical methods used for data processing: correlation analysis, Kruskal–Wallis test, Conover test, confidence interval method, logistic regression. All calculations were performed using the "R" programming language on the interface of the "RStudio" program. **Results**. A downward trend has been established in the number of respondents who consider tolerance to be the most important quality formed in the family. Differences were identified in the groups of respondents with different attitudes towards the development of tolerance. For older people with higher education, its formation is more significant. In 2017, the level of education and social class of those who think so is declining. **Discussion**. Tolerance is one of the most important qualities that are formed in the family, but the number of respondents who think so is decreasing over time. We found that a tendency to increase the importance of the formation of tolerance in the family depends on the older age, level of education and social class of the respondents.

Keywords: tolerance, formation of tolerance, family, socio-demographic characteristics, age, gender, education, immigrants, refugees, logistic regression

Highlights:

▹ The dynamics of attitudes towards the tolerance formation in the family among representatives of various social groups in the period from 1990 to 2017 were analyzed.

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- Despite the importance of the formation of tolerance in the family noted by the respondents, a tendency to reduce its importance among other formed psychological qualities was identified.
- Attitudes towards the formation of tolerance in the family differ among individuals with various socio-demographic characteristics (age, education, social class).
- Respondents who consider and do not consider it important to develop tolerance in the family show significant differences in age, education, and social class.

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Introduction

More than 20 years have passed since the implementation of the Federal Targeted Programme "Development of tolerant attitudes and extremism prevention in Russian society". The need for its implementation was determined, first of all, by the need to harmonize relations in the Russian multi-ethnic state. Was this programme effective? Probably "yes", if for no other reason than the issue of tolerant behavior and attitudes in Russian society was raised, tolerance was defined as respect and recognition of equality with Others, and ways of approaching the future studies in this area were outlined (Asmolov & Soldatova, 2001). Over the next two decades, this issue did not lose its relevance, but, on the contrary, the concept of tolerance turned out to be universal and in demand by representatives of various sciences. It has become a kind of continuity in the studies of interethnic and interfaith interaction. Despite the fact that in the future the targeted programme initiators shift away in their works from the social analysis of tolerance and turn to its psychological and pedagogical aspects, the number of studies of tolerance as a social and even political phenomenon is increasing (Medushevsky & Gordeeva, 2017). At the same time, tolerance often began to be associated with an ideological superstructure, patriotism, protecting the interests of society, defending its interests (Beregovaya & Karlova, 2020; Ivanov, 2018).

Despite the importance of the theoretical and methodological understanding of tolerance, it can be noted that these works did not always end with the possibility of their practical application. While the new political and social realities – terrorism and emergence of a large number of immigrants and refugees from the former Soviet republics – required the scientific intervention of scientists.

In this regard, one can distinguish a group of researchers who study the issues of integration of immigrants and refugeesinto Russian society, the attitude of Russians towards them (Shcherbak & Tryapkin, 2019; Demidova, 2021; Monusova, 2021) taking into account the demographic characteristics of the respondents (Prokhoda, 2021; Mukomel, 2017). The growth of terrorist and extremist activity has led to the studies of a new topic for Russian psychologists – prevention and counteraction to it, especially among young people (Muftakhova & Gilyazeva, 2019). There are studies of tolerant attitudes among young people (Kustova et al., 2018; Merkulov et al., 2017), the search for the causes of xenophobic attitudes among them (Mukomel, 2017). However, it soon became clear that it is necessary to develop tolerance well before.

This naturally led to an increase in the number of pedagogical studies. One can agree with Medushevsky, Gordeeva (2017) that in Russian science they take up at least 40 % of the total number of publications devoted to tolerance. He explains this by the diversity of pedagogical practices existing on the territory of Russia and the instability of the Russian educational system, which since the 1990s. has been reformed manifold. In addition, there is a "state order" to overcome ethnic and religious separatism through the development of "correct values" (Medushevsky & Gordeeva, 2017, p. 3). Drawing attention to tolerance coincided with the discussion of the education humanization (Ryumshina, 2014), the search for new ways of communication between teachers and students (Ryumshina et al.,2022; Dainova et al., 2018), especially in relation to the issue of attitudes towards people with special needs, which has not yet been resolved in Russia (Beregovaya & Karlova, 2020).

It is proposed to study tolerance at various stages of education, and its formation should begin from preschool age by means of art, the development of aesthetic taste, in the process of project-based learning. Much attention is paid to the civil and patriotic education of students (Ruban, 2017). Since the main means of developing the tolerance in society, according to scientists, is educational activity, attention is paid to the training of educators capable of developing tolerance in younger generation (Smolyaninova et al., 2017) and leaders of educational organizations focused on solving the issue of social justice, able to create the necessary conditions for the development of the child's personality in a new socio-cultural environment is also noted (Shestakova et al., 2022).

Nevertheless, despite the growth of such works, the studies of G. U. Soldatova and A. G. Asmolov, directly devoted to the development of attitudes of tolerant consciousness, where the individual is the starting point in the development of tolerance, which involves protecting the right of the individual to the possibility of a different vision of reality (Asmolov, 1998; Asmolov et al., 2001) can still be considered the most significant publications of a pedagogical orientation.

Therefore, it is extremely important to foster tolerance among the younger generation not only in educational institutions, but also in the family. None of the scientists denies this, as well as the fact that the values formed by parents, their parenting style reproduce in the development of various personal traits of the child (Sobkin & Halutina, 2017). However, probably due to the complexity of studying family education, there are very few empirical studies devoted to the peculiarities of the formation of tolerance in the family. It is significant that since 2000 of the 21268 works in Elibrary devoted to the problem of tolerance, only 54 directly relate to the upbringing and formation of tolerance in the family.

Such a small quantity of works related to the family education of tolerance is also characteristic of foreign studies, where the number of its studies has been steadily growing lately.

Modern Western scientists historically associate tolerance with pluralism, a quality that is considered inherent in all modern European nations (Beregovaya & Karlova, 2020), tolerance is related to prejudices, stereotypes, and ethnocentrism (Pettigrew et al., 2011). Since Europe is also facing an increase in terrorist activity and an immigration flow, the issues of terrorism are being discussed there as well as in Russian psychology (Fischer-Preßler et al., 2019). A large group of studies is devoted to the search for mutual understanding between representatives of different religions (Eskelinen et al., 2022; Husain, 2020; Edwards, 2018; Mansouri & Vergani, 2018) and the integration of refugees and asylum seekers, therefore volunteering is also studied (Albanesi et al., 2019). The issue of immigration is included in the social context (Akbarzadeh & Roose, 2011),

in this regard, differences in cultural values, the issue of national identity are analyzed (van der Werf et al., 2022).

Particular attention is paid to the factors that contribute to tolerance: democracy, population's standard of living (Cvetkovska, 2020), people's satisfaction with life (Tenenbaum et al., 2018), openness to experiences and identification with all of humanity (Shrira et al., 2018), a sense of security that provides a reliable basis of tolerance.

Along with the analysis of the gender aspect and the issue of sexual minorities (Simon et al., 2019), as in Russian psychology, a large number of studies is devoted to the formation of tolerance, but these are specific studies rather than the development of various theoretical and methodological approaches. Thus, the authors from the Netherlands build age-specific response patterns to diversity tolerance and conclude that tolerance/intolerance can manifest itself at any age and depends on what, how, why and when people are asked to tolerate differences in beliefs and dissent (Verkuyten & Killen, 2021). At the same time, the intolerant behavior of students in various state institutions (Kyere et al., 2020), the impact of teachers on anti-immigrant attitudes of students (Miklikowska, 2019; Sandoval-Hernandez et al., 2018; Vedder et al., 2016) is analyzed. The influence of the environment of family communication and upbringing on the development of tolerance is also being studied (Odenweller & Harris, 2018; Walters, 2020), but such works are clearly insufficient to understand the causes of students' intolerant behavior.

Thus, the study of tolerance turned out to be more relevant than ever, both for Russia and foreign countries; the phenomenon has acquired the status of one of the existential problems, closely woven into the development of civil society, political and social events. The importance of forming tolerance not only towards representatives of other ethnic groups living nearby in a multinational state, but also to immigrants, and then a little later to refugees, emerged.

We can agree with a number of scientists that there are differences in foreign and Russian studies of tolerance. In our opinion, they refer to the approaches to the study of this phenomenon rather than the role of tolerance in human life. Foreign scientists, when analyzing tolerance as patience and respect, proceed from democratic principles, recognition of the rights of others, and are more focused on finding specific factors that influence the formation of tolerance and its implementation. Russian scientists – on the theoretical and methodological foundations of tolerance. However, over twenty years of increased interest in tolerance, Russian psychologists have not developed a unified approach to this phenomenon, but they, like foreign scientists, believe that the issues of tolerant/intolerant behavior begin with the individual, therefore it is extremely important to form a tolerant attitude among the younger generations, who then will build a tolerant society as a society of equal opportunities for its members. At the same time, the main attention is paid to the means of forming tolerance in educational institutions. There are very few studies that would reveal the significance and features of the formation of tolerance in the family, both in Russian and foreign science. However, the fact that this is an actual world problem is evidenced by various surveys of an international nature. For example, in the World Values Survey (WVS) conducted every four years, the analysis of attitudes to the formation of tolerance in the family becomes part of a global study.

Methods

The *aim* of the study was to analyze the dynamics of attitudes in the formation of tolerance among Russians in the period from 1990 to 2017, depending on their age, gender, social class and education.

The work uses the WVS database with the participation of Russia in the following waves: second (1990, 1961 people), third (1995, 2040 people), fifth (2006, 2033 people), sixth (2011, 2500 people), seventh (2017, 1810 people). The total sample includes 10344 people. In accordance with the socio-demographic characteristics of the respondents presented in the database, the following were taken into account: gender (male, female), age (under 29, 30–49, over 50), level of education (no education, primary, secondary, higher), social class (lower, working, lower middle, upper middle, higher).

To achieve this goal, the answers of Russian respondents to the question concerning the importance of "tolerance and respect for other people" in the upbringing of children were analyzed. The question is as follows: "On the card in front of you there is a list of qualities that can be brought up in children in the family. Which of them, if any, are, in your opinion, the most important?"

The following statistical analysis methods were used for data processing: correlation analysis, Kruskal–Wallis test, Conover test, confidence interval method, logistic regression. All calculations were performed using the programming language "R" on the interface of "RStudio" program.

Results

Answering the question about the significance of the formation of various qualities in children, the respondents could choose 5 qualities out of 10. Based on the analysis of their answers, the following data were obtained (Table 1, Fig. 1.).

Table 1

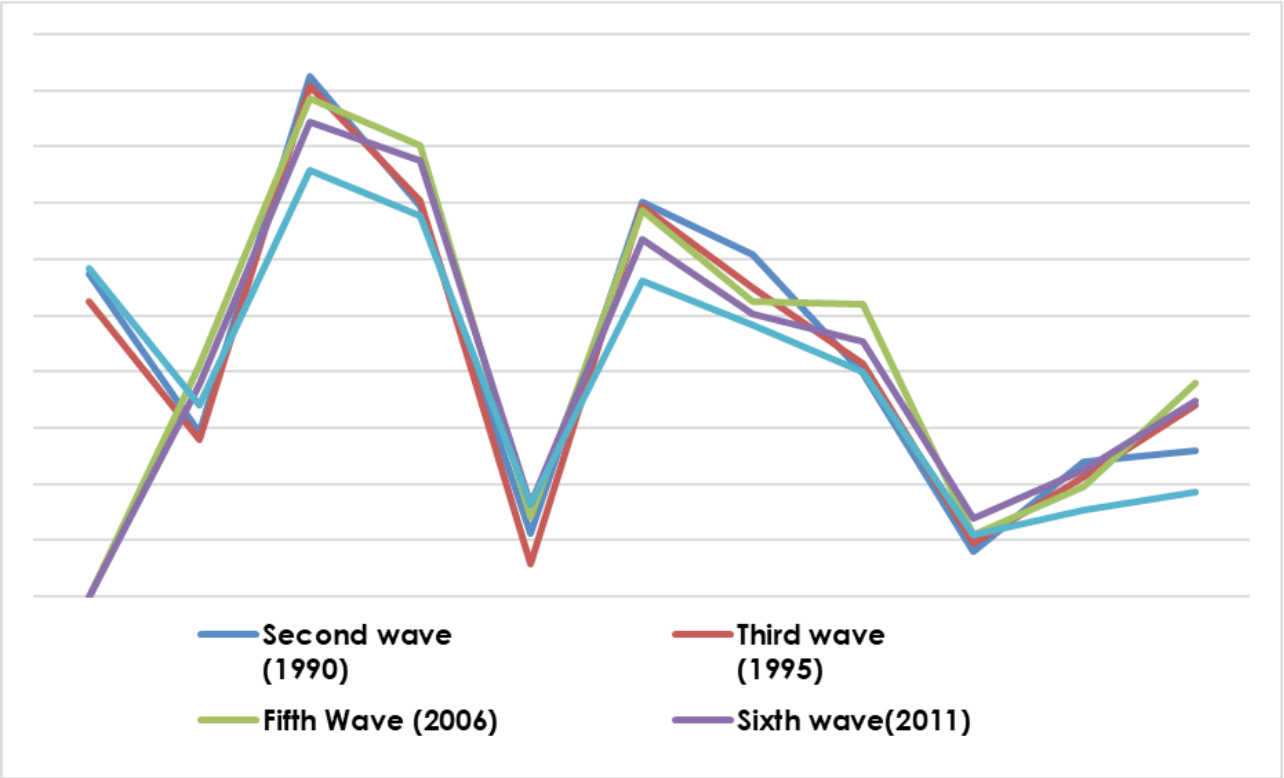
Significant qualities for upbringing (in %)

Qualities	Second wave (1990)	Third wave (1995)	Fifth wave (2006)	Sixth wave (2011)	Seventh wave (2017)
Good manners	57.3	52.4	0	0	58.4
Independence	29.2	27.8	41.3	37.8	34.1
Diligence	92.6	90.7	88.6	84.5	75.8
Responsibility	69.5	70.4	80.2	77.5	67.6
Imagination	11.3	5.9	14.2	16.5	16.5
Tolerance	70.2	69.5	68.6	63.5	56.2
Thrift	60.9	55	52.5	50.3	48.2
Decisiveness, perseverance	39.7	41.4	52	45.4	39.9
Religious commitment	8	9.4	11	13.9	11
Unselfishness	24	21.3	19.6	22.6	15.5
Obedience	25.9	34	37.9	34.8	18.5

The number of respondents who consider tolerance an important quality that should be developed is 65.6 % of the total number of respondents in all five waves, or 6,791 out of 10,344 people. Thus, according to Russians, the development of tolerance among the younger generation is quite important.

Figure 1

Assessment dynamics of the significance of qualities necessary for upbringing in a family



However, as one can see, the importance of tolerance, along with such qualities as diligence, thrift, unselfishness and obedience, decreases from the second to the seventh wave.

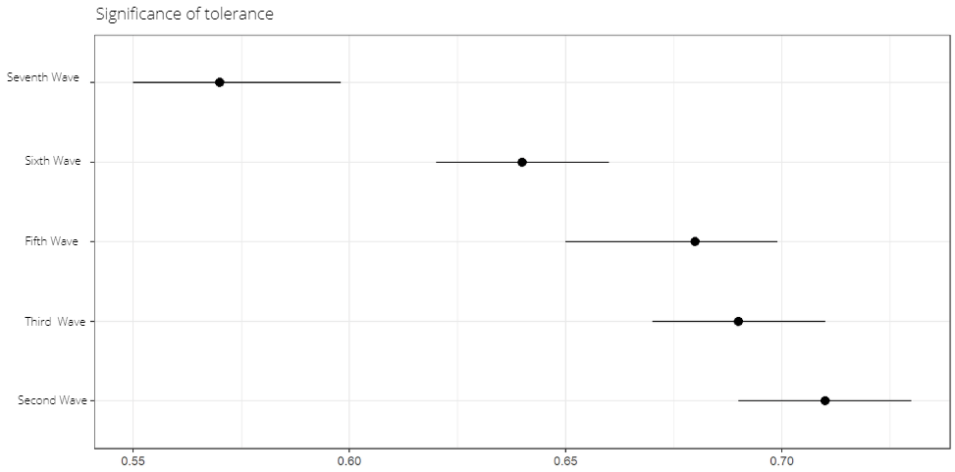
In order to statistically verify the changes in the significance of tolerance we carried out an analysis of the total sample (N = 10344) on the "tolerance" parameter using the Kruskal–Wallis one-way analysis of variance, which showed the following: the significance of tolerance is statistically valid (84.607, df = 4, p-value < 2.2e–16, p < 0.001) and it differs in various waves of the study with a weak effect size (0.00913).

The confidence interval method was used to clarify the direction of these differences (Fig. 2).

Thus, there is a statistically established trend towards a decrease in the importance of tolerance development from 1990 to 2017.

Figure 2

Dynamics of the tolerance significance by waves



All graphs are made with "RStudio".

Upon further analysis of the survey results, the respondents were divided into two groups depending on whether they considered it important to develop tolerance and respect for other people in the family: the group of respondents considering it important is labeled by us as "FT", and the group that did not think so – "NFT".

6791 people were attributed to the FT group, and 3553 people to the NFT group. The results of the comparison of their socio-demographic characteristics are given in Table 2.

Table 2

Differences between FT and NFT groups

Question number	Variable	Kruskal–Wallis chi-squared	df	p-value	eta.squared
A-WAVE	Wave (year of study)	74.753	1	< 2.2e–16	0.00835
Q260	Gender	40.792	1	1.693e–10	0.00451
Q262	Age	72.167	1	< 2.2e–16	0.00806
Q275	Level of education	7.8442	1	0.005098	0.000775
Q287	Social class	9.7623	1	0.001781	0.000992

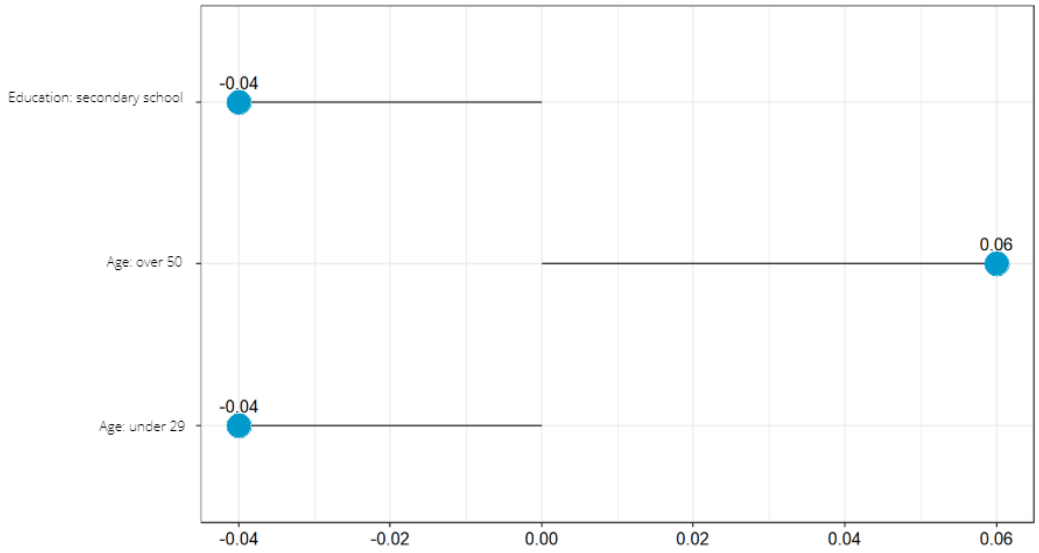
Note: Previously, all question numbers were corrected to a single sample. The numbers are given from the 7th wave questionnaire.

As follows from Table 2, all variables show a high level of differences significance with a small effect size. Correlation analysis of binary variables using the contingency phi-coefficient showed that there is a statistically significant, albeit weak, negative interrelation between male sex and tolerance ($r = -0.08$ at $p = 0.0004475411$), which suggests that tolerance in raising children is more significant for women than for men.

To identify the probability of a respondent of a certain age and level of education entering the FT group, the method of logistic regression was applied. People with higher education were selected as a reference group by the level of education, people aged 30–49 were selected as a reference group by age. All other socio-demographic characteristics were compared with the reference groups indicating by what percentage they are more or less likely to enter the FT group rather than the reference group (Fig. 3).

Figure 3

Logistic regression of the 2nd wave, 3rd wave, 5th wave, 6th wave, 7th wave in "age" and "level of education" parameters

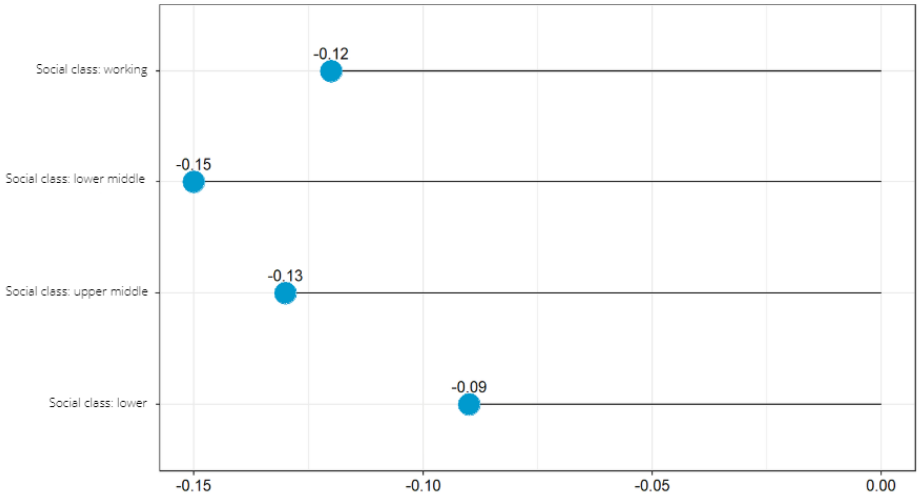


As can be noted, compared to people with higher education, people who have graduated only secondary school are 4 % less likely to be in the FT group. The same can be said about people under the age of 29 compared to the reference group, and people aged over 50, on the contrary, will be included in the FT group with a 6 % higher probability.

Upper-class people are most likely to be in the FT group: upper-middle and lower-middle class people have 13 % and 15 % lower probability, respectively, working-class people have 12 % lower probability, and lower-class people have 9 % lower probability (Fig. 4).

Figure 4

Logistic regression of the 2nd wave, 3rd wave, 5th wave, 6th wave, 7th wave in "social class" parameters



Thus, an interrelation was established between the significance of tolerance, on the one hand, and age, education level, and social class, on the other. A tendency that the importance of tolerance increases with age, in connection with higher education and belonging to the upper class, has been identified.

The results of the analysis of socio-demographic characteristics in the FT group for the period 1990–2017 are shown in Table 3.

Table 3

Differences in socio-demographic characteristics in the FT group depending on the year of the study

Question number	Variable	Kruskal–Wallis chi-squared	df	p-value	eta.squared
Q260	Gender	13.308	4	0.009865	0.00159
Q262	Age	108.94	4	< 2.2e–16	0.018
Q275	Level of education	3380.2	4	< 2.2e–16	0.578
Q287	Social class	4775.8	4	< 2.2e–16	0.818

As follows from the table, the differences are significant ($p < 0.001$), the effect size for gender has an insignificant effect, for age it is weak, while for the level of education it is strong, and for social class it is very strong.

In order to find differences between the years of research (waves), the Conover criterion was applied. Table 4 shows the results, excluding incorrect data due to their absence in some waves.

Table 4

Comparative analysis of socio-demographic characteristics in the FT group (paired comparisons depending on the wave)

Question number	Variable	Paired comparisons	mean.rank.diff	p-value
Q260	Gender	3–2	–34.79241	1.0000
		5–2	132.44497	0.1798
		6–2	73.07554	0.9965
		7–2	–58.83747	1.0000
		5–3	167.23737	0.0363 *
		6–3	107.86794	0.3520
		7–3	–24.04506	1.0000
		6–5	–59.36943	1.0000
		7–5	–191.28243	0.0332 *
		7–6	–131.91300	0.2785
Q262	Age	3–2	400.09424	6.2e–09 ***
		5–2	–88.70316	0.5676
		6–2	483.53188	3.0e–12 ***
		7–2	326.35368	4.7e–05 ***
		5–3	–488.79741	4.6e–12 ***
		6–3	83.43764	0.5676
		7–3	–73.74057	0.5676
		6–5	572.23504	1.0e–15 ***
		7–5	415.05684	2.7e–07 ***
		7–6	–157.17821	0.1415

Question number	Variable	Paired comparisons	mean.rank.diff	p-value
Q275	Level of education	5–3	301.29173	9.5e–12 ***
		6–3	392.14778	< 2e–16 ***
		7–3	–639.27643	< 2e–16 ***
		6–5	90.85605	0.0397 *
		7–5	–940.56817	< 2e–16 ***
		7–6	–1031.42421	< 2e–16 ***
Q287	Social class	6–3	–19.54155	0.4854
		7–3	–223.76284	2.1e–12 ***
		7–6	204.22129	1.9e–10 ***

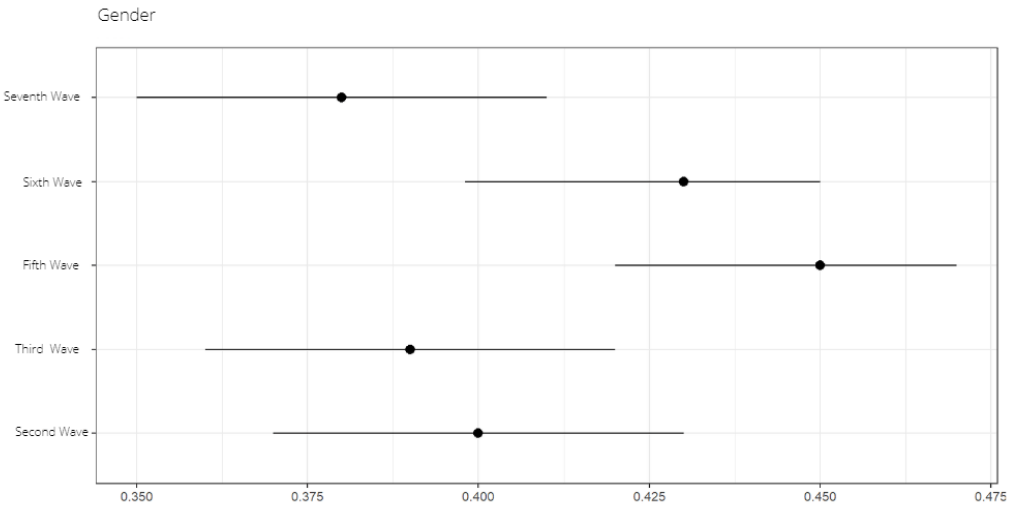
Note: Signif. codes: *0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.*

Significant differences between socio-demographic data in the FT group, presented in different waves, were found in the following parameters: by gender – in two comparisons, by level of education – in all comparisons, by social class – in two comparisons.

The method of confidence intervals was used in order to determine the direction of differences (Fig. 5, Fig. 6, Fig. 7, Fig. 8).

Figure 5

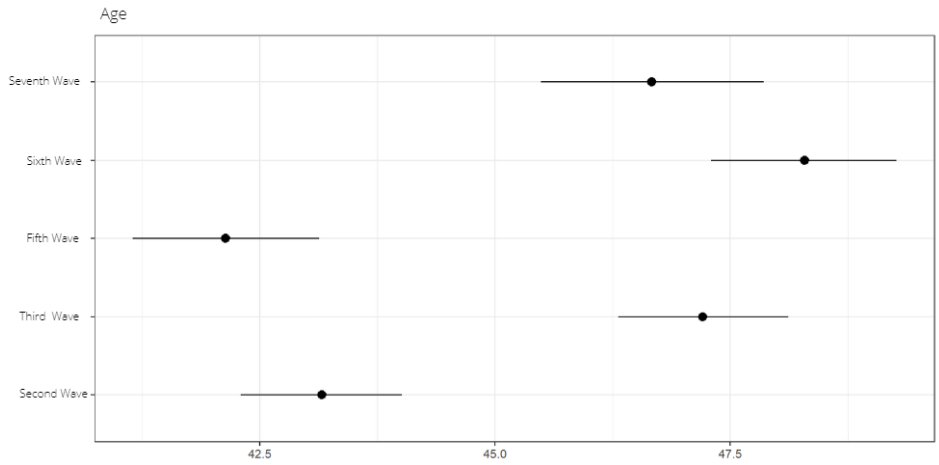
Differences by gender in the FT group in different years of the study



Women predominate in the group of respondents who consider it important to develop tolerance in the family, at the same time, the largest number of men for whom this is important was observed in the fifth wave (2006).

Figure 6

Differences by age in the FT group in different years of the study



As can be noted, in the second and fifth waves, the age indicator of respondents is lower than in the rest.

Figure 7

Differences by the level of education in the FT group in different years of the study

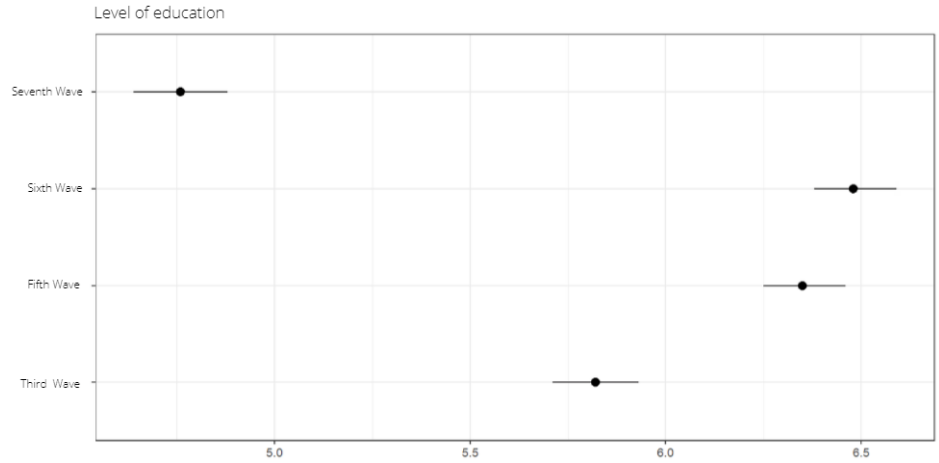
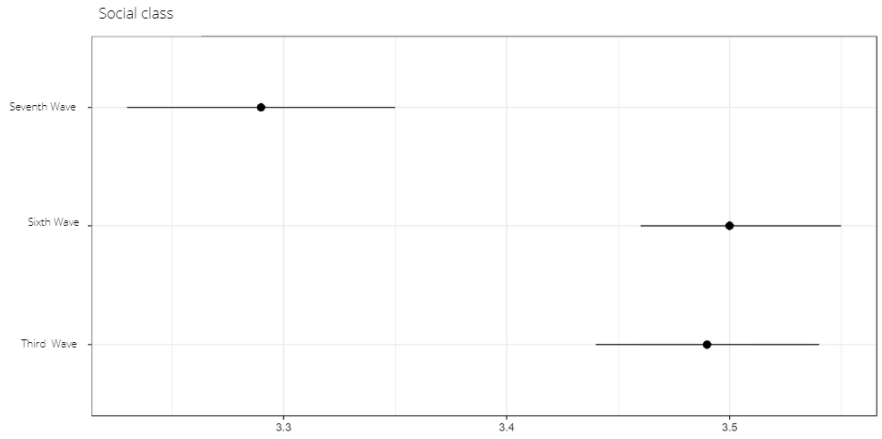


Figure 8

Differences by social class in the FT group in different years of the study



Based on the figure, it becomes clear that the level of education of respondents in the FT group consistently increases until the sixth wave, and then decreases in 2017.

We would especially like to draw attention to the fact that, as in the analysis of the level of education, in the seventh wave (2017) there is also a decrease in the indicator of the social class of the respondents of the FT group.

Discussion

Let's see how much the data obtained correspond to the results of other sociological and psychological studies that, to one degree or another, reveal the characteristics of Russian tolerance. They mainly concern ethnic tolerance.

Thus, according to the results of processing of some data from the European Social Survey (ESS) project (Dontsov et al., 2019), there has been a steady increase in ethnic intolerance among Russians from 2014 to 2016. This coincides with the conclusions of Shcherbak & Tryapkin (2019) that in 2016 the attitude towards migrants in Russia worsened compared to 2010.In 2004, 70% of the youth and 50 % of the adult population of Kursk assessed migration to the region as a negative phenomenon (Antsiferova, 2007). The results of studies of tolerance among the youth of the Oryol region in 2015 show that 45.5 % of the respondents have a negative attitude towards migration from neighboring countries, and 46.7 % of young people tend to consider themselves nationalists (Merkulov et al., 2017). The data of the authors' study on the manifestation of tolerance among the young people from the city of Togliatti, conducted in 2016, despite more positive results, is also not encouraging: only 7 % of respondents consider tolerance to be the basis for reasonable conflict resolution (Kustova et al., 2018).

This is also confirmed by the studies of Mukomel (2017): among Russians showing tolerant attitudes, older ages are more represented, while respondents of younger and middle age are more often among those who are hyper in tolerant. The author explains this trend by the fact that Russians who grew up in the Soviet era are nostalgic about international friendship. However,

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according to the research data of Prokhoda (2021), based on the results of the seventh wave of the European Social Survey (ESS), a cross-country sociological survey conducted in 2014, young people perceive migrants more positively. Most likely, the author believes, the most tolerant are young people and the older generation. Demidova (2021) also comes to this conclusion, noting that young people and representatives of the oldest generation have the most positive attitude towards immigrants. At the same time, financial security (Monusova, 2021) and education (Demidova, 2021; Mukomel, 2017; Carvacho et al., 2013) increase the degree of tolerance.

In general, the analyzed works confirm the results of our research, although they indicate socio-demographic differences in interethnic tolerance and do not reveal the main reason leading to this – the peculiarities of tolerance education in the family. In this regard, a study by Moscow scientists (Sobkin & Halutina, 2017), consonant with ours, is of particular interest, analyzing the structure of attitudes of parents of preschool children over the past twenty years. It generally remains invariant, although it depends on the socio-role positions of the respondents (their education, financial situation, social role). Parents believe that it is necessary to form in children, first of all, a moral and ethical sphere (kindness, responsiveness, respect for elders). As for the importance of the formation of tolerance, this is more typical for parents with a high financial situation. However, the authors note that over the past 20 years there has been a decline in the trend towards a "democratic style" of education (Sobkin & Halutina, 2017, p. 14). They explain this by changes in the socio-political situation in the life of Russians. It is likely that this is one of the reasons for the decline in attitudes of tolerance formation in the family, found in our research.
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Conclusion

Time has set its priorities and, despite the desire of psychologists at the beginning of the century to consolidate the inhabitants of the multi-ethnic regions of Russia, most of the studies of recent years are devoted to tolerance towards migrants and refugees. Unfortunately, the reduction of this phenomenon only to ethnic tolerance simplifies it. Tolerance begins in a person with the recognition of the right of another person, who may be a representative of one's own culture, to be different, to have a different point of view, etc.

A positive point can be considered that, according to the Russians, tolerance is one of the important qualities that need to be formed in the family. However, a weak but significant trend towards a decrease in its significance was statistically established. At the same time, supporters

and opponents of this point of view differ in all socio-demographic characteristics.

The older generation (50 years and over) is more tolerant – most of them consider it necessary to form tolerant attitudes in the younger generation. Perhaps this is really connected with nostalgia for the international friendship in the Soviet era, but it cannot be ruled out that this is a consequence of the acquired life experience, understanding of the diversity of the human world, rejection of ethnocentrism, etc.

We cannot unequivocally state who, men or women, are bigger supporters of the formation of tolerance, but according to the data obtained, there is a tendency for it to be more manifested among women. Interestingly, for men and young people, the same trend is observed only in 2006, during the period of economic growth in the country, and since 2014 it has been falling.

People with higher education are more likely to be in the group of respondents for whom it is important to form a tolerant attitude towards other people than those with secondary education. However, in 2017, the level of education among supporters of the formation of tolerance in the family, which had previously increased, is decreasing. Their social class level is also going down this year. However, it should be noted that the respondent's assignment of oneself to a certain class has a greater degree of subjectivity than other socio-demographic characteristics.

If you try to describe a person for whom tolerance in raising children is most important, then it will most likely be over 50 women with a higher education, belonging to the upper class.

We would also like to note the following. Conspicuously, this is not the first attempt by Russian scientists to take into account the results of sociological studies conducted on a large group of people (Artemov & Pinkevich, 2020; Dontsov et al., 2019; Avanesian et al., 2021), including World Values Survey.

For psychologists, the value of such work lies in the fact that it "brings psychology to life", allowing us to take into account not only the opinion of people obtained in the laboratory, but also the real attitude of respondents to psychological phenomena. In this regard, based on the analysis, the following discrepancy is alarming: over the past twenty years, the number of publications on tolerance, the significance of its development, indicating specific technologies for each age, etc., has significantly increased, while for the Russians the significance of the formation of tolerance towards other people is falling.

Restrictions

The analysis carried out does not fully reveal the motives behind the tolerant/intolerant behavior of Russians. It shows attitudes towards the significance of the formation of tolerance towards Others, including another ethnic group, among the younger generation. This aspect of the study of tolerance is extremely important. Unfortunately, we were not able to trace the differences in attitudes towards the formation of tolerance between those who are and are not citizens of Russia, who were born in this country, and those who moved from another country, i.e. immigrants themselves. This is due to the fact that almost all respondents are Russian citizens born in Russia. However, in our opinion, this increases the significance of the study, since it shows the attitudes of Russians towards how they would like to see the society of the future.

These attitudes are limited by social conditions and cannot characterize Russian culture as a whole. The change of social conditions can also change attitudes. This is reflected in the World Values Survey: as society develops, so do values.

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Author Contributions

L. I. Ryumshina developed of the concept of the study, literature review on the topic of the article; analyzed and interpreted the obtained data; participated in the writing of the article, scientific advice; edited the article.

E. V. Zinchenko reviewed the literature on the topic of the article, participated in the collection and processing of the material, analyzed the obtained data, participated in the article's writing.

A. A. Chernova organized the empirical research, participated in the processing of the material, interpreted the obtained data, participated in the article's writing.

Ju. V. Berdyanskaya participated in the processing of the material, participated in writing and editing the article and conclusion, designed the final version of the article.

O. V. Batychko participated in the processing of the material, analyzed the obtained data, participated in writing the article, designed the final version of the article.

Author Details

Liubov Ivanovna Ryumshina – Dr. Sci. (Psychology), Professor of the Social Psychology Department, Southern Federal University, Rostov-on-Don, Russian Federation; Scopus Author ID: 6506836314, ResearcherID: P-6488-2015, SPIN-code: 7027-4206, ORCID: https://orcid.org/0000-0003-2228-8140, e-mail: ryumshina@sfedu.ru

Elena Valeryevna Zinchenko – Cand. Sci. (Psychology), Associate Professor of the Social Psychology Department, Southern Federal University, Rostov-on-Don, Russian Federation; ResearcherID: R-7513-2016, SPIN-code: 9403-7635, ORCID: https://orcid.org/0000-0002-7262-9583, e-mail: evzinchenko@sfedu.ru

Anastasia Alexandrovna Chernova – Cand. Sci. (Psychology), Associate Professor of the General and Pedagogical Psychology Department, Southern Federal University, Rostov-on-Don, Russian Federation; SPIN-code: 6291-6568, ORCID: https://orcid.org/0000-0001-7734-8775, e-mail: achernova@sfedu.ru

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Julia Vladimirovna Berdyanskaya – Assistant of the Social Psychology Department, Southern Federal University, Rostov-on-Don, Russian Federation; SPIN-code: 9293-8861, ORCID: https://orcid.org/0000-0001-7878-9097, e-mail: yber@sfedu.ru
Olga Vladimirovna Batychko – Master Degree Student of the Social Psychology Department, Southern Federal University, Rostov-on-Don, Russian Federation; ORCID: https://orcid.org/0000-0002-1518-1161, e-mail: batychko@sfedu.ru

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Mediation of Moral Disengagement on Cyberbullying Perpetration Influenced by Emotional Intelligence and Anonymity of Indonesian Adolescents on Social Media

Ahmad Yazid Lubis[1]✉, Hera Lestari Mikarsa[2], Inge Andriani[3]
[1, 2, 3] Gunadarma University, Jakarta, Indonesia

✉ ahmad_yazid@taff.gunadarma.ac.id

Abstract: Introduction. The use of social media in a scope of adolescents confirms that without any sufficient digital literacy, it shall leads to an increased dysfunctional behavior. Adolescents who feel anonymous and think that attacking others on social media shall not violate morals will make them portrayed as the cyberbullying perpetrator, even though they have any good emotional intelligence as well. This research aims to examine the mediating role of moral disengagement on cyberbullying perpetration which is influenced by emotional intelligence and anonymity of Indonesian adolescents on social media. Methods. The measurement applied on this research uses Adolescent Cyber-Aggressor Scale, Schutte Self-Report Emotional Intelligence Test, Anonymity Scale, and Moral Disengagement Scale. All scales have good reliability and have been tested for validity using confirmatory factor analysis (CFA). The structural model was tested by path analysis using the Amos program and the mediating effect was tested by using the Sobel test. Results. The results show the goodness of fit structural model with Chi-square = 2.604 ($p > 0.05$), RMSEA = 0.068, GFI = 0.996, AGFI = 0.963, dan TLI = 0.916. The acceptance on the hypothesis shows that moral disengagement significantly mediates the effect of emotional intelligence and anonymity on cyberbullying perpetration, whereas moral disengagement has the strongest direct effect. Discussion. The mechanism of moral disengagement in cyberbullying perpetrators can occur at the behavioral, agency, effect, and victim locus. Instilling awareness of moral values and increasing digital literacy in adolescents is very important to do to suppress any cyberbullying perpetration.

Keywords: cyberbullying perpetration, moral disengagement, emotional intelligence, anonymity, adolescents, social media, internet aggression, digital literacy, confirmatory factor analysis, path analysis

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Highlights:

- The influence of emotional intelligence and anonymity through the mediation of moral disengagement was investigated in 346 adolescents (by mean age = 19.81 years) who were cyberbullying perpetrator on social media, which were selected using purposive sampling technique.
- Anonymity and moral disengagement have a direct influence on the cyberbullying perpetration of Indonesian adolescents on social media.
- The emotional intelligence of participants is in the high category and the majority have anonymous accounts on social media.

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Introduction

The lack of digital literacy in Indonesia during the rapid penetration of information and communication technology (Humaira, 2022), make adolescent internet users are actually way of abuse it to behave deviantly such as in terms of cyberbullying. Cyberbullying is an act of aggression that uses internet-based digital devices (Kowalski et al., 2012; Langos, 2012; Smith et al., 2012), so in this case digital literacy which includes digital skills, digital ethics, digital culture, and digital safetyis very important. Digital literacy reflects how the use of new media technology appeared as should be, as a fence to prevent dysfunctional behavior in cyberspace (Livingstone, 2008; Leung & Lee, 2012; Miao et al., 2020).

Data released by We Are Social and Kepios in 2022 (Kemp, 2022), shows that internet penetration in Indonesia reaches 73.7 % of the total population, while social media users in the age range of 13–17 years are 22 % and those aged 18–24 years reach 32 %, bringing a total of 83.2 million social media users. The number of adolescent social media users in Indonesia raises concerns because it is not be accompanied by any sufficient digital literacy along the way, coupled with the absence of assistance and supervision from parents because they think that adolescents are old enough to use any kinds of social media. In fact, adolescents are the group that most closely related to cyberbullying perpetration (Kowalski et al., 2012; Robson & Witenberg, 2013; Balakrishnan, 2015).

Digital Civility Index (DCI) data released by Microsoft in 2020 shows that the level of digital civility of Indonesian netizens is the lowest in Southeast Asia, the civility in question is related to hate speech, trolling, and others cyberbullying perpetration (Mazrieva, 2021). Cyberbullying perpetration is very contrary to the universally believed values of goodness, so that cyberbullying perpetrators carry out moral disengagement, a cognitive mechanism to justify their actions and distortthe effects of guilt caused (Bandura, 2016). This moral disengagement mechanism occurs at the behavioral, agency, effect, and victim locus (Bandura, 2016). For example, the perpetrator only feelscriticizing the victims, compares his actions with others, feels he is just joining in, sees his actions asa joke, and may also think that the victims deserve to be attacked. Several studies (e.g. Robson & Witenberg, 2013; Gini et al., 2014; Kowalski et al., 2014) have shown that moral disengagement is indeed positively correlated with any cyberbullying behavior.

Basically, adolescents who do not have the ability to manage emotions will tend to be easier toattack and hurt others (Krahe, 2005). In addition, if using an anonymous account, adolescents

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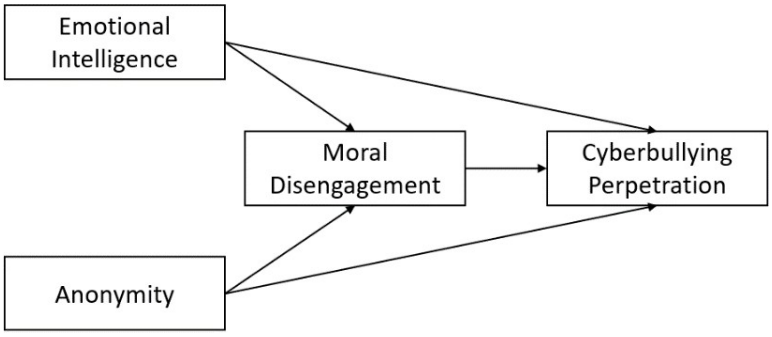
will feel safer to carry out their actions (Suler, 2004; Nixon, 2014). However, this may not happen if the teenager realizes that the act is not good and is against social rules and moral standards. Several previous researches have shown emotional intelligence to have a negative relationship with cyberbullying perpetration (e.g. Elipe et al., 2015; Adiyanti et al., 2020) and moral disengagement (e.g.Marin-Lopez et al., 2020; Parlangeli et al., 2019). Meanwhile, anonymity has been shown to have a positive relationship with cyberbullying perpetration in several researches (e.g. Barlett, 2015; Barlett et al., 2016) and moral disengagement (e.g. Wang & Ngai, 2020).

The impact of cyberbullying perpetration is very dangerous for teenagers, both perpetrators and victims. Victims can experience psychological problems such as depression which can trigger suicide (Hinduja & Patchin, 2010). Several cases of suicide have occurred in Indonesia (Edward, 2013; Prastiwi, 2020). On the other hand, perpetrators will tend to be aggressive, violent, irritable, impulsive, want to dominate, and lack of empathy (Nixon, 2014). Victims are also very likely to become perpetrators when retaliating with similar acts of cyberbullying (Ak et al., 2015). Based on a study by the Indonesian Internet Service Providers Association (APJII), 7.9 % of cyberbullying victims in Indonesia responded with the same action (Pratomo, 2019). Thus, cyberbullying can become a continuous cycle.

Based on the description that has been stated, this research aims to determine the role of moral disengagement on cyberbullying perpetration committed by adolescent on social media users in Indonesia. This research hypothesizes that moral disengagement mediates the effect of emotional intelligence and anonymity on cyberbullying perpetration (Figure 1).

Figure 1

Research hypothesis model



Methods

Participants

Participants are Indonesian adolescents who are indeed be part of cyberbullying perpetrators on social media such as Facebook, Instagram[1], TikTok, YouTube[2], Snapchat, and other social me-

1 Editorial note: Facebook and Instagram are online social media owned by Meta Platforms, recognized as extremist organizations, and banned in Russia since 2022.
2 Editorial note: Site that violates Russian legislation.

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dia applications. The sampling technique used purposive sampling by sending a direct message containing a request to be willing to become a respondent to adolescents aged 17–21 years who were caught doing cyberbullying perpetration on social media. Collecting data using an online questionnaire, a total of 346 participants (133 males) with an average age of 19.81 (SD = 1.03) were collected.

Measurement Validity and Reliability

Measurements using the Adolescent Cyber-Aggressor Scale (18 items CYB-AGS; Buelga et al., 2020), Schutte Self-Report Emotional Intelligence Test (33 items SSEIT; Schutte et al., 1998), Anonymity: Unlinkability, Pseudonymity, Unobservability (8 items ANO-UPU; Lee et al., 2013), and the Moral Disengagement: A Framework for Understanding Bullying Among Adolescents (18 items MD-FUBA; Hymel et al., 2005). All scales were tested for reliability using SPSS (ver.22). Furthermore, the construction validity of each scale was tested by confirmatory factor analysis (CFA) with a minimum factor loading value of 0.4 (Harrington, 2009). All scales produce a fit model with good validity and reliability (Table 1).

Table 1

Validity and reliability of measuring instrument

Scale	Cronbach alpha	Chi-square	RMSEA	GFI	AGFI	Factor loading range	Total ValidItem
CYB-AGS	0.761	41.602*	0.024	0.979	0.966	0.44–0.83	10
SSEIT	0.932	91.157*	0.025	0.967	0.953	0.42–0.87	14
ANO-UPU	0.850	7.975*	0.029	0.993	0.976	0.54–0.88	6
MD-FUBA	0.919	53.566*	0.017	0.977	0.963	0.45–0.86	12

Note: * $p > 0.05$.

Data Analysis Technique

The initial analysis examined differences in cyberbullying perpetration, emotional intelligence, anonymity, and moral disengagement based on gender, and tested the correlation of each variable using SPSS (ver.22). The hypothesis model was tested by path analysis using the Amos program (ver.22). The criteria used were *Chi-square*, $p \geq 0.05$, RMSEA ≤ 0.08, GFI ≥ 0.9, and AGFI ≥ 0.9 (Haryono & Wardoyo, 2012). Finally, the mediating effect was tested using the Sobel test with the criteria of statistical value ≥ 1.967, and $p \leq 0.05$ (Widhiarso, n.d.).

Results

Descriptive Analysis and Variable Correlation

The results of the descriptive analysis of the measurements showed, although not much different, the empirical mean of male cyberbullying perpetration (M = 14.81, SD = 4.92) was higher than that of female (M = 14.75, SD = 4.77). The results of the correlation test show that emotional intelligence is negatively correlated with cyberbullying perpetration, while anonymity and moral disengagement are positively correlated with cyberbullying perpetration (Table 2). Regarding anonymity, the data shows that 68.8 % of participants (N = 346) have anonymous accounts on social media (Table 3).

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Table 2

Means, standard deviations, and correlations of the main study variables

Variables	Male		Female		1	2	3	4
	M	SD	M	SD				
1. CBP	14.81	4.92	14.75	4.77	1			
2. EI	44.10	7.36	43.96	6.76	–0.154**	1		
3. ANO	14.43	4.46	14.86	4.58	0.259**	0.031	1	
4. MD	22.12	7.89	22.53	8.18	0.307**	–0.330**	0.267**	1

Note: ** $p < 0.01$, $N = 346$, *CBP:* Cyberbullying Perpetration, *EI:* Emotional Intelligence, *ANO:* Anonymity, *MD:* Moral Disengagement.

Table 3

Anonymous account on social media

Have an anonymous account	Male	Female	Total
Yes	79	159	238 (68.8 %)
No	54	54	108 (31.2 %)

Note: $N = 346$.

Model test Results

Based on model test result with the Amos program (ver.22), the research hypothesis was proven to be accepted. The model meets the goodness of fit criteria with *Chi-square* = 2.604, $p > 0.05$, RMSEA = 0.068, GFI = 0.996, AGFI = 0.963, and TLI = 0.916 (Figure 2).

Figure 2

Model test results

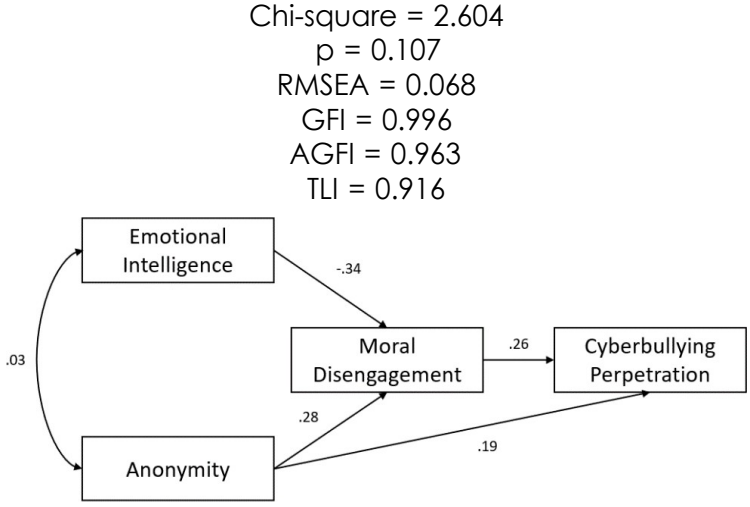

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Table 4

Estimates regression weights

			Estimate	S.E.	C.R.
Emotional Intelligence	→	Moral Disengagement	–0.391***	0.056	–6.965
Anonymity	→	Moral Disengagement	0.492***	0.086	5.699
Moral Disengagement	→	Cyberbullying Perpetration	0.153***	0.031	4.908
Anonymity	→	Cyberbullying Perpetration	0.202***	0.055	3.649

Note: *** $p < 0.001$, $N = 346$.

Table 5

Standardized direct, indirect, total effect, and Sobel test result

					Direct effect	Indirect effect	Total effect	Sobel test
EI	→	MD			–0.339***			
ANO	→	MD			0.277***			
EI	→	CBP			–			
ANO	→	CBP			0.190***			
MD	→	CBP			0.256***			
EI	→	MD	→	CBP		–0.087***	–0.087	–4.030***
ANO	→	MD	→	CBP		0.071***	0.261	3.737***

Note: *** $p < 0.001$, $N = 346$, *CBP:* Cyberbullying Perpetration, *EI:* Emotional Intelligence, *ANO:* Anonymity, *MD:* Moral Disengagement.

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Moral disengagement has the strongest influence on cyberbullying perpetration (β = 0.256, p < 0.001). Emotional intelligence and anonymity significantly predict moral disengagement (β = –0.339, p < 0.001 and β = 0.277, p < 0.001). The results of the mediation test show that moral disengagement significantly mediates emotional intelligence on cyberbullying perpetration (Sobel test = –4.030, p < 0.001), so that the indirect effect of emotional intelligence on cyberbullying perpetration is –0.087. Moral disengagement also significantly mediates anonymity on cyberbullying perpetration (Sobel test = 3.737, p < 0.001), so that the indirect effect of anonymity on cyberbullying perpetration is 0.261.

Discussion

The results show that cyberbullying perpetration that appears in adolescents is a contribution from emotional intelligence, anonymity, and moral disengagement. Moral disengagement significantly mediates the effect of emotional intelligence and anonymity on cyberbullying perpetration. Anonymity and moral disengagement are known to have a direct influence on cyberbullying perpetration, where moral disengagement has the strongest direct effect.

Adolescence is the most vulnerable period to experience any emotional fluctuations (Santrock, 2004), so it will escalates the tendency to act aggressively because of the uncontrolled emotions (Krahe, 2005). Individuals with good emotional management will have the ability to empathize and build relationships with other people (Goleman, 2009), automatically lowering the possibility of doing harm or hurting others, including cyberbullying perpetration. However, this does not seem to be the case when the moral disengagement mechanism occurs, the findings of this study prove this. The results show that moral disengagement mediates the effects of emotional intelligence and cyberbullying perpetration, while it can be seen that participants who are cyberbullying perpetrators have high emotional intelligence (Table 2). This means that even though adolescents have high emotional intelligence, it does not necessarily guarantee that adolescents will not engage in cyberbullying perpetration.

The occurrence of a moral disengagement mechanism will make the perpetrator lose a sense of empathy for the victim (Bandura, 2016) which automatically increases cyberbullying perpetration. In other words, moral disengagement plays its role as a mediator. The findings of this study are in line with the research of Nusantara et al. (2020) and Fang et al. (2020). The findings of research conducted by Nusantara et al. (2020) showed that moral disengagement mediates one aspect of emotional intelligence, namely empathy with cyberbullying behavior, where empathy has a significant negative relationship with moral disengagement and cyberbullying behavior. Fang et al. (2020) in their research also found that moral disengagement mediates a positive relationship between callous-unemotional traits and cyberbullying behavior, where callous-unemotional traits characterize adolescents who have no remorse or guilt, and do not care about the negative consequences of their actions.

The factor of the difference in interactions in social media compared to the real world on the other hand is a catalyst for the role of moral disengagement. According to Pornari & Wood (2010), virtual world interactions can create a user's perspective that all actions taken in cyberspace will not harm and only think of it as a joke or fun thing, so that it can trigger an increase in moral disengagement. In the context of social media, the implementation of the perpetrator's emotional intelligence level can shift due to the lack of non-verbal messages when interacting (Pornari & Wood, 2010; Runions & Bak, 2015; Marin-Lopez et al., 2020). For example, cyberbullying

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perpetrators cannot see the victim's actual emotional responses and expressions, thus eliminating the possibility of the perpetrator's empathy for the victim.

The findings of this study indicate that anonymity directly predicts cyberbullying perpetration, this finding is in line with the research of Barlett (2015) and Barlett et al. (2016). Anonymity is one of the characteristics of interactions on social media that allows users not to display their real identity (Suler, 2004; Nixon, 2014), this situation makes adolescents who are cyberbullying perpetrators feel freer without fear of being identified. Research conducted by Barlett (2015) shows that anonymity develops an individual's positive attitude towards cyberbullying, which in itself predicts cyberbullying behavior. Barlett et al. (2016) in their study also showed the perception of anonymity was related to cyberbullying behavior, where the higher the sense of anonymity online, the more likely it was to cyberbully others.

The results of the mediation test also show that moral disengagement is significant as a mediator of the influence of anonymity on cyberbullying perpetration, where the effect of anonymity becomes stronger through mediation. In addition, descriptive analysis (Table 3) also shows that the majority of participants have anonymous accounts on social media. According to Suler (2004), anonymity on the internet can trigger behavior that has never been done in the real world because they feel they can't be monitored, so that perpetrators ignore rules and a sense of responsibility. This is in line with the moral disengagement mechanism stated by Bandura (2016). The results of this study are in line with the research of Wang & Ngai (2020) which shows that moral disengagement acts as a mediator of anonymity and cyberbullying behavior. However, there are differences related to the direct effect of anonymity, Wang & Ngai (2020) in their research show that anonymity does not have a direct effect on cyberbullying behavior, there is no significant relationship related to the mediating effect of moral disengagement (Wang & Ngai, 2020).

In addition to significantly mediating emotional intelligence and anonymity, the results of this study indicate that moral disengagement has the strongest direct effect on cyberbullying perpetration. This finding strengthens the previous research conducted by Gini et al. (2014), and Kowalski et al. (2014). The meta-analysis study conducted by Kowalski et al. (2014) showed that moral disengagement was the most strongly associated factor with cyberbullying behavior compared to other factors. While Gini et al. (2014) in their meta-analysis study also found that moral disengagement was strongly related to aggressive behavior in adolescents and children, including cyberbullying.

Cyberbullying perpetrators will consider the act of attacking and hurting others on social media as a natural thing and not an immoral act because many social media users engage in similar behavior. This is supported by research by Robson & Witenberg (2013) who found diffusion of responsibility at the agency locus of moral disengagement, predicting cyberbullying behavior. On the other hand, it is possible that the perpetrator actually knows that his action is not right, but the perpetrator activates the moral disengagement mechanism to reconstruct his own mind by assuming that his act is not a bad thing with the aim of reducing uncomfortable effects such as feeling guilty or feeling like a bad person.

Referring to Bandura (2016), the mechanism of moral disengagement in cyberbullying perpetrators can occur at the behavioral locus, agency locus, effect locus, and victim locus. At the behavioral locus, the perpetrator will justify his actions as right. For example, the perpetrator thinks that the victim is the one who did bad things, so the perpetrator feels that he only gives good criticism. Perpetrators will also compare their actions with the actions of others who are

worse. At the agency locus, the perpetrator will think that he/she is not the one who should be responsible because he is just joining in on cyberbullying or just sharing and forwarding, the perpetrator will think that the first content creator must be responsible. At the locus of effect, the perpetrator will feel that his/her actions will not have a negative impact on the victim and perceive it as a joke or fun thing. While at the victim locus, the perpetrator will assume that his actions occurred due to the victim's own fault. For example, the perpetrator thinks that the victim's content on social media deserves to be blasphemed.

Adolescents in the digital age spend most of their time on social media. Meanwhile, adolescents tend to still not be able to understand their identity and are easily influenced by the environment (Santrock, 2004). The use of social media that is not accompanied by digital literacy and supervision makes teenagers think that intimidating, blaspheming, demeaning, or insulting others on social media is an act that does not violate social rules and norms, by itself will trigger teenagers to do cyberbullying, several studies have shown this (e.g. Stodt et al., 2016; Tao et al., 2022). In addition, the virtual world, which knows no boundaries of time and place, has made cyberbullying a continuous threat to victims (Tokunaga, 2010; Kowalski et al., 2012; Langos, 2012).

Conclusions

Based on the results of the research, moral disengagement was proven to mediate the effect of emotional intelligence and anonymity on cyberbullying perpetration in Indonesian adolescents on social media. It can also be seen that the role of moral disengagement has a vital role related to cyberbullying perpetration. The advice that shall be given is the importance of efforts to reduce the level of moral disengagement by instilling awareness of moral values in adolescents in order to reduce the possibility of cyberbullying. Future research is expected to be able to be conducted and proved this. In addition, it is necessary to escalates any digital literacy in adolescents which includes digital skills, digital ethics, digital culture, and digital safety, especially in developing countries such as Indonesia.

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Author Contribution

Ahmad Yazid Lubis contributed to conceptualizing and designing research, finding respondents and collecting data, statistical analysis and interpreting the results, writing and editing research report manuscripts as well.

Hera Lestari Mikarsa contributed to the conceptualization of the research, preparing the theory and literature reviews, compiling and validating the measurement scales, and interpreting the results.

Inge Andriani contributed to planning research and data collections, analyzing data and interpreting results, and writing the research reports as well.

Author Details

Ahmad Yazid Lubis – M.Si. (Communication Psychology), Candidate of Dr. (Psychology) at Doctoral Program of Psychology Science, Gunadarma University, Jakarta, Indonesia; ORCID: https://orcid.org/0000-0001-5667-917X; e-mail: ahmad_yazid@taff.gunadarma.ac.id

Hera Lestari Mikarsa – Ph.D (Psychology), Professor at Doctoral Program of Psychology Science, Gunadarma University, Jakarta, Indonesia; Scopus Author ID: 22635041300; e-mail: hera@staff.gunadarma.ac.id

Inge Andriani – Dr. (Psychology), Lecturer at Doctoral Program of Psychology Science, Gunadarma University, Jakarta, Indonesia; ORCID: https://orcid.org/0000-0002-1529-772X; e-mail: inge_andriani@staff.gunadarma.ac.id

Conflict of Interest Information

The authors have no conflicts of interest to declare.