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Detection of Intellectual Giftedness in Children of Different Ages and Methods of its Development as an Aspect of Neurophysiological Development

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Abstract: *In this article, the concept of giftedness in children of different ages, its types and characteristics, the basics of diagnosis and methods of development of factors contributing to intellectual abilities were studied. In this context, quite a lot of opinions and worldviews of thinkers of different historical eras, including Plato, Confucius and others, were analyzed regarding the definition of the concept of giftedness in children. The neurophysiological features of mental thinking were also investigated. It was concluded that giftedness is a unique combination of abilities that are the result of neurophysiological processes, which is a prerequisite for achieving certain successes or certain achievements in a certain activity. Thanks to such unique features, the child differs from others in a certain way. Giftedness is some unique feature of children, which is determined by the neurophysiological features of the body's development.*
The relevance of such topics is extremely important, because the scientific and technical development of modern society forces creative approaches in solving a number of problems. The presence of a perfect system for identifying and educating gifted and creative children is a necessary component of the successful activity of society. The purpose of the article is to clarify the necessary features and signs of giftedness in children with the aim of developing effective mechanisms for diagnosing giftedness in children of different age groups and methods of its development as an aspect of the neurophysiological approach to personality.
In the research process, the method of analysis of the available theoretical information of the selected area, synthesis of all existing points of view was used. The result is the determination of the characteristics of giftedness, taking into account its types, characteristics, and the creation of methods of dealing with gifted children and developing their abilities.

Keywords: *Skills and abilities; child's potential; trial tests, neurophysiological features of giftedness; level of intelligence; IQ test.*

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Introduction

The main task of parents, kindergartens, educational institutions is the comprehensive development of their children. In this process, you must first identify the various talents, abilities of the child, inclinations. After all, the development of children is not just bringing them to common standards of knowledge and skills. In this area it is necessary to select an individual approach to each child, to diagnose his/her special abilities. Along with the general aspects of development in the form of communication skills, cognition and perception of the world, the ability to read, write, count, which are necessary components of the formation of social personality, it is necessary to take into account the uniqueness of each person. The problem of determining the giftedness of each child, his/her features and methods of development is extremely important and necessary for research (Berbets et al., 2021; Demchenko et al.,, 2021; Karasievych et al., 2021; Kosholap et al., 2021; Prots et al., 2021; Sarancha et al., 2021).

Despite the fact that the basis for imitation and trust for children is the family, but the pedagogical principles that are available in schools, at least there should be, better and more professionally reveal the identity of children in specific areas (Zavhorodnia, 2006). It is the rules and features of pedagogical psychology that are designed to recognize and realize the potential of each gifted child, which are formed by neurophysiological processes.

Without the necessary psychological analysis of the phenomenon of giftedness, its characteristics, determining the age and psychological characteristics of the child, the disclosure of their potential is almost impossible (Gallagher, 2008). Also important aspects are the definition of the main trends and dynamics of improvement of gifted children intellectually and personally. It should be noted that the necessary criteria for professional and psychological support of gifted children are the presence of an atmosphere of mutual respect, cooperation between teachers and children, new approaches in the educational process.

In modern society there is a tendency to stereotype the concept of gifted children, shifts the emphasis and forgets certain individual characteristics of gifted children (Klymeniuk, 2015). In other words, the pedagogical community is mostly inclined to believe that only those who can win are gifted, ie various tournaments, Olympiads and other competitions where you can show yourself and your abilities. Thus, a distorted view of this concept is created and the study of the unique features of each child

recedes into the background. After all, people are satisfied with the fact that they consider gifted and unique only some people who achieve success.

At the same time, in the education system there are gradual shifts and changes in the social direction towards the maximum disclosure and further development of the potential of each child (Antonova, 2005). More and more we are talking about such concepts as self-improvement, self-determination and self-realization. These processes will best help to reveal the giftedness and uniqueness of each individual.

Well-developed countries, such as the United States, for example, have been developing the problem of giftedness since the middle of the twentieth century. At that time, schools for gifted children and youth were being established (Davis et al., 2013). In 1975, the same United States even established the International Association of Gifted Children. Instead, the Center for the Study of Gifted Children and Youth was established in the United Kingdom. However, in some countries, separate classes for gifted students have been introduced in schools. That is, the general idea of countries in this context was the need for timely identification of talented, gifted children and the development of their abilities.

One of the factors in the formation of a child's giftedness is the neurophysiological features of the child's development. An attempt by neurophysiologists to explain different levels of intellectual development is the resource theory, according to which more accurate and faster intellectual activity requires the involvement of additional brain resources. It is assumed that with a high level of intelligence, these resources can be provided both by involving more areas and areas of the cortex in the thinking process, and by increasing the activation of the brain departments usual for this type of activity, for example, the frontoparietal neural network. It is also assumed that people with high intelligence have greater resources or are more easily engaged in solving complex tasks compared to their less able peers. At the same time, the origin of these additional resources is actually unknown.

The purpose of the study is to study the factors of giftedness in children with the aim of developing effective diagnostic mechanisms as an aspect of neurophysiological personality development.

Theoretical substantiation of the concept of giftedness, its features and characteristics

Timely identification of a child's giftedness, and even more so to choose the right approach and methodology of working with them is a very difficult task for psychologists, parents, teachers. Therefore, it is necessary to understand and know every aspect, every detail and feature of the concept of

giftedness (Karpenko, 2013). Moreover, it is necessary to take into account the historical experience of working with gifted children in order to develop a clear strategy for identifying unique features and tendencies in children of different ages and their proper development.

In terms of studying the physiological foundations of giftedness, psychologists traditionally consider the key issue to be the relationship between hereditary and social factors in the development of giftedness. In their research, scientists tried to prove the thesis that intellectual giftedness is hereditary. Later, some authors demonstrated the opposite position. Attempts to find physiological causes consist in confirming innate differences in mental abilities. Some scientists believe that all brain structures that have formed since the beginning of human ontogenesis, from the very beginning of the child's immersion in the environment, are a fusion of biological and social, and this fusion, ultimately, is expressed only in the form of psychophysiological processes.

For many years, it was believed that with age, brain processes gradually lose the ability to reorganize neurons. However, modern data have shown that neuron plasticity is also possible in adulthood. Research in neurophysiology shows that the formation of neural structures is a self-organized and self-determined process that depends equally on hereditary and environmental factors. In particular, in one of the latest works of British scientists, there is a psychophysiological study of the memory of London taxi drivers. It is interesting that in those people who had considerable experience working as a taxi driver and, accordingly, were very well oriented in the location and name of the streets, larger hippocampal structures were found in the tomography than in the rest.

Thus, even in the days of ancient Greece, a systematic plan was devised to identify and develop gifted children (Al-Hroub & Khoury, 2018). This was done by the world-famous philosopher Plato. That is, in ancient times emphasized the importance of understanding giftedness. The ancient Greek thinker insisted on the view that only individual children who took the test could go further on the educational level. Others simply had to be rejected. At the same time, Confucius proposed to identify and develop gifted preschool children (Ford & Harmon, 2001). Such approaches to giftedness, on the one hand, correlate with the structure of the society of that time, when there was no opportunity, the necessary knowledge to seek an individual approach to each. Such views are similar to those that have been said before. However, on the other hand, every child needs to learn.

Researchers have begun to study giftedness more closely and in depth, linking the concept to science since the 16th century. First of all,

during this period, such issues as: types, signs of giftedness, the relationship of science, art and giftedness were covered.

Nowadays, there are many government programs and associations that provide gifted children in science. Thus, with the development of science and better knowledge of the world, people are increasingly aware of the definition of giftedness and characteristics of this concept.

The Chief Education Officer in the United States (Marland, 1972) insisted on the definition of giftedness through academic performance criteria. His definition was as follows: gifted and talented are children who stand out from others due to outstanding abilities and the ability to high productivity. There was a growing awareness that such children needed special educational programs in addition to those already provided by the school curriculum, in order to intellectually realize themselves. Again, it was about the strategy and tactics of development of individual children who had special tendencies to intellectual activity.

Considering the correspondence of the notion of giftedness to certain historical epochs, we conclude that modern beliefs about giftedness are the result of the evolution of various ideas. Each generation of gifted theories builds on the previous one, thus combining and synthesizing previous research, adding components of novelty that reflect current advances in science. (Kaufman & Sternberg, 2008). By the way, Alfred Binet created the first IQ test in 1905. Its goal was purely an assessment of school success, not an analysis of innate intelligence or human potential (Gardner, 1992).

Unfortunately, a large cohort of researchers, psychologists, educators, and people in general believe that IQ is a basic criterion for determining intelligence and giftedness (Sarouphim, 2004). Those scholars who oppose these views believe that such indicators do not provide sufficient basis to decide whether a child is gifted or not. After all, in this case, the IQ test serves only to test only linguistic and logical-mathematical abilities. That is, other important abilities are overlooked, such as spatial, personal, musical, and artistic skills, which may indicate a child's giftedness. Such tests do not take into account and, in fact, exclude other important factors: motivation, effort and creativity, which are key components of giftedness. Another argument why IQ tests cannot be considered as the only method of identifying giftedness is that its use has led to a significant under-representation of students from culturally diverse and economically disadvantaged groups (Clark, 1988). This can be explained by the high dependence of IQ tests on verbal skills, in which minority students often lag behind (Sarouphim, 2009).

In the modern world, scientists have come to the conclusion that giftedness is a set of giftedness and abilities that under certain conditions and circumstances allow to succeed in a certain type of activity (Petrychenko, 2011). Thus, we can say that a gifted child is one who has a natural inclination to a certain type of activity, as well as talents and a high level of development of various abilities. Such children can be developed in intellectual, creative, critical aspects and stand out with curiosity (Bandura, 2012).

Neurophysiological features are an important factor in the development of a child's giftedness. At the same time, much more recognition received another explanation. The neurobiological underpinnings of high intelligence, namely: the brain efficiency hypothesis, which predicts not so much more active, but more efficient brain functioning in highly intelligent people compared to their less gifted peers. Primary work in this context was research that measured the rate of glucose metabolism in the brain using positron emission tomography during various tasks: Raven's progressive matrices, Wechsler subtests, and the computer game "Tetris". Higher intelligence was associated with lower levels of glucose metabolism and, accordingly, brain activation. This made it possible to conclude that intelligence is not a function of the intensity of the brain's work, but its efficiency, which can be expressed in the non-use of many areas of the brain that are not needed to solve the task, as well as in the more purposeful involvement of areas necessary for this solution.

The following characteristics are characteristic of gifted children:

• high level of abilities (ability to formulate concepts, think spatially and abstractly, quickly analyze and process information, learn at a fast pace, be aware of their own development processes, independent activities, feel the need for self-study);

• intellectual curiosity or curiosity (curiosity is directly related to intellectual growth, as it is a motivating force in motivating the intellect. A child who is quite inquisitive, prone to comprehensive active contemplation of world phenomena, she has well-developed cognitive abilities);

• creative abilities (developed by adapting to changes in the search for solutions and their rapid adoption);

• ability to intense motivation (high level of personal energy, the ability to set goals and achieve them, the ability to work to achieve specific success, the desire to improve in a particular activity);

• self-criticism (constant dissatisfaction with the quality of their own work, high level of ethical development).

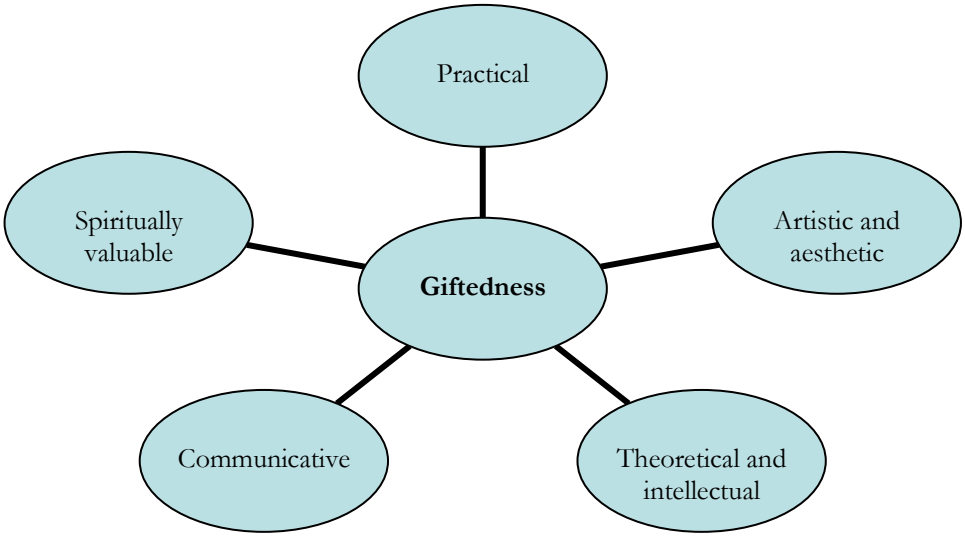

Fig.1. Types of giftedness possessed by a child (developed by the authors)

Using the above information on giftedness, we will equip a system for diagnosing the presence of special skills, abilities and aptitudes in children of different ages. Thus, in early childhood (age: 1-3 years) giftedness is manifested in restless curiosity, endless questions, the ability to concentrate on several events at once, as well as the availability of a large vocabulary. At the age of 4-7 years, a gifted child can have an excellent memory, vivid imagination, fine motor coordination, a tendency to actively explore the environment, an acute reaction to injustice. Gifted school children, about 8-17-year-old children, achieve success or high results in various activities, have a great sense of humor, developed working memory, developed logical thinking skills, emphasis on creative problem solving, building a clear image their future activities or occupations (Matiushkyn, 1989). When the adult period comes, ie after 18 years, at this time the giftedness can be evidenced by the easy assimilation of new ideas, thoughts, knowledge in general. Such children also have well-developed communication skills, inherent independence in behavior and expression of their own opinions; they do not restrain their emotions and feelings, prefer complex tasks.

Thus, understanding the theoretical evolution of etymology and the importance of the concept of gifted children, awareness of the shortcomings of the emphasis on giftedness at a particular historical stage, modern

research on characteristics, types of gifted children can best develop schemes and systems for identifying unique abilities, tendencies of children of different ages. their development at a later stage.

Neurophysiological factors in the development of a gifted personality

The results of the above studies indicate that individual differences in intelligence are associated with the variability of the brain's responses to different cognitive situations. However, intelligence, as the most studied construct, is only one aspect of the complex domain of mental abilities. Talented and gifted people are distinguished not only by a high level of logical and analytical thinking, understanding, working memory, but also by a "way of thinking". Specialists in the field of gifted psychology recognize creativity as a key component of the complex phenomenon of giftedness, although there is no agreement on the definition and measurement of creativity.

In the definition of creativity, the difference between convergent (the search for the single best solution to the problem) and divergent (the search for many solutions to the problem) thinking is often indicated, and creativity is operated using the fluency index, or the productivity of thinking, which is measured by the number of proposed ideas - solutions to a specific problem.

Perhaps because of the complexity of defining and measuring creativity, research into possible brain states associated with creative thinking has been relatively recent. Nevertheless, data on possible brain mechanisms of divergent thinking were obtained, for example, when setting the following tasks: name as many unusual ways of using ordinary objects or possible consequences of a hypothetical situation as possible. Data were obtained on the greater complexity of the EEG pattern in divergent than in convergent thinking, which, according to the researchers, indicates an increase in independent oscillations of minimal neural ensembles in divergent thinking.

According to these ideas, creative individuals are more able to move along the continuum of primary (free association, synesthesia, thinking by analogy) - secondary (abstract, logical, reality-oriented) processes, or towards the primary process, which is necessary for the creation of new, original ideas. They are also characterized by a "flat" (a large number of distant associations per stimulus) as opposed to a "steep" (a small number of trivial associations per stimulus) association hierarchy and the ability to unfocused attention - holding several objects or ideas in the mind at the same time.

The activity of the cerebral cortex in the alpha range of the EEG was recorded during the performance of verbal creative tasks: requiring an

explanation (the so-called insight problems) and two hypothetical, utopian situations. Solving a creative task was usually accompanied by lower levels of cortical excitation, that is, a stronger alpha rhythm in the period from the pre-stimulus mark to the moment of solving the problem. This task-related synchronization of alpha activity contrasts with the phenomenon of its desynchronization observed in ordinary (predominantly convergent) cognitive tasks. An increase in power in the alpha range, although not reaching statistical significance, was noted more often in the anterior than in the posterior cortex, which, according to the authors, may reflect a reduced level of excitability of neurons in the frontal regions or some "hypofrontality" when performing creative tasks. In addition, more original responses were associated with stronger increases in alpha rhythm power in posterior (semantic) cortical regions, especially in individuals with high situational anxiety. Neurophysiological studies of gifted children and adolescents remain rare.

The neurophysiological basis of the manifestations of individual characteristics of a person, in particular his intelligence, should be sought in the general properties of the central nervous system, namely in the parameters of the regulatory apparatus of the brain. This problem was widely discussed in psychophysiology in connection with the study of the correlation of psychophysiological indicators. Trends related to the mental activation of the asymmetry index of single waves of frontal lead rhythm were also revealed. The frontal lobes contain the richest bidirectional connections with many cortical and subcortical structures of the brain, including the reticular formation, which is a kind of "accumulator" for them, providing a charge of activity. Using a bipolar recording method with an original electrode scheme, the authors managed to find a significant inverse relationship between the peak latency of the visual evoked potential components in the region from 142 to 374 ms and the 1p level. Repeated studies confirmed the existence of a statistically significant negative correlation between values and latency periods of the visual evoked potential.

Thus, the research led to the creation of an original paradigm that unifies early work on the relationship between the characteristics of evoked potentials and intelligence. When processing information by the cerebral cortex, errors occur, possibly related to processes in synapses. To assess the level of fidelity of information processing, two characteristics of the evoked potential were proposed: variability and configurational complexity, which, as expected, express errors in the passage of nerve impulses in the form of smoothing of evoked potential waves.

Individual differences in the modulation of brain bioelectrical activity by new or unexpected stimuli are associated with differences in intelligence. His hypothesis is that a well-functioning brain needs fewer neurons to process familiar stimuli, while the introduction of a new stimulus causes more neurons to fire. A person with high intelligence and, accordingly, high nervous adaptability will more quickly show habituation to irritation, that is, in fact, there will be a faster extinction of the orientation response. This should be reflected in a smaller amplitude of the evoked potential. On the other hand, the same person will perceive unexpected stimuli with greater intensity, which, on the contrary, will cause an increase in amplitude.

In general, a literature review of works in the field of finding a possible connection between intelligence and neurophysiological parameters, such as the electroencephalogram and the evoked potential, shows that the latter do contain some information about the higher integrative processes of the brain. At the same time, the parameters of even "elementary" sensory evoked potentials, apparently, reflect the efficiency of the brain's system-wide activity, which at the behavioral level is expressed in the success of the test tasks in the test and constitutes psychometric intelligence.

Heuristic, in our opinion, are ideas about the connection with the accuracy and speed of information processing in neural networks, with the participation of higher coordination centers of the prefrontal cortex, with the role of activating brain systems, with the presence of specific regularities in the coordinated activity of various brain departments. The works reviewed by us are very productive in terms of the variety of theoretical and methodological approaches supported by relevant research. It is very remarkable that in psychophysiological studies of intellectual giftedness there is a clear turn from a purely phenomenological approach, when only the facts of the detection of electroencephalogram features or evoked potentials in people with high intelligence are established, to a fundamental approach that includes hypotheses about the physiological mechanisms of the phenomenon of intellectual giftedness.

However, it must be stated that the level of development of the problem of psychophysiological correlates of intellectual giftedness is currently at the stage of producing and testing various hypotheses, each of which mainly affects a certain limited field of application. We have to admit that the task of diagnosing the level of intelligence by psychophysiological indicators is still very far from being solved and, accordingly, used in the everyday work of a psychologist.

Nevertheless, the use of simple stimuli is not devoid of meaning for the diagnosis and prognosis of the intellectual development of young children. Modern researchers note that "underdevelopment of "lower" zones inevitably causes underdevelopment of higher, superstructure formations as a secondary systemic effect.

Methods of working with gifted children and methods of development of their unique aptitudes and skills

At this stage, we move directly to the stage of applying different methods of giftedness in children of different ages.

First of all, it should be noted that for the development of giftedness in children it is necessary to build their education and upbringing on the basis of diagnostic tests (Iliichuk, 2013).

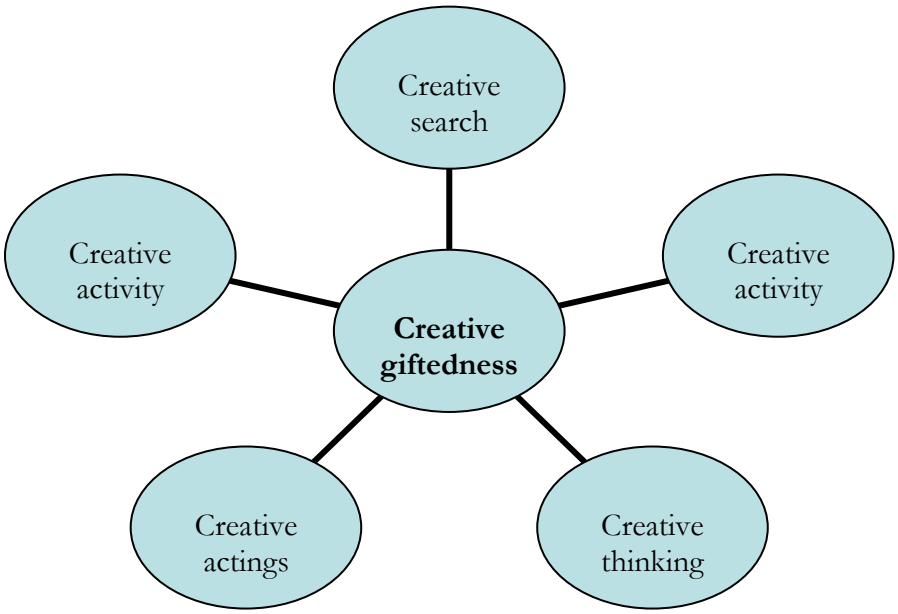

Fig.2. Methods of developing the creative component of giftedness (developed by the authors)

In the context of methods for improving giftedness, it should be understood that the process of development and improvement should take place with the full support of parents, teachers, psychologists. In general, only combined activities can lead to positive results.

Thus, taking into account the intellectual talent, it is necessary to constantly demonstrate friendliness and promote the aspirations and ambitions of gifted children in this specialization (Panov, 2001). It is also important to be flexible and able to make concessions to such children who also show exceptional leadership qualities. It is worth remembering that when working with a gifted child, you need to take into account the peculiarities of his psychosocial behavior (Chernyshov, 2010). The focus of psychophysiological studies of intellectual giftedness should be focused on the study of the already largely formed system of structures of higher functions. At the same time, it is necessary to remember that in the implementation of behavior and higher forms of conscious activity, not specific structures are important, but their coordinated ensemble - a functional system.

The main principles of development of gifted children are:

• the principle of maximum diversity of activities for personal development and better self-knowledge;

• the principle of increasing extracurricular activities to improve various aspects;

• the principle of individuality and differentiation, which is one of the basic;

• the principle of fruitful interaction of children in their environment without the participation of the teacher for the development of team traits;

• the principle of free choice of activity for the development of decision-making techniques.

However, given that the teacher spends a long time with children and has some training, we can say that teachers to successfully work with gifted children of all ages must be:

• interested in their own activities;
• capable of experimental, creative and scientific activities;
• sufficiently erudite;
• connoisseur of all spheres of human life;
• psychologist and just a close friend to his wards;
• skilled organizer of the educational process.

The most common and effective activities in terms of improving the various abilities and aptitudes of children are:

• creative clubs;
• group classes;
• competitions;
• scientific and practical conferences;
• participation in competitions;

• interest groups.

Thus, it can be stated that the study of intelligence and creativity as components of giftedness using neurophysiological methods, despite the persistent ambiguity of the results, continues to attract both foreign and domestic researchers. In general, most of the data support the hypothesis of greater brain efficiency in individuals with a high level of intelligence.

At the same time, the desynchronization of rhythms, primarily the alpha rhythm, as well as the topographic patterns of activation during the performance of intellectual activity may differ depending on the gender and age of the subjects, their ability profile, the type and complexity of those presented during the registration of the task. The resource hypothesis of intellectual giftedness finds its confirmation much less often.

Conclusions

A study was conducted in order to form an effective mechanism for identifying the giftedness of children and its development. To do this, the existing theoretical basis on this issue was analyzed. The views of various scholars on the definition and interpretation of the very concept of giftedness are reviewed. These views directly influenced the very approaches to identifying unique traits and abilities, methods of working with gifted children. If most of the time it was popular to associate the concept of giftedness directly with the level of intelligence and only this explained it. As a result, only a small cohort of children who achieved some success only in the field of science was considered special. Now this worldview is changing in the direction of individualization and differentiation, which, in my opinion, is correct. After all, each child according to the list of gifted children has a certain uniqueness. Teachers, psychologists and parents need to do their daily work to develop it.

Teachers should take an individual approach to each child in order to reveal their potential to the maximum. Various creative, intellectual activities must be created so that the child can realize what is closest to him. Instead, educators, knowing a number of characteristics of gifted children of different ages, should build their work in such a way as to learn as much as possible about the giftedness of everyone.

Ideas about the neurophysiological features of high creativity are even more complex and ambiguous. It is about differences in reactions during the performance of various creative tasks (verbal and figurative, simple and complex, divergent and associative), at different stages of solving the task and in people with different levels of creativity. Nevertheless, the results of research conducted in this field indicate that the features of

activation reflect not only different levels of intellectual and creative abilities, but also the level of academic success. This indicates that, in the long term, neurophysiological studies of giftedness can help identify the causes of academic failure of gifted students and develop ways to overcome difficulties that prevent the realization of their high creative potential.

The novelty of this article is the shift of emphasis towards the individualization of the process of determining the giftedness of children and taking into account the diversity of types of giftedness. That is, not only a child who is successful in intellectual activities is gifted, but also one who is successful in creative fields, has an impressive memory, who can serve as a helper in various activities, and so on. As a result, the methods of identifying and developing children's giftedness are directly related to the characteristics of each individual and his psychological state.

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Authors 3, 4 – collection of materials and writing of the section Neurophysiological factors in the development of a gifted personality.

Authors 5, 6 – collection of materials and writing of the chapter Methods of working with gifted children and ways of developing their unique tendencies and skills.

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