FEATURES OF THE PERFORMANCE OF COGNITIVE AUDITORY 
EVOKE POTENTIALS BY ADOLESCENTS WITH 
INTELLECTUAL DISABILITIES

INTRODUCTION

A sharp increase in the requirements of society and the state to the level and quality of mental development of the younger generation is forcing specialists in various fields of knowledge: biologists (ROMANOVA, 2016; DUGNIST et al., 2017), electrophysiologists (KOSTINA, 2002), preschool teachers (CHISTYAKOVA, LAPSHINA, 2016), university professors (MAKUNINA, 2017) and correctional schools (LAPSHINA, 2008) to revise the key concepts of modern social reality, such as «health», «development»; «philosophy of health» (TOMLIN, 2017), «healthy lifestyle», «health-saving technologies» (ROMANOVA, 2016; 2017).

Today, the term «health» ceases to be exclusively medico-biological (ROMANOVA, 2016; DUGNIST, MILKHIN, GOLOVIN, ROMANOVA, 2017), shifting the emphasis from the psychological and pedagogical aspect (CHISTYAKOVA, LAPSHINA, 2016; LAPSHINA, 2018; CRISTIÁN OYANADEL Y GUALBERTO BUELA-CASAL, 2017) to study of the possibility of the child to withstand and qualitatively perform the amount of intellectual activity determined by FSES. Therefore, study of the features and mechanisms of mental development of children with disabilities – limited opportunities of health (LOH) - (LAPSHINA, 2009; 201; WENXIN XU, ZIJIAN ZHAO, MENGJUAN CENG Y JIWEI YAO, 2018) is considered as a priority area of comprehensive study of the child’s organism for organize effective support of their education and development.

At this aspect, a group of adolescents with intellectual impairment (intellectual disabilities) is a particular interest, and, above all, those parameters of their mental development that allow a deeper understanding of the mechanisms for carrying out intellectual activity. For deciding this problem, the study of special mechanisms of cognitive operations by pupils with intellectual disabilities is seen as a priority (LAPSHINA, 2008; 2009; 2016; 2018) at the process of dosed mental load (ALTMAN, 2003; YAKOVENKO, 2003; DOROKHOV, 2009). Thus, the subject of this study is very topical.

MATERIALS AND METHODS

The purpose of this study was to empirically identify and theoretically substantiate the features of the amplitude-time characteristics of the P1 wave of cognitive AIP the adolescents, having intellectual disabilities (diagnosis F10) during they get cognitive activity.
1. In the course of comparative analysis of amplitude-time indicators of AIP of adolescents with normal mental development and adolescents with intellectual disabilities, it is assumed to identify and describe highly informative indicators of features of intellectual activity at age norm.

2. In the course of comparative analysis of amplitude-time indicators of AIP of adolescents with normal mental development and intellectual disabilities, it is assumed to identify and describe the features of intellectual activity in case of intellectual retardation.

3. Justification the features of amplitude-time indicators of AIP the adolescents with intellectual disabilities when they carry out intellectual activity as one of the possible mechanism of intellectual disabilities.

Achievement of the main purpose of the study was due to the use of a combination of adequate and highly informative research methods – method of analysis of obtained data; retrospective analysis of scientific and periodic literature, results of own, conducted earlier, neurophysiological study (LAPSHINA, 2008; 2009; 2016); content-analysis of materials from scientific events at various levels from international to regional (scientific and practical conferences, symposia and meetings on the problem of research); methods of primary mathematical processing; free description method; diagnostic methods of data collection.

The study was based on international principles (CASTALDELLI-MAIA, BHUGRA, 2020), standards and research methods SQUIRE Standards for Quality Improvement Reporting Excellence (OGRINC et al., 2015); STARD statement for reporting diagnostic accuracy studies (BOSSUYT et al., 2015), AGREE reporting checklist to improve reporting of clinical practice guidelines (BROUWERS, et al., 2015); CONSORT statement for reporting randomized controlled trials (SCHULZ et al., 2010); COREQ consolidated criteria for reporting qualitative research (TONG, et al., 2007).

The research is based on a pedagogical experiment and on the P300 methodology (ZENKOV, 2013). Analysis methods were applied to the results of a neurophysiological examination of the state of the cerebrospinal system of two groups of schoolchildren 13-14 years old:

- the first group - the examination group (EG) - 26 pupils of correctional school for pupils with intellectual disabilities No. 119 of Chelyabinsk were observed; all examined had a diagnosis of F70 (intellectual disabilities);

- the second group - the control group (CG) was made up of 22 pupils of the School No 112 of Chelyabinsk; these children, according to the results of a psychological examination, had a level of mental development within the age norm.

The work done does not infringe on the rights and does not jeopardize the well-being of adolescents in accordance with the ethical standards of the Committee for the Rights of Experiments of the Helsinki Declaration (WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects). Parental consent to examine children was obtained. The experimental study was organized at the basis of the functional diagnostics department of the School No 1 of Chelyabinsk.

We used the P300 diagnostic method. The P300 technique is a cognitive evoked potentials technique (ZENKOV, 2013). This technique is necessary for the assessment of cognitive disorders in the clinical and preclinical stages, the dynamics of cognitive responses during treatment. The P300 technique is used to assess the severity of dementia of various origins and early preclinical detection of cognitive impairments, to assess brain function in children with problems of behavior, attention, and learning. Also, the method is used in professional selection and assessment of side effects of drugs. It is used in both adults and children. The P300 technique is based on the delivery of a series of various stimuli (sound, visual), among which significant and insignificant stimuli are given. The subject must respond to significant stimuli. A significant stimulus differs from an insignificant one in certain characteristics, it is served among a large number of insignificant ones in a random order, it needs to be identified and counted. Thus, the endogenous processes in the brain associated with the recognition of...
the stimulus, its processing and storage in memory are distinguished and analyzed. Before starting the test, the doctor will place several electrodes on the head. The doctor will give the patient instructions on what to do during the exam. After the study, the doctor will analyze the results and determine the conclusion.

Electroencephalography (EEG) is a highly informative method for diagnosing the state of the nervous system, based on the registration of bioelectric potentials of the cerebral cortex in the course of its vital activity. Registration of EEG, auditory induced potentials was carried out on the Neuron-Spectrum-4, 4 VP multichannel electroencephalograph of NeuroSoft (Russia) according to the standard P300 methodology traditionally used to evaluate cognitive impairment; and to assess brain activity in the situation of performing cognitive tasks in children with disabilities caused by organic and functional Cerebrospinal System dispositions.

The P300 technique was used in the situation of an «accidental event» («oddball» paradigm). Auditory stimulation was performed with the presence of separate triggers for triggering and averaging rare (significant) stimuli - tone clicks (filling frequency 2000 Hz) and frequent (insignificant) auditory stimuli - clicks with filling frequency 1000 Hz. Stimuli were delivered binaurally in a random sequence with a probability of appearance: 70% for insignificant stimuli and 30% for meaningful stimuli.

Pupils were asked to consider only significant, rare stimuli. To record the results, monopolar leads C3-M1 and C4-M2 were used according to an international system of 10-20%, with the location of the grounding electrode at the point Fpz. EEG registration was performed to 16 channels (bandwidth 0.5 to 70.0 Hz, sensitivity 100 μV/d.). The electrodes were arranged according to an international system of 10-20%. Each patient was in a soundproofed room in a state of calm waking with his eyes closed, when registering IP.

This study focused on changes in the P3 component in frontal leads. Diversions of F3, F4 were chosen as the most informative for the study of long-latent components of induced potentials in the cognitive activity of a child (DOROSHENKO, 1994; NAATANEN, 1990; CAMPBELL, 2002). Such a sample of study participants and a set of methods used allows us to substantiate the amplitude-time indicators of AIP of adolescents with intellectual disabilities as one of the specific mechanisms for carrying out intellectual activity in intellectual disabilities (LAPSHINA, 2008).

RESULTS

The results of studying the amplitude-time characteristics of the P3 wave in the CG of adolescents with normal mental development presented at the table 1.

Table 1. Amplitude-time characteristics of the P3 wave in the CG of adolescents with normal mental development (n=22)

|                    | Right hemisphere of the brain, diversions F4 | Left hemisphere of the brain, diversions F3 |
|--------------------|---------------------------------------------|--------------------------------------------|
|                    | Insignificant stimuli | Significant stimuli | Insignificant stimuli | Significant stimuli |
| Amplitude, mcV     | 11,47±1,36          | 13,26±1,17*         | 13,96±1,12          | 15,57±1,84*         |
| Latency period, ms | 308,15±21,65        | 445,81±35,17*       | 321,72±22,44        | 372,29±27,56*       |

Source: Search data.

Analysis of the results of studying the amplitude-time characteristics of the P3 wave in the CG of adolescents with normal mental development shows that all the parameters studied are within the age norm (ALTMAN, 2003; DOROSHENKO, 1994) both in the situation of identifying insignificant incentives and in the situation of drawing attention to a significant incentive. This feature concerns the structures of both the right and left hemispheres. When moving from identifying insignificant stimuli to significant ones in adolescents with a developmental norm, there is a statistically significant (p ≤ 0.5) increase in the amplitude characteristic of the P3 wave along with an increase in the latency of its period.

This trend most pronounced in the right hemisphere of the surveyed, although a statistically reliable difference is observed in the studied characteristics of the left hemisphere. It is very
interesting, that the time parameters of the wave P3 in the CG are predominantly represented in the long-wave range P3 (P4v – range).

It should be noted that the quality of the task in the CG was high: 86,37% of pupils (19 people) coped with the task on an absolute indicator, that is, they correctly counted the number of significant incentives - 30. Only 3 people made mistakes, but the number of such errors did not exceed 3% of the total number of 100 incentives presented. It is interesting to note that the maximum number of incorrectly allocated signals (3) in the entire sample allowed only 1 teenager and 2 adolescents made mistakes by 2 clicks - one to increase the number of significant signals and one to decrease them (LAPSHINA, 2008). Absolutely different pattern is observed at a group of adolescents with intellectual disabilities (ID). The results of studying the amplitude-time characteristics of the P3 wave in the CG of adolescents with ID presented at the table 2.

Table 2. Amplitude-time characteristics of the P3 wave in the CG of adolescents with intellectual disabilities (n=26)

| Source: Search data. |
|----------------------|
| Analysis of the results of the study of amplitude-time characteristics of the P3 wave shows that all the parameters under study, although they do not go beyond the limits of possible critical absolute indicators, are nevertheless statistically significantly less than in the CG (p ≤ 0,5). It should be noted that the spread of individual latency indicators is characterized by a larger spectrum than the amplitude spread (YAKOVENKO, 2003; DOROKHOV, 2009). The latent period and the identification of a significant stimulus with ID as a whole is significantly shorter, than in the CG (NAATANEN, 1990).

It is interesting to note the fact that the latences of P3 waves at ID are shifted towards the short ranges of the component P3 (P4v), and the quality of the cognitive task performed can be estimated as low. The characteristic «quality of the completed task» should be stopped specially. The first, it is the resulting final; the second, there are the most significant discrepancies with the CG (CAMPBELL, 2002).

19,25% adolescents with ID – (5 people) coped with the proposed task for an absolute result. The most pupils (21 people) made mistakes; the range of absolute indicators of which ranged from 8 to 57. We exclude understanding the task (the teacher worked taking into account the specifics of the methodological component of teaching mentally retarded schoolchildren (LAPSHINA, 2008; 2018): the task was clearly explained to children, followed by checking his understanding through suggestive questions). We allow the possibility of reducing the quality of their differentiation of sound signals. This feature is one of the characteristics of the decrease in intelligence. It is a consequence of the underdevelopment of the cortex of the large hemispheres, especially its highly specialized zones, caused by early organic damage to the Cerebrospinal System at intellectual disabilities. However, such a significant number of errors made by pupil's ID should have sufficiently clear psychophysiological mechanisms - mechanisms of the identity of brain activity in performing cognitive tasks (LAPSHINA, 2009; 2016). Today is the most common view that particularly sensitive to stimuli with varying significance components of the P3 wave of AIP in frontal lobes (CAMPBELL, 2002). According to the research of D.A. Farber et al. (1982), the age of seven, the activity of the frontal cortex increases dramatically, which in a situation of attention attraction (in our study this attraction of attention to a significant stimulus) leads to a significant change in the late components of IP in non-projection zones. This fact reflects the optimal involvement of these departments to the given activity (YAKOVENKO, 2003). The participation of the cortical associative zones in cognitive activity ensures a good quality of its performance at the age of seven years already. A quantitative measure of the implementation of the described intelligent load mechanism, according to some authors (NAATANEN, 1990), will be a change in the amplitude of the P3 wave component to significant stimuli to a greater extent than to insignificant ones. The rates
of adolescents, having intellectual disabilities, at our study coincide with the above-described pattern. The whole complex of amplitude-time characteristics of the $P_3$ wave at the CG, corresponding to the age norm (FARBER, 1982; LAPSHINA 2008) indicates the functional maturity of the bark of adolescents with normal development (LAPSHINA, 2008). Together: this fact, and the qualitative doing of a cognitive task, and the normal mental development of CG, it allows us to consider this complex as a psychophysiological correlate of normal intellectual development (LAPSHINA, 2009; 2016).

Another characteristic of the amplitude-time organization of the frontal lobes of the cortex when identifying a significant stimulus in the CG is the displacement of the main peak of the $P_3$ wave into the long-wave range. Given the functional role of component $P_{3b}$ at the cognitive organization (ALTMAN, 2003), said displacement of latent periods of the $P_3$ wave at adolescents of the CG into this range indicates a rather complex organization of cognitive function at the normal development of the child.

The results of the study in ID have their own features. The amplitude-time characteristics of $P_3$ waves that differ in ID and CG can be explained as terms as «structural-functional features» of the hemispheric cortex adolescents with intellectual disabilities.

The revealed features of the reaction of the frontal lobes the cortex to the appearance of a significant stimulus, namely: the absence of a reliable increase the latency time for its analysis, the absence of interhemispheric asymmetry during the processing of information about a significant stimulus - can be interpreted as the non-formation of the component composition of AIP, which is observed with morpho-functional immaturity of brain systems (LAPSHINA, 2009; 2016).

**DISCUSSIONS**

Analyzing the results of the study of amplitude-time parameters of the $P_3$ wave in ID, it should be noted that the data of this study are consistent with the results of their own clinical-psychological study (LAPSHINA, 2018), conducted relatively recently.

As part of the psychological aspect, these results of latency indicators of the right and left hemisphere can be explained by the «primitiveness of the primary sensory analysis of the stimulus» (term M. N. Fishman), carried out in the structures of the right hemisphere of adolescents with impaired intelligence - carried out at a qualitatively insufficient level. It is the relatively short time taken by the right hemisphere to analyze the relevant stimulus that is an indicator of the primitivity of the primary sensory analysis. Possibly, this primitivity of the primary sensory analysis complicates the qualitative final analysis carried out in the left hemisphere. This situation is due to the need for more time on the brain organization of such complex cognitive functions as comparison and differentiation. These cognitive functions - comparison and differentiation - are the base of differentiation the significant and insignificant signals. The processing of the significant and insignificant signals to doing definitively at the left hemisphere. At the AIP- schedule drawing, this result can obviously be expressed in the appearance of interhemispheric asymmetry when processing a significant stimulus (ALTMAN, 2003; DOROSHENKO, 1994), which is observed in the CG and was not found at the ID.

It is very interesting, that the latences of the $P_3$ waves at the ID are shifted towards the short ranges of the component $P_3$ ($P_{3b}$). Given the importance of the $P_{3b}$ wave at the organization of cognitive activity (DOROKHOV, 2009), it can be assumed two facts: the first - that it is the lack of primary processing of sensory information at the cortex of the right hemisphere. Obviously, that it is one of the mechanisms for reducing the quality of cognitive function at an intellectual disability. The second - the latency $P_{3b}$ wave in frontal leads - psychophysiological indicator of this process.

Some authors (NAATANEN, 1990; CAMPBELL, 2002; YAKOVENKO, 2003) note, and the results of our own studies are consistent with them (LAPSHINA, 2008; 2009; 2016; 2018): along with the fairly pronounced underdevelopment of the cortical departments of the right hemisphere the adolescents with intellectual disabilities. Also these results confirm violations of the structural and functional organization of the crust of the left hemisphere - the biological substrate of logical thinking.
As a result, the brain provision of the cognitive function of isolating a significant stimulus the adolescents with intellectual disabilities has a different organization, then adolescents with normal intellectual development. During this type of brain activity, the structures of the left frontal cortex are involved in integrative activity in a much smaller volume, which is observed normally.

Another result of this «peculiar» functional brain organization is a decrease the quality of cognitive work performed - the appearance of a large number of errors when differentiating signals presented for hearing.

CONCLUSION
1. At the group of adolescents with normal mental development during cognitive function – the isolation of a significant stimulus according to the P300 method - a statistically reliable (p≤0.5) increase in latency and wave amplitude P3 in frontal leads is observed.

2. At the group of adolescents with intellectual disabilities during cognitive function – the isolation of a significant stimulus according to the P300 method - an increase in latency and amplitude P3 wave are not observed in frontal leads.

3. At the group of adolescents with intellectual disabilities, the latency indicators of the wave P3 do not shift towards the long-latent component of the wave – P3b. Perhaps this is a characteristic of performing intellectual tasks in case of intellectual disabilities.

4. The absence of bias towards the long-latent component of the wave - P3b auditory induced potentials when performing intellectual tasks at a group of adolescents with intellectual disabilities is possibly one of the neurophysiological mechanisms of intellectual disabilities.

5. At the group of adolescents with normal mental development, the indicators of wave latency P3 shifted towards the long-latent component of the wave - P3b, which is an indicator of the more complex brain organization of cognitive activity. Obviously, this is one of the conditions for the qualitative performance of cognitive activity – choice of a significant stimulus.

CONFLICT OF INTERESTS
The authors declare no conflict of interest.

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Features of the performance of cognitive auditory evoked potentials by adolescents with intellectual disabilities

Características del desempeño de potenciales cognitivos evocados auditivamente por adolescentes con discapacidad intelectual.

Resumo
O artigo informa sobre os resultados do estudo teórico-prático sobre as características da implementação da carga cognitiva por adolescentes com deficiência intelectual. O envolvimento do sistema cerebroespinal e, em particular, do cérebro, no desempenho da carga cognitiva foi determinado usando o método P300 padronizado de potenciais evocados, tradicionalmente usado para detectar deficiências cognitivas e avaliar a função cerebral em crianças com problemas de comportamento, atenção e aprendizagem. Como resultado do experimento, foi demonstrado que com carga cognitiva normativa - a alocação de estímulos significativos - ao grupo de adolescentes com desenvolvimento intelectual normal, foi observada uma mudança estatisticamente significativa na amplitude e latência da onda P3. No grupo de adolescentes com deficiência intelectual esses resultados não foram revelados. Recomendações. Os autores desenvolveram métodos pedagógicos de trabalho com adolescentes com deficiência intelectual.

Palavras-chave: Adolescentes com deficiência intelectual. Desenvolvimento intelectual prejudicado. Potenciais acústicos provocados. Carga intelectual.

Abstract
The article informs about the results of theoretical and practical study the features of the implementation of cognitive load by adolescents with intellectual disabilities. The involvement of the cerebrospinal system and, in particular, the brain, in the performance of the cognitive load was determined using the standardized P300 method of evoked potentials, traditionally used to detect cognitive impairments and assess the brain function in children with problems of behavior, attention, and learning. As a result of the experiment, it was shown that with normative cognitive load - the allocation of significant stimulus - at the group of adolescents with normal intellectual development, a statistically significant change in wave amplitude and latency was observed P3 wave. At the group of adolescents with intellectual disabilities these results were not revealed. Recommendations. The authors have developed pedagogical methods of working with adolescents with intellectual disabilities.

Keywords: Adolescents with intellectual disabilities. Impaired intellectual development. Acoustical caused potentials. Intellectual loading.

Resumen
El artículo informa sobre los resultados del estudio teórico y práctico de las características de la implementación de la carga cognitiva por parte de adolescentes con discapacidad intelectual. La participación del sistema cerebroespinal y, en particular, del cerebro, en el desempeño de la carga cognitiva se determinó mediante el método estandarizado P300 de potenciales evocados, tradicionalmente utilizado para detectar deterioros cognitivos y evaluar la función cerebral en niños con problemas de conducta, atención y aprendizaje. Como resultado del experimento, se demostró que con la carga cognitiva normativa, la asignación de estímulos significativos, en el grupo de adolescentes con desarrollo intelectual normal, se observó un cambio estadísticamente significativo en la amplitud de la onda y la latencia de la onda P3. En el grupo de adolescentes con discapacidad intelectual estos resultados no fueron revelados. Recomendaciones. Los autores han desarrollado métodos pedagógicos para trabajar con adolescentes con discapacidad intelectual.

Palabras-clave: Adolescentes con discapacidad intelectual. Desarrollo intelectual dañado. Potenciales acústicos provocados. Carga intelectual.