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Auditory Evoked Potential P300 and Risk of Internet Addiction in Young People

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Abstract

Background: Young people spend a lot of time using Internet resources; therefore, they are most susceptible to Internet addiction (IA), in which the parameters of speed and accuracy of information processing by brain structures can change. The aim of the work was to evaluate the parameters of the auditory evoked potential P300 in young people aged 16-17 years with different risk levels of IA.

Methods and Results: A total of 46 healthy young people (14 boys and 32 girls, aged 16-17 years) living in Nadym city (Russia) took part in the study. Signs of IA were determined using the Chen Internet Addiction Scale (CIAS) in the Russian version of Malygin et al.(2011). The parameters of the auditory evoked potential P300 were evaluated using an electroencephalograph (Neuron-Spectrum-4/EPM, Russia) using a standard auditory oddball paradigm. According to CIAS scores, two groups were identified: Group 1 (n=11/23.9% [6 boys, 5 girls]) with minimal IA risk, Group 2 (n=29/63% [8 boys, 21 girls]) with a moderate IA risk, and Group 3 (n=6/13.1% [all girls]) with a pronounced and stable IA pattern. Group 3 showed the lowest P300 latency in the temporal leads (F8, T4) on the right. Correlation analysis showed that the P300 latency in the F8 lead negatively correlates with the overall CIAS score (r_s=-0.36, P=0.01).The persons of Group 2 had significantly higher P300 amplitude compared to Group 1 in the C3 (P_{1-2}=0.010) and C4 (P_{1-2}=0.013) leads. In Group 3, the P300 amplitude was significantly lower than in Groups 1 and 2 in the anterior temporal (F7 F8) and in frontal (F4) leads on the right ($P_{3-1,3-2}$=0.010). Inverse correlations between the total CIAS score and the P300 amplitude were revealed in the F7 (r_s=-0.60, P=0.003), F8 (r_s=-0.70, P=0.001), F4 (r_s=-0.71, P=0.001), and F3 (r_s=-0.50, P=0.018) leads.

Conclusion: In young people, the severity of Internet-dependent behavior is associated with a decrease in the P300 latency in the right temporal lobe of the brain. Individuals with a moderate risk of IA showed a maximum amplitude of P300 in the central parts of the brain whereas individuals with signs of IA showed a minimal amplitude of P300 in the anterior temporal (F7 F8) and frontal (F4) brain regions on the right. The data obtained allow us to consider the revealed changes in the amplitude-time characteristics of the P300 in the temporal lobe of the brain as neurobiological markers of the risk of developing Internet addiction. (**International Journal of Biomedicine. 2020;10(2):157-160.**)

Key Words: young people • Internet addiction • auditory evoked potential P300 • Internet addiction

Introduction

The diversification of digital technologies into everyday life significantly changes the composition of life values of the modern young generation. The significance of this or that information and written word, training and spending free time undergo permanent transformation in modern society. Neurophysiological mechanisms and cognitive characteristics in people with excessive use of Internet resources (Internet overuse) are currently being actively studied and are not fully disclosed. The literature has demonstrated that as a result of interaction with the environment, as well as the assimilation of new information and new experience, physiological changes occur in the brain as a result of its neuroplasticity.[1,2] In most cases, attention is paid to the features of brain activity with the excessive use of video games and social networks,[3] but there is no answer to the question of how much an involvement in the use of Internet resources can have a damaging or optimizing effect on brain activity. Particular attention is paid to the developing brain of adolescents, since many cognitive functions are actively formed during this period and are strongly influenced by environmental factors.[4] Therefore, the search for neurobiological markers of IA in the form of

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local changes in the function of brain structures responsible for cognitive functions is relevant.

The aim of the work was to evaluate the parameters of the auditory evoked potential P300 in young people aged 16-17 years with different risk levels of IA. An assessment of the P300 component, or cognitive potential, was used for assessing neurophysiological processes associated with recognition, decision making, directed attention and random access memory.[5] The P300 component is a measurable direct reaction of the brain to a certain sensory, cognitive or mechanical stimulus. It belongs to ERP (event related potentials), which are stereotypical electrophysical answers to stimulants.[6] P300 components are most easily provoked by a simple discriminating task. The examinee is presented with two randomly repeating stimuli so that one of them is repeating proportionally rarely. In the auditory version of this test (auditory evoked potentials) two different, repeating tones are used, where the targeted stimulus (tone) appears fewer times than the non-targeted stimulus (tone). The examinee must count tones (i.e. classify the frequency of the targeted tone).[7,8]

Materials and Methods

A total of 46 healthy young people (14 boys and 32 girls, aged 16-17 years) living in Nadym city (Yamal-Nenets Autonomous Okrug of Russia) took part in the study in March 2020. The study was approved by the Ethics Committee of the N. Laverov Federal Center for Integrated Arctic Research, RAS (Protocol №3 dated 12.02.2020). Written informed consent was obtained from all participants.

The exclusion criteria at the time of the examination were infectious diseases, cardiovascular diseases, and neurological diseases. Signs of IA were determined using the Chen Internet Addiction Scale (CIAS)[9] in the Russian version of Malygin et al.[10] The CIAS is a self-report measurement consisting of 26 items on a 4-point Likert scale—from 1 point (does not match my experience) up to 4 points (definitely matches my experience). Thus, the minimum CIAS score was 26 points, and the maximum was 104 points. The subjects with CIAS scores 27-42 had a minimal risk of IA, 43-64 - a moderate risk of IA, and ≥65 - a pronounced and stable IA pattern.

The parameters of the auditory evoked potential P300 were evaluated using an electroencephalograph (Neuron-Spectrum-4/EPM, Russia) using a standard auditory oddball paradigm. The signal was filtered with a band pass filter with a 1.5 Hz–30 Hz range. The study was carried out according to the standard method in a situation of a randomly occurring event in response to auditory non-verbal stimulation at the touch of a button. Binaural stimulation was performed with a stimulus duration of 50ms, an intensity of 80dB, a period between stimuli of 1sec, a tone frequency of 2000 Hz (for a target stimulus, probability of 30%) and 1000 Hz (for a non-target stimulus, probability of 70%). The number of averagings for targeted stimulus was 25-30. The amplitude-time parameters of the response were estimated: the peak-to-peak amplitude (mcV) of the N250-P300 wave and the P300 latency (ms). The amplitude and latency of the P300 was estimated in accordance with the International 10-20 system of applying Electroencephalogram leads using a monopolar ear reference electrode. The studied brain regions included F3, F4 (frontal), C3, C4 (central), P3, P4 (parietal), F7, F8 (anterior temporal), and T3, T4 (mid-temporal) leads, with even leads on the right and odd leads on the left.

Statistical analysis was performed using the statistical software «Statistica» (v. 13.0, StatSoft, USA). Median values are presented with interquartile (IQ) ranges (IQR; 25th to 75th percentiles). A non-parametric Kruskal-Wallis test was used for comparisons of median values among three groups ($P<0.05$), followed by post-hoc testing using un-paired Mann-Whitney U tests ($P<0.017$). The Spearman correlation coefficient (r_s) was used to assess the relationship between variables ($P<0.05$).

Results

According to CIAS scores, three groups were identified: Group 1 (n=11/23.9% [6 boys, 5 girls]) with minimal IA risk, Group 2 (n=29/63% [8 boys, 21 girls]) with a moderate IA risk, and Group 3 (n=6/13.1% [all girls]) with a pronounced and stable IA pattern. The latency and amplitude values of P300 in all recorded leads in girls and boys in Groups 1 and 2 did not statistically differ, which made it possible to consider P300 parameters in the whole group. Group 3 showed the lowest P300 latency in the temporal leads (F8, T4) on the right (Table 1).

Table 1.

P300 latency (ms) in young people, Me (P_{25};P_{75})

Parameter	Group 1	Group 2	Group 3	*P*
F4	307(292;335)	302(297;323)	298(292;312)	0.572
F3	314(299;324)	305(290;325)	308(284;312)	0.223
C4	296(292;335)	299(284;322)	298(292;308)	0.923
C3	308(284;326)	299(278;325)	302(286;308)	0.212
P4	294(280;313)	296(278;320)	298(286;304)	0.684
P3	296(271;310)	297(272;319)	298(284;304)	0.883
F8	327(311;335)	304(290;322)	300(286;308)	0.001
F7	318(296;338)	314(294;330)	300(284;316)	0.343
T4	313(294;322)	300(282;313)	296(292;296)	0.024
T3	302(284;313)	302(287;322)	298(291;307)	0.921

Correlation analysis showed that the P300 latency in the F8 lead negatively correlates with the overall CIAS score (r_s=-0.36, P=0.01), which also indicates a shortening of the processing time of sensory information by the structures of the temporal part of the brain in individuals with pronounced signs of Internet-dependent behavior.

The P300 amplitudes were different in the groups, according to the Kruskal-Wallis criterion, in most brain leads, and the largest P300 amplitude was detected in individuals in Group 2 (i.e. in people with a moderate risk of IA) (Table 2). Nevertheless, in pairwise comparisons among the three groups

at the required level of significance (Mann–Whitney U-test, $P<0.017$), the persons of Group 2 had significantly higher P300 amplitude compared to Group 1 in the C3 ($P_{1-2}=0.01$) and C4 ($P_{1-2}=0.013$) leads. In Group 3, the P300 amplitude was significantly lower than in Groups 1 and 2 in the anterior temporal (F7, F8) and in frontal (F4) leads on the right ($P_{3-1'3-2}=0.01$).

Table 2.

Amplitude P300 (mcV) in young people, Me (P_{25};P_{75})

Parameter	Group 1	Group 2	Group 3	*P*
F4	16.6(15.2;19.1)	20.6(13.6;24.7)	11.5(10.7;12.9)	0.023
F3	14.3(10.3;18.4)	19.2(14.2;23.5)	12.5(11.5;13.3)	0.034
C4	13.3(10.9;16.4)	20.8(13.4;27.3)	14.1(13.1;15.1)	0.040
C3	11.5(6.6;16.7)	19.6(12.2;25.9)	12.8(12.1;15.9)	0.031
P4	11.6(8.7;13.7)	16.8(10.4;22.9)	13.1(10.7;15.9)	0.032
P3	9.6(6.6;15.2)	16.2(9.2;19.1)	14.7(8.7;17.6)	0.503
F8	10.8(7.7;16.2)	12.4(7.2;16.3)	6.6(5.8;7.3)	0.021
F7	11.0(8.8;13.6)	11.3(7.4;12.7)	6.1(5.2;6.6)	0.014
T4	9.8(8.4;14.3)	13.8(9.3;17.1)	11.6(8.4;15.2)	0.244
T3	10.7(5.6;12.2)	11.9(9.7;14.7)	9.7(7.8;11.7)	0.121

Inverse correlations between the total CIAS score and the P300 amplitude were revealed in the F7 ($r_s=-0.60$, $P=0.003$), F8 ($r_s=-0.70$, $P=0.001$), F4 ($r_s=-0.71$, $P=0.001$), and F3 ($r_s=-0.50$, $P=0.018$) leads. These data confirm the pattern in the form of a decrease in the P300 amplitude in individuals with pronounced Internet-dependent behavior.

Discussion

The distribution of the average latency and amplitude of the P300 was gender-independent in Groups 1 and 2, that is, the differences obtained in the P300 parameters were due precisely to the severity of the Internet-dependent behavior. The greater participation of girls in the study and their exclusive presence in Group 3 can be explained by the fact that girls are more sincere in discussing psychological and social problems than boys.[11] This may affect the CIAS score. The main areas of the brain that are associated with the generation of brain activity during signal detection include the temporoparietal, medial temporal lobes, and lateral prefrontal cortex.[12]

It is assumed[13] that the temporal lobe is most involved in the processing of audiovisual information, and is also among the key areas involved in the integration of auditory and visual signals, as well as in the emotional perception of information.Ezzyat et al.[14] showed that electrical stimulation of the temporal lobes of cerebral hemispheres improves memory and subsequent reproduction of information. It is likely that a decrease in P300 latency and an increase in P300 amplitude in individuals with a moderate risk of IA can be associated with an increase in the functional load on cortical processing centers of various types of sensory stimulation while working on the Internet. Nevertheless, at a certain stage, signs of IA are formed, which are accompanied by a pronounced decrease in the P300 amplitude. According to other authors, the P300 amplitude is a very sensitive indicator, the variance of which depends on genetic[15] and environmental factors, emotional state, and anxiety level.[16] The reduced P300 amplitude has been found in people suffering from other types of addiction (alcoholism, substance abuse).[17,18] It is assumed that the low P300 amplitude reflects a violation of the functions of inhibitory control of the central nervous system associated with the frontal lobe of the brain.[19] A decrease in the P300 amplitude is associated with a change in the activity of neurotransmitter systems that are involved in generating the P300.[20] People with symptoms of IA have shown a decrease in the susceptibility of dopamine D2 receptors in the striatum.[21] Pogarell et al.[22] found that the susceptibility of D2/D3 receptors to dopamine in the striatum positively correlated with the P300 amplitude in patients with depression. The increasing need for alternating multiple windows and hyperlinks in the browser of Internet resources, the desire to open new hyperlinks and the increase in search queries on the Internet can be caused by the easy receipt of information rewards related to the stimulation of the dopaminergic system of the brain.[23]

Thus, in young people, a relationship was found between the P300 parameters and the severity of Internet-dependent behavior. The severity of Internet-dependent behavior is associated with a decrease in the P300 latency in the right temporal lobe of the brain. Individuals with a moderate risk of IA showed a maximum amplitude of P300 in the central parts of the brain whereas individuals with signs of IA showed a minimal amplitude of P300 in the anterior temporal (F7, F8) and frontal (F4) regions on the right. The data obtained allow us to consider the revealed changes in the amplitude-time characteristics of the P300 in the temporal lobe of the brain as neurobiological markers of the risk of developing Internet addiction.

Competing Interests

The authors declare that they have no competing interests.

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