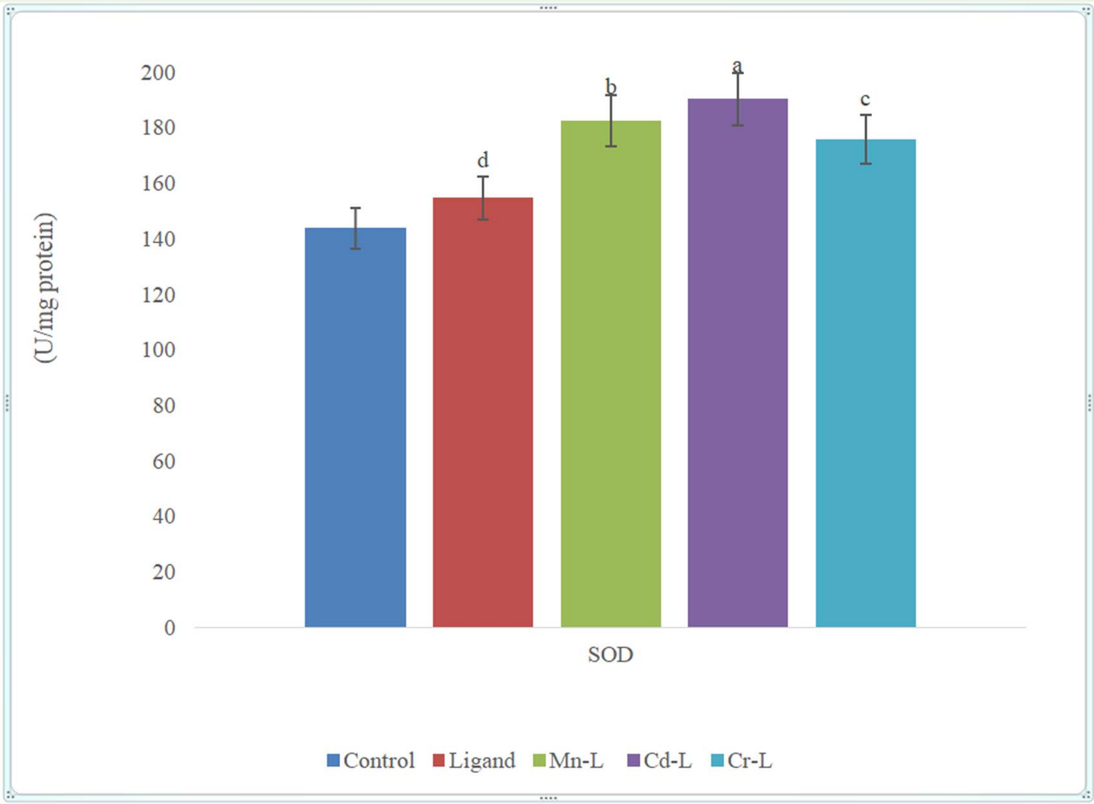
E-ISSN: 2149-7222 (Online)

Journal Cellular Neuroscience and Oxidative Stress

http://dergipark.gov.tr/jcnos

Former name; Cell Membranes and Free Radical Research



OPEN ACCESS and
NO PUBLICATION FEE

Editor in Chief
Prof.Dr. Mustafa NAZIROĞLU

Volume 11, Number 1, 2019

Journal of Cellular Neuroscience and Oxidative Stress

http://dergipark.gov.tr/jcnos

BSN Health Analyses, Innovation, Consultancy, Organization, Industry and Trade Limited Company

http://www.bsnsaglik.com.tr/

info@bsnsaglik.com.tr

Formerly known as:

Cell Membranes and Free Radical Research (2008 - 2014)

Volume 11, Number 1, 2019

[CONTENTS]

797 Relationship between some element levels and oxidative stress parameters in rats liver treated with hydroxyurea derivative compounds
Yusuf Karagozoglu, Akif Evren Parlak, Naci Ömer Alayunt, Semra Turkoglu, Isil Yildirim, Mustafa Karatepe

805 Neurophysiological Mechanisms of Regulation of Sensorimotor Reactions of Differentiation in Ontogenesis
Lizohub Vladimir Sergeevich, Chernenko Nataliia Pavlovna, Ahmet Alperen Palabiyik

815 Pregabalin protected cisplatin-induced oxidative neurotoxicity in neuronal cell line
Kemal ERTILAV

Volume 11, Number 1, 2019
E-ISSN Number: 2149-7222 (Online)
Indexing: Google Scholar, Index Copernicus, Chemical Abstracts, Scopus (Elsevier), EBSCOhost Research Database, Citation Index Database,

AIM AND SCOPES

Journal of Cellular Neuroscience and Oxidative Stress is an online journal that publishes original research articles, reviews and short reviews on the molecular basis of biophysical, physiological and pharmacological processes that regulate cellular function, and the control or alteration of these processes by the action of receptors, neurotransmitters, second messengers, cation, anions, drugs or disease.

Areas of particular interest are four topics. They are;

A- Ion Channels (Na^{+}- K^{+} Channels, Cl^{-} channels, Ca^{2+} channels, ADP-Ribose and metabolism of NAD^{+}, Patch-Clamp applications)

B- Oxidative Stress (Antioxidant vitamins, antioxidant enzymes, metabolism of nitric oxide, oxidative stress, biophysics, biochemistry and physiology of free oxygen radicals)

C- Interaction Between Oxidative Stress and Ion Channels in Neuroscience
(Effects of the oxidative stress on the activation of the voltage sensitive cation channels, effect of ADP-Ribose and NAD^{+} on activation of the cation channels which are sensitive to voltage, effect of the oxidative stress on activation of the TRP channels in neurodegenerative diseases such Parkinson's and Alzheimer's diseases)

D- Gene and Oxidative Stress
(Gene abnormalities. Interaction between gene and free radicals. Gene anomalies and iron. Role of radiation and cancer on gene polymorphism)

READERSHIP

Biophysics	Biochemistry
Biology	Biomedical Engineering
Pharmacology	PhysiologyGenetics
Cardiology	Neurology
Oncology	Psychiatry
Neuroscience	Neuropharmacology

Keywords
Ion channels, cell biochemistry, biophysics, calcium signaling, cellular function, cellular physiology, metabolism, apoptosis, lipid peroxidation, nitric oxide, ageing, antioxidants, neuropathy, traumatic brain injury, pain, spinal cord injury, Alzheimer's Disease, Parkinson's Disease.

RESEARCH ARTICLE

J Cell Neurosci Oxid Stress 2019;11(1): 805-814.

Neurophysiological Mechanisms of Regulation of Sensorimotor Reactions of Differentiation in Ontogenesis

Lizohub Vladimir SERGEEVICH[1], Chernenko Nataliia PAVLOVNA[1], Ahmet Alperen PALABIYIK[2*]

[1] *The Bohdan Khmelnytsky National University of Cherkasy, Educational-Scientific Instutue of Physical Culture, Sport and Health, Cherkasy, Ukrainian.*

[2*] *Department of Nursing, Faculty of Health Sciences, Ardahan University, Ardahan, Turkey*

Received 23 August 2019 ; ***Accepted*** 30 August 2019

Abstract

The amplitude-frequency characteristics of the late and early components of brain- evoked potentials (EP) and the speed of motor (MK), central (central information processing (CIP) and sensory (SC) component of the reaction of choice 2 from 3 stimuli (RC_{2-3}), presented in mode go/nogo/go investigated in children, teenagers and young people. It was found that the formation of sensorimotor reactions of differentiation in children, teenagers and young people is characterized by a gradual decrease in the quantities of mistakes and time of RC_{2-3}, MK, SC, CIP, also latency and an increase in amplitude the evoked potential (EP). In children was invented simultaneous activation of the early (N_1, P_1, N_2, P_2) and deactivation of late (P_3) EP of the cerebral cortex and significant more mistakes and lower speed of RC_{2-3}, MC, SC, CIP which indicates the presence of cortical-subcortical dysfunction of the sensor-motor system. In young people high speed of RC_{2-3}, MC, SC, CIP and a smaller quantities of mistakes coincided with short latencies and a high amplitude of inter- peak intervals N_1-P_2 and P_2-N_2 and P_{300}. The results testify the formation of neurophysiological mechanisms of sensory-motor differentiation reactions happens with participation, mainly, of the early (N_1, P_1, N_2, P_2) components of children whereas late components of the EP (P_3) are more actively involved in young people.

Keywords: Ontogenesis, paradigm go/nogo/go, sensory motor, central components of the reaction, evoked potential, amplitude and latency of P_{300}.

***Author for correspondence :**
Ahmet Alperen Palabıyık
Department of Nursing, Faculty of Health Sciences,
Ardahan University, Ardahan, Turkey.
Tel: +90 544 614 13 03
E-mail: aalperenp@hotmail.com

List of Abbreviations;

EP, evoked potentials; **MC**, component of motor; **CIP**, central information processing; **SC**, sensory component; **RC_{2-3}**, reaction of choice 2 from 3 stimuli; **EP**, evoked potential; **Ms**, millisecond;

Introduction

In recent years much attention is given to the problems of neurosensory integration, functional connections of the sensory and motor zones of the cerebral cortex (Ivanitsky, 2015; Yakovenko et al., 2004; Satterfield et al., 1994). Neurosensory integration is investigated in the task of differentiating complex sensorimotor reactions during processing of data in a two-simulation test go/nogo (Kuptsova et al., 2016; Yakovenko et al., 2004), that is, the ability of the brain to deliberately and quickly switch attention between stimuli, and in the three-step test go/nogo/go when the test is done with two hands (Lizohub et al., 2018a, 2018b, 2018c). For studying the neurophysiological mechanisms of selection of actions it uses tasks with random presentation of signals – go, that require action and nogo – inhibit the motor act. The examine must not only switch attention, but also make the motor acts with both left and right hand or inhibit such reactions in the go/nogo/go mode.

In organizing a complex reaction of differentiation in the go/nogo/go mode researchers identify several important milestones: signal detection, decision making process and the implementation of the motor response (Gould, 2009). At the beginning, evaluation of the functional organization of neurosensory integration during processing of information in the go/nogo/go mode was carried out by indicators of latent periods $RC_{2\text{-}3}$ and later was used sensory (SC), motor (MK) and central (CIP) components of such reactions (Makarenko et al., 2014; Makarenko et al., 2011).

Scientists note significant difficulties in understanding the functional organization of neurosensory integration and interpretation of the results have obtained during researching of processing information in the go/nogo/go mode. Neurophysiological and psychophysiological researches have shown that the quantity of mistakes, time of reactions and influence of interferences on the managerial functions of the brain decrease with age (Lizohub et al.,2018; Okhrei et al., 2016; Rovny and Lyzozhub, 2016; Bondarenko et al., 2016).

It is noted, the state of the central component of sensorimotor differentiation reactions and clarification of its brain neurophysiological mechanisms during processing of information in the go/nogo/go mode is one of the most difficult problems of physiology (Makarenko et al., 2011; Monastra et al., 1999; Riccio et al., 1993).

Traditionally, component composition of EP is used for explaining the brain mechanisms of complex sensory-motor reactions as objective criteria of research (Gnezditsky and Shamshinova, 2013; Bazanova, 2010; Beleteleva and Sinitsin, 2008).

The focus is specifically onthe early and late components of EP which arise in response to stimuli that rarely appear and require an appropriate reaction.

At the same time, there are conflicting data in the literature regarding to the change of the amplitude and latency of the early and late components of EP in ontogenesis. Some authors point out that the difference in amplitude and latency of components of P_3 for children and adults is absent (Satterfield et al., 1994), others have found significant differences in the change towards lower amplitude of the component P_3 for children (Karayanidis et al., 2000).

Increasing of the latency of the P_3 wave was detected for children compared with older examinees (Jonkman et al., 2000; Linden et al., 1996).

In some of the works it was found decrease the latency of the early components of EP for children compared with older age groups of teenagers and young people (Lizohub et al., 2018; Karayanidis et al., 2000; Jonkman et al., 2000; Satterfield et al., 1994). Thus, it must be stated that brain mechanisms of neurosensory integration during processing of information in the mode of go/nogo/go for people of different ages have not been disclosed yet.

The question of neurophysiological mechanisms of sensorimotor integration at different stages of ontogenesis is still controversial. Are these changes due to plasticity at the sensory and motor level or these processes include the higher parts of the central nervous system. The hypothesis is proposed for a structural-functional heterochrony in the formation of neurophysiological mechanisms of integration of complex differentiation reactions in ontogenesis (Korobeinikova et al., 2016; Makarenko et al., 2011).

Taking into account the above mentioned, it would be logical to assume that children and teenagers maybe have different peripheral and central neurophysiological mechanisms of regulation, which also have different for older examinees during the processing of complex visual information. In this regard, the purpose of the research was to reveal age-related features of neurophysiological mechanisms of regulation of sensory-motor differentiation reactions and processing information in the go/nogo/go mode for children, teenagers and young people.

Organization and methods of research

The study was conducted in accordance with the Helsinki Declaration (adopted in Helsinki, Finland, in 1964 and revised in October 2000 in Edinburgh, Scotland) and approved by the Ethics Committee of the Cherkasy National University.

Evoked brain activity was investigated according to indicators EP and also investigated speed and qualitative characteristics of differentiation of visual information in the mode go/nogo/go with using a set of instrumental examination methods in 27 children 8-9 years old, 40 teenagers 12-13 years old and young people 18-20 years old. The research and evaluation of speed and qualitative characteristics of visual information processing was carried out on a computer system according to the specially developed method and program "Diagnostic-1M" (Makarenko et al., 2014). The differentiation reaction in the three-stimulus paradigm go/nogo/go was necessary to carry out by the researched person during the processing of information. It was offered to the examinee on the appearance of the circle quickly press and release the right-hand button (go) with the right-hand finger. Fast pressing on the left button (go) with the left-hand finger was required when the square appeared. There was no need to click on the button when the triangle appeared. This was a brake signal (nogo).

The time of sensory-motor reaction was determined (RC_{2-3}) and its sensory, motor and central components and also the absolute and relative quantity of false reactions (Makarenko et al., 2014). 30 second differentiation of irritants in the optimal mode of supply of visual stimuli was used. The certainty of the appearance of each stimulus, that required the reaction go or nogo was 33%. Groups of children, teenagers and young people compared for researching age dynamics EP.

Registration was made using the computer complex "Neyrocom" KhAI Medica, in a screened sound- and light -isolation chamber in the sitting position with photostimulation of the right and left eyes with screwed-up eyes. EP were registered in response to LED flashes. The energy of the flash does not exceed the standard in the clinic - 0,24-0,35 kJ. The total quantity of flashes in the sample was 100. Duration of stimulus generation was 5-7 s. with period of alternation 1c±15%. The epoch of analysis was 500 ms. The 300 ms time interval before the LED flash was also taken into account. The number of averages for significant stimuli was within of 50-70. Non-artifact realization was analyzed. The latent periods of wave peaks P_1, N_1, P_2, N_2, P_3 and the amplitude of between peaks intervals N_1-P_2 and P_2-N_2 were taken into account. Biopotentials, outgoing from the occipital areas O_1 and O_2, were analyzed, because the P_3 component had the maximum amplitudes of indicators in this placement. Ear ipsilateral electrodes used as reference.

Statistical analysis of data was carried out using mathematical statistics and program packages Exel, Statistica, StatSoft, USA, 2001. The statistical significance of the differences between the research indicators were evaluated according to the criterion of differences significance (Student`s t-test) and a nonparametric test - Mann-Whitney U-test. Critical level of significance (p) was perceived at the level of 0.05 on condition to the statistical hypothesis testing.

Results

The research results of the dynamics of formation of sensorimotor differentiation reactions RC_{2-3} and the absolute and relative quantity of mistakes for children, teenagers and young people during the processing of information processing in the go/nogo/go mode are presented in Table 1.

Research of the quantitative characteristics of the reaction time of the differentiation PB_{2-3} in the mode of go/nogo/go (two positive and one inhibitory of three stimuli) showed that the low values of time. In the future, the gradual increase of speed (time reduction) of sensory-motor response was observed with age. And this was 385.4±8.5 ms for the examinees 18-20 years old. Changes of indicators RC_{2-3} had significant differences depending on age ($p<0.05$).

Table 1. Indicators of speed and quality of information differentiation in go/nogo/go mode for the examinees of different ages.

Research indicators	8-9 (1)	13-14 (2)	18-20 (3)	p-value, P
RC_{2-3}, ms	522.9±14.1	443.3±9.3	385.4±85	$P_{1-2}<0.05$; $P_{1-3}<0.05$; $P_{2-3}<0.05$;
Absolute quantity of mistakes, ($\overline{x}$ ± S)	3.4±0.5	2.4±0.2	1.2±0.3	$P_{1-2}<0.05$; $P_{1-3}<0.05$; $P_{2-3}<0.05$;
Relative quantity (%) of mistakes, ($\overline{x}$ ± S)	1.3±1.0	0.8±0.2	0.4±0.1	$P_{1-2}>0.05$; $P_{1-3}<0.05$; $P_{2-3}>0.05$;

The research of the qualitative characteristics of the processing of sensorimotor information in the go/nogo/go paradigm showed that he best results had young people 18-20 years old. According to the absolute and relative number of mistake reactions of this age group allowed 1.2±0.3 (0.4±0.1%) of false reactions. At that time, in the group of children 8-9 years old, this indicator was greater and was 3.4±0.5 (1.3±1.0%) ($p<0.05$). Interestingly, the quantity of mistakes, made by the examinees during the task of switching visual information, decreases with age.

The presumption is that this may be due to increased activity of the cerebellum (Kuptsova et al., 2016). It is known that one of the functions of the cerebellum is the calculation of possible mistakes, because and afferent and efferent signals pass through it. The cerebellum is able to predict possible mistakes and correct the following behavioral actions by calculating the difference between the expectation and the results obtained. Thus, the cerebellum makes adaptive behavioral reactions: slows or accelerates motor responses to stimuli.

Although each examinee set the optimum tempo of information processing in go/nogo/go mode, we discovered still found more mistakes for children 8-9 years old than for teenagers and young people. Maybe, insufficient activation of the cerebellum, that have younger persons, and a large number of mistakes (associated with it) cannot be compensated by mechanisms which appear on insufficient adaptive plasticity of the cerebral cortex, which exists in the early stages of ontogenesis, and maybe, it cannot compensate of low performance of the task of processing information in go/nogo/go mode. According to results of differentiation of stimuli in go/nogo/go mode for children, teenagers and young people, the maximum concentration of psychophysiological functions and high speed and quality of information processing is achieved at the age of 18-20 years. Results show, the younger the examinee is - the greater the absolute and relative quantity of mistakes they make.

Such results, maybe, attributable to the fact that examinee must respond as quickly as possible and do not make mistakes during the go/nogo/go test. The data of a probable connection between the reaction time of RC_{2-3} and the number of mistakes indicate in favor of such assumptions ($r=0.37$, $p<0.05$). It turns out, that the examinees, who make a large number of mistakes, in most cases, have more time of sensorimotor reaction to solve the problem of differentiation and processing information in the go/nogo/go mode. It was necessary to slow down the speed of response in order to complete the task and not to make mistakes for such examinees. While examinees, who did less number of mistakes, processed the information much faster. The differences, we have received, show that the speed and quality characteristics of differentiation and processing of information in go/nogo/go mode are improved with age.

Thus, the general patterns of the formation of the visual-motor differentiation reactions in the go/nogo/go mode are established in the course of ontogenesis for all examinee groups. So, we have proven that age factor of the examinees has implications for the visual-motor reactivity of complex differentiation reactions in the task go/nogo/go. Since the functional organization of complex differentiation reactions consists of several stages: signal detection, decision-making process and realizing motor response (Gnezditsky VV, 2003), we believe that can be made available peculiarities in formation of neurophysiological mechanisms at different levels of their functional organization and manifest in the characteristics MK, SC and CIP due to the age dynamics of speed RC_{2-3} in the go/nogo/go task.

Sensory, motor and central components of reaction time RC_{2-3} have been researched and analyzed to identify the characteristics of the formation of complex sensorimotor reactions in the age range from 8 to 20 years. The research results of MK, SC and CIP for the examinees of various ages are presented in Table. 2.

The presented results showed that the time of the sensory-motor reaction RC_{2-3} in the go/nogo/go mode gradually decreases, as well as the speed characteristics of the SC, CIP and MC increase with age. The research of speed MK showed that the greatest time was found for children 8-9 years old. The gradual increase of MK was observed in groups of teenagers and young people up to the maximum in 18-20 years.

So, the age dynamics of MK formation is established during the course of ontogenesis. It is a gradual increase of the speed of motor reactivity.

Statistically significant differences between the average values of MK were detected for groups of children, teenagers and young people.

A longer time of MK for children can be explained by an increase in the number of motor units required to mobilize of rapid reduction and the time of their activation as a result of the spatial and temporal summation of the motor units for the implementation of the motor act. A lower level of the speed of realization of a mechanical reaction can be explained by the fact that the children` muscles contain a lower percentage of high-speed muscle fibers.

Another interesting fact that deserves attention - we detected significant changes of the dynamics of SC for children, teenagers and young people during performance of RC_{2-3}, which may be due to age-related features of the rearrangement of sensor systems. Researching of the time of SC showed that the greatest time of the sensory component was found for children 8-9 years old. The gradual reduction of SK`s time was observed in groups of teenagers and young people up to the maximum in 18-20 years. Therefore, the age dynamics of the formation of SC is established during ontogenesis - gradual increase of the speed of sensory reactivity.

Table 2. Age dynamics of the motor, sensory and central component of the time of visual-motor reaction of differentiation for the examinees of of various ages during the task in the go/nogo/go mode.

Research indicators	8-9 (1)	13-14 (2)	18-20 (3)	p-value, P
SC, ms	129.3±13.9	115.2±8.5	105.9±6.5	$P_{1-2}>0.05$; $P_{1-3}<0.05$; $P_{2-3}>0.05$;
CIP, ms	226.7±12.3	199.9±13.3	161.3±5.9	$P_{1-2}>0.05$; $P_{1-3}<0.05$; $P_{2-3}<0.05$;
MC, ms	165.2±10.2	129.3±8.9	119.7±6.8	$P_{1-2}<0.05$; $P_{1-3}<005$; $P_{2-3}>0.05$;

Note. * - significance of differences (level – p<0.05) for ages groups

Statistically significant differences between averages of SC were found for children and teenagers and for children and young people ($p<0.05$). It is well known that the speed of a sensorimotor reaction depends not only on the speed of perception and motor realization, but also on the decision-making. The examinees performed a complex differentiation reaction in the go/nogo/go mode in accordance with the terms of our research, which required much more time to formulate the answer and make a decision according to the results of the researches (Makarenko et al., 2011).

It is possible to predict that time for processing information in the higher divisions of the central nervous system should be more in this case. Our assumptions were confirmed by the results of researches that showed that the time for CIP was greater than for the SC and MC. It made up 41.5 - 43.6 percent of the all-time of reaction RC_{2-3}. While, SC and MC was only 24 - 30%. The time of the CIP gradually decreased for teenagers and young people with the age. The greatest values of the time of CIP were established for a group of children 8-9 years old - 226.7±12.3 ms. Whereas, the time of CIP was 161.3±5.9 ms. for a group of youths 18-20 years old. Research has shown that the speed of CIP depends on the time of signal analysis, the decision, its transfer to the effector. For its part, these processes are provided by complex analytical and synthetic activities, specific information mechanisms, the emergence and termination of nerve processes, the speed of their movement through the nervous networks of the cerebral cortex. In this case, the individual differences of CIP parameters will depend on the dynamic properties of the cortical structures, that is, the entire working functional system.

Such a generalization can be fair - if we consider the increase of the speed of CIP during ontogenesis, in our opinion, is also the result of age-related morpho-functional transformations of the complex integrative activity of the brain in the conditions of rapid discrimination of ensembles of excitation, as well as of individual brain operations (Makarenko et al., 2011). The presence of the difference between RC_{2-3} and CIP in age groups in our researches suggests that the task of processing the complex sensory-motor information in the go/nogo/go mode occurs with the participation of a complex analytical and synthetic activity of the higher divisions of the central nervous system and with the corresponding involvement of the structural and functional organization of brain activity (Makarenko et al., 2011). Such features of age dynamics RC_{2-3} and its components MC, SC and CIP for persons of different ages can be explained by the gradual maturation of various structures of the brain which provides processing of complex information.

It is known that children, teenagers and young people have noticeable changes in the development of the precentral area of the cerebral cortex. (Beleteleva and Sinitsin, 2008). Intercentral interactions are improved at 11-12 years and, in general, the functional maturation of the associative zones of the cerebral cortex, which regulates complex motor activity, is completed. In addition, increasing of the speed of information processing for teenagers and young people, maybe, related to the subsequent conjugation of morphological and functional changes in the neural networks of the cerebral cortex and the neuromuscular apparatus (Beleteleva and Sinitsin, 2008).

So, we have proved that the differentiation reaction in the go/nogo/go paradigm is a complex visual-motor act that requires rapid signal perception, its analysis, decision-making and an urgent address response in a short period of time, a high level of concentration and switching attention, taking into account the presented stimulus, as well as the corresponding activation and integration of various brain sections.

To confirm this generalization, we researched the EP for the presentation of high-frequency stimulation with light for children, teenagers and young people. Results reflect children have shorter latency periods and between peaks intervals at early and longer ones at the later stages of information processing. These facts are supported by results found of significantly lower latency peaks P_1, N_1, P_2 and N_2 and longer P_3 for in children 8-9 years old ($p<0.05$). (Table 3).

Table 3. Components of P_{300} for targeted stimuli in the Cz examinees of different ages.

Age groups, years	Amplitude, µV		Latency, ms		Duration, ms	
	N_{200}	P_{300}	N_{200}	P_{300}	N_{200}	P_{300}
8 – 9	6.7	4.8	76	421	115	432
13 – 14	5.5	5.6	98	388	78	402
18 – 20	5.2	11.2 *	103*	332*	64*	355*

Note. * significance of differences (level – $p<0.05$) for groups of 8-9 and 18-20 years old.

It is known that EP components such as N_1, N_2, and P_2 are connected with different stages of perception and identification of the stimulus (Minyaeva et al., 2009; Kokoszka et al., 2003) and P_3 - with selective attraction of attention and memory, which include information processing and decision making (Gnezditsky and Endogenous, 2001). Children (8-9 age) had lower amplitudes of between peaks intervals N_1-P_2 and P_2-N_2 than teenagers and young people. The quantitative values of the amplitude of between peaks intervals N_1-P_2 and P_2-N_2 were within the limits of 10.1±0,2 and 7.0±0.3 for the group of young people (18-20 years old), while they reached 7.0±0.2 and 3.6±0.1 mV for children (8-9 years old) ($p<0.05$ - 0.01).

As to the level of the potential amplitude of P_3, its value was statistically significantly lower (4.8 mV) in the group of children than in the examined youth (11.2 mV), ($p<0.05$). The amplitude of between peaks intervals N_1-P_2 was 30%, P_2-N_2 was 40%, and P_3 was 38.3% lower for the children than the quantitative values of the amplitudes of these intervals and peaks for the young people.

Thus, the value of between peaks intervals N_1-P_2 and P_2-N_2 and peak P_3 was lower for the children than for the young people, which can point to processes with attraction of fewer quantity of neurons to the formation of memorable traces and assess of information at all stages of its follow-up (Jebrailova et al., 2011; Faraci and Heistad, 1991).

Using fewer neurons may indicate the local activity of neurons that directly participate in the evaluation and analysis of information (Jebrailova et al., 2011; Ilyukhina 2010). Reduced amplitude of oscillations (which children have) reflects imperfect adaptive mechanisms of neuron activity and, probably, less selective brain activity (Aloshina et al., 2009), which reduces the possibilities of processing information. It is possible that children have not completely formed cortical-cortical and cortical-subcortical connections yet. Which confirms, the earlier and simultaneously lower tonic activity of cortical structures, which comes from the limbic-reticular complex, as evidenced by the lower latencies of P_1, P_2 and bigger P_3. Such results might be characteristic for diffuse cortical-subcortical integration that still occurs in childhood.

Furthermore, it is recognized that P_1 and P_2 waves (waves of EP) reflect analysis of information in subcortical centers and are indicators of the involvement of differentiation of stimuli of nonspecific systems. In contrast to them, component P_3 is an indicator of a specific understanding of the material involving not only the primary but also the secondary and tertiary fields of the cerebral cortex (Jebrailova et al., 2011). P_3 component is considered an indicator of brain activity in the primary and secondary zones of the cortex, non-specific nucleus of the thalamus and reticular formation (Makarenko et al., 2011).

Obviously, that the differences for the temporal characteristics of this component between persons 8–9 and 18–20 years old testifies to the imperfection of the formed neural connections for children and excessive strain of neural processes in neural networks. Component P_2 displays processes of non-specific information processing (Ivanitsky, 2015; Jebrailova et al., 2011) it, maybe, can be another position of explaining the functional integration of the visual system in children. From this position, the examinees (8-9 years old) differed in their greater reactivity of the cortex cells at the initial stages of signal perception.

Thus, numerous data of literature and our results allow us to state that in childhood there is a faster involvement in the processing of information of non-specific structures of the brain (shorter latency P_1, N_1, P_2, N_2), which are rapidly being depleted (reducer amplitude of peaks P_1, N_1, P_2), which reduces the level of functioning of the cerebral cortex (higher latency periods and lower amplitude P_3). We expect, there is an increase of dependence of brain activity from endogenous mechanisms in the age of 8-9, which led to faster in the early and longer – in the later stages of information processing and points to a diffuse functional organization in the cortical and cortical subcortical structures of the brain.

So, it has been established that the age of the examinees ambiguously affects to the processing of information in the go/nogo/go mode. Firstly, research of high-speed and qualitative characteristics of information processing showed significantly lower performance and lability of neurosensory integration of visual-motor function system for children than for teenagers and young people. Secondly, we could state that high reactivity of the cortical and subcortical units of the brain had been established at the early stages of information processing for the group of 8-9 years old. Probably, the following results, obtained for sensory-motor system of children, on the one hand, are related to the optimal development of the cerebral cortex due to the systematic influence of visual afferentation. And on the other hand, it points to a lack of integrative processes and associative connections in the.

Thirdly, the results of EP and processing of information of the young people examinees indicate that their higher departments carried out neurosensory integration during differentiation and processing of information more effectively. This was reinforced by latency and power components P_3, which indicated a greater lability of modulation of the neurons (Makarenko et al., 2011).

Discussion

So, significant differences of the amplitude-frequency characteristics of the EP, have revealed by us, allow to assert that various brain mechanisms for the processing of visual information are formed in neuroontogenesis for children, various brain mechanisms for processing visual information are formed in neuroontogenesis for children, teenagers and young people. Dysfunction of neurophysiological mechanisms is characteristic for children. Neurophysiological mechanisms are characterized by simultaneous activation in the early stages (N1, P1, N2, P2) and deactivation of EP in the late (P3) stages of information processing. Activation in the early stages (N1, P1, N2, P2) is associated with mechanisms of primary signal processing (Jebrailova et al., 2011). Deactivation of EP in the late (P3) stages show the processes of decision making and preparation of motor reaction in the cerebral cortex (Baevsky and Berseneva, 2008).

The obtained results may indicate that the improvement of the quality of the processed information in the go/nogo/go mode for children, teenagers and young people occurs in parallel with the increase of the speed of sensorimotor reactions and its components ($RC_{2\text{-}3}$, SC, MC, and CIP) with simultaneous increase of amplitude, as well as decrease the latency and duration of the P_{300} wave. The latency of the P_{300} peak was reduced. This indicates an increase of the speed of the nervous processes in the young people. The P_{300} component for children 8-9 and teenagers 12-13 years was longer. There was no unambiguous age variation of amplitude, latency and duration in the case of N_{200}.

Consequently, the neurotonogenesis of the children, teenagers and young people was characterized by a decrease of the latency and duration of the peak P_{300} and an increase in amplitude. This was a consequence of the general development and improvement of cortical processes. Reduced latency of the P_{300} is associated with improved processing of information and modal-specific working memory.

The substantial increase of amplitude is noted as an improvement of orientation processes and directed attention (Livanov, 1972). This may also indicate the involvement of functional reserves by activating additional neural networks, because this is a prerequisite for processing information in the go/nogo/go mode. The presence of significant differences between the indicators of speed and quality of information processing, time values of RC_{2-3}, MK, SC, CIP amplitude, latency and duration of the peaks N_{200} and P_{300} can be experimentally proof of the fact that these indicators are related to one another for groups of children, teenagers and young people. These indicators have also positive age dynamics at all levels of the functional organization: from the sensory to the central and motor component of it. At the same time, this indicates a gradual formation of high temporal and spatial synchronization, coherence and discriminating ability of several different neuronal networks in ontogenesis. Neuronal networks were activated during the processing of complex information in the operating memory during the go/nogo/go paradigm (Medvedev, 2003).

Thus, the analysis of the speed and quality of the processed information in the go/nogo/go mode, the speed of RC_{2-3}, SC, CIP, MC, latency, duration and amplitude of P_{300} wave allowed to reveal the age-sensitive of structural and functional peculiarities of the time of signal perception, its analysis, decision making and transmission to the effector. These processes provide complex analytical and synthetic activities, the involvement of specific mechanisms, the emergence and termination of nerve processes, the movement through neural networks of the cerebral cortex, as well as the appearance of excitation in the receptor, reduction / relaxation of muscle groups that carry out a motor act. All this points to the reorganization of both central and peripheral mechanisms of functional organization of information processing during neurotonogenesis.

Conclusions

a. The results of the research of age dynamics of neurophysiological mechanisms of regulation of sensorimotor differentiation reactions in children, teenagers and young people identified gradual increase of speed of reaction of choice 2 from 3 irritants (RC_{2-3}), motor component (MC), sensory component (SC) and the amplitude of the evoked potential (EP), central information processing (CIP), decrease of the quantity of mistakes and latency. Indicators reach the highest level at the age of 18-20 years.

b. Different neurophysiological mechanisms of regulation of differentiation reactions have revealed in children, teenagers and young people during the processing of information in the go/nogo/go mode. It has been proven formation of neurophysiological mechanisms of regulation of sensorimotor reactions of differentiation occurs with participation, mainly, early components (N_1, P_1, N_2, P_2) of children, while these processes occur in young people with participation late components EP (P_3).

c. It was detected that children have simultaneous activation of the early (N_1, P_1, N_2, P_2) and deactivation of the late (P_3) EP of cortex of the brain and significantly more mistakes and a lower speed of RC $_{2-3}$, MC, SC, CIP. It points the presence of cortical subcortical dysfunction of the mechanisms of regulation of differentiation reactions.

d. It was detected that young people have high speed of RC_{2-3}, MC, SC, CIP and fewer mistakes. These results coincided with short latencies and high amplitude of between peaks intervals N_1-P_2 and P_2-N_2 and P_{300}.

References

Aloshina ED, Koberskaya NN, Dumalin IV. 2009. Cognitive evoked potential of R_{300}: methods, experience of use, clinical significance. journal of neurology and psychiatry. 7:77-84.

Baevsky RM, Berseneva AP. 2008. Introduction to prenosological diagnostics. Moscow: Slovo, 220.

Bazanova OM. 2010. variability and reproducibility of the individual frequency of the maximum peak in various experimental conditions. Journal vys. nervous activities named after P.I. Pavlova. 60:767-776.

Bekhtereva NP. 2007. The magic of the brain and the maze of life. Moscow, St. Petersburg, 383.

Beleteleva TG, Sinitsin SV. 2008. Related potentials at the different stages of the realization of visual working memory. Physiology of man. 34:5-15.

Bondarenko MP, Kravchenko VI, Mukarchuk MYu. 2016. EEG-Activity of the brain of the right and left hands in mono-and binocular perception of verbal emotionally colored information. Neurophysiology. 48:47-57.

Faraci FM, Heistad DD. 1991. Regulation of cerebral blood vessels by humoral and endothelium-dependent mechanism. Update on humoral regulation of vascular tone. hypertension. 17:917-923.

Gnezditsky VV. 2003. Evoked brain potentials in clinical practice. Gnezditsky VV, Shamshinova AM, MED-press-inform. 264.

Gnezditsky VV, Endogenous VP. 2001. Experience of using evoked potentials in clinical practice. Antidor. 9:103-119.

Gould D, Flett, MR, Bean E. 2009. Mental preparation for training and competition. In: Brewer BW, ed., Sport Psychology, 1st ed. International Olympic Committee: Wiley–Blackwell, pp. 53-63.

Ilyukhina VA. 2010. Psychophysiology of functional states and cognitive activity of a healthy and sick person. St. Petersburg. 362.

Ivanitsky AM. 2015. The descending influences from mental to physiological level as a possible base for free will mechanism. Journal of higher nervous activity named after Pavlov I.P. 67:728-729.

Jebrailova TD, Korobeynikova II, Karatygin NA, Umryukhin EA. 2011. The spatial organization of the biopotentials of the cerebral cortex and the decision-making time for purposeful human activity. Journal of Higher Nervous Activity. 61:180-189.

Jonkman L, Kemner C, Verbaten M Engeland H, Camfferman G, Buitelaar J, Koelega H. 2000. Attentional capacity, a probe ERP study: Difference between children with attention-deficit hyperactivity disorder and normal control children and effects of methylphenidate. Psychophysiology. 37:334-346.

Karayanidis F, Robaey P, Bourassa M, Koning D, Geoffroy G, Pelletier G. 2000. ERP Differences in visual attention processing between attention-deficit hyperactivity disorder and control boys in the absence of performance differences. Psychophysiology. 37:319-333.

Kokoszka A, Holas P, Bielecki A. Revised 2003. Version of the concept of digesting mental information. Psychiatr. 37:703-712.

Korobeinikova LH, Korobeinikov GV, Radchenko YA, Danko TG. 2016. Diagnosis of the psychophysiological state of the organism as one of the key problems of sports medicine sports medicine and physical rehabilitation. 1:3-10.

Kuptsova SV, Ivanova, MV, Petrushevsky AG, Fedina ON, Zhavoronkova LA. 2016 Sex and age features. Fiziol. hum, 62:15-26.

Linden M, Gevirtz R, Isenhart R, Fisher T. 1996. Event related potentials of subgroups of children with attention deficit hyperactivity disorder and the implications for EEG biofeedback. J. Neurotherapy. 1:1-11.

Livanov MN. 1972. Spatial organization of brain processes. Moscow, Nauka. 181.

Lizohub VS, Chernenko NP, Palabiyik AA, Bezkopulna SV. 2018. Method of definitions mental performance during processing of information with different speed of presentation of stimuli. Cherkasy University bulletin: biological sciences series). 1:70-80.

Lizohub VS, Chernenko NP, Pustovalov VA, Kozhemyako TV, Palabiyik AA, Khomenko SN. 201. Functional organization of brain mechanisms of information processing depending from age. Science and education a new dimension. natural and technical sciences 17: 30-34.

Lizohub VS, Chernenko NP, Palabiyik AA, Bezkopulna SV. 2018. Mental working capacity of children 8-9 years old on the submission of irritants with different modulation and speed in the go / nogo / go mode Science and Education a New Dimension. Natural and Technical Sciences, 21:45-50.

Makarenko NV, Lizohub VS, Beskopulniy OP. 2014. Methodological instructions to the workshop on differential psychophysiology and physiology of higher nervous human activity. Ministry of Defense of Ukraine, Ministry of Education and Science of Ukraine. Kyiv-Cherkassy, 102.

Makarenko MV, Lyzohub VS, Galka MS, Yuhimenko LI, Khomenko SM. 2011. Psychophysiological evaluation of the functional state of the auditory analyzer. 02225, Bull. 21. Pat. 96496.

Makarenko MV, Lizohub VS, Kozhemyako TV, Chernenko NP. 2011. Age features of the speed of central processing of information in people with different levels of functional mobility of nerve processes. Physiological journal. 47:88-94.

Medvedev VI. 2003. Human adaptation. Publisher institute of the human brain. St. Petersburg, 584.

Minyaeva NR., Kyra VN., Gusach YuI. 2009. Called human brain activity in perception of illusing incentives. Physiology Of Man. 35:19-24.

Monastra V, Linden M, Green G, Phillips A, Lubar J, VanDeusen P, Wing, Fenger T. (1999. Assessing attention deficit hyperactivity disorder via quantitative electroencephalography: An initial validation study. Neuropsychology. 13:424-433.

Okhrei AG. 2016. Performance of working memory of musicians and non-musicians in tests with letters, digits, And geometrical shapes. Okhrei AG, Kutsenko TV, Makarchuk MY. Biologija. 62:207-215.

Riccio C Hynd G, Cohen M, Gonzalez J. 1993. Neurological basis of attention deficit hyperactivity disorder. Exceptional children. 60:118-124.

Rovny, AS. 2016. Psychosensory mechanisms for controlling the movements of athletes: Monograph. Rovny AS, Lyzozhub VS. Cherkassy NU them. B. Khmelnitsky – Kharkiv. 360.

Satterfield JH, Schell AM, Nicholas T. 1994. Preferential neural processing of attended stimuli in attention-deficit hyperactivity disorder and normal boys. Psychophysiology. 31:1-10.

Yakovenko EA, Kropotov YuD, Chutko LS, Ponomarenko VA, Sushkina SYu. 2004. Changes in the component composition of evoked potentials in the GO/NOGO paradigm in adolescents with attention deficit hyperactivity syndrome. Bulletin of St. Petersburg University. 2:94-100.