

Psychophysiological markers of students' Internet addiction in the era of digitalization

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Abstract. The article is devoted to the current problem of Internet addiction of young people in the context of digitalization of modern education and the practical implementation of interactive learning technologies. The authors pay attention to the definitions of such concepts as virtual educational environment, virtual learning process, interactive learning. The article analyzes the manifestations and consequences of Internet addiction among modern youth. The authors emphasize that the psychophysiological mechanisms that can affect the development of Internet-dependent behavior are insufficiently studied. One of these mechanisms can be the inhibitory control, which, according to the authors of the article, is able to signal the presence of a danger of the formation of the Internet addiction. The article presents the results of an experimental study aimed at studying young men and women's computer and Internet addiction with the help of "The method of screening diagnostics of computer dependence" (Yuryeva L.N., Bolbot T.Yu.) and the "Internet addiction" test by K. Young (adaptation by V.A.Loskutova). It was found that most of the subjects have a high level of dependence. Also, the assessment of the formation of the inhibitory control was carried out using the ReBOS technique, reflex metric measurements (by E. G. Vergunov). The authors concluded that young men and women with a higher degree of dependence demonstrate a low level of formation of the inhibitory control, subjects who have a lower degree of dependence both on a computer and on the Internet have a more flexible nervous system, which is indicated by the higher level of the inhibitory control formation. Thus, it can be assumed that students who are less dependent on the Internet will be able to adapt more easily to a fast-changing environment.

1 Introduction

The 21st century is today called the century of innovation. This is due to the fact that at the current stage of development of society, almost all spheres of human life are influenced by information technologies and the Internet. Modern realities of the life of society have determined the need for informatization and the active introduction of interactive technologies that ensure the development of new forms of education. The Internet and digital technologies are actively involved and largely determine the socialization of today's youth. It is a well-known fact that socialization is, on the one hand, a spontaneous process, on the

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other hand, however, it has a directed nature. This is the reason why there are difficulties in understanding the phenomenon under study, and modern trends in the development of education and the development of society as a whole determine the need to find relevant ways to improve the socialization of students.

In modern society and in science, the educational process is associated with such terms as virtual educational process, interactivity, informatization, virtual educational environment, videoconference.

Informatization, due to the use and active penetration of the latest computer and telecommunication systems into our life, is connected and studied within the framework of the functioning of a huge number of information and communication elements of modern life support. It has been proven that the society informatization is directly impacted by qualitative changes in the social structure and social process, which, for their part, are influenced by modern information technology tools.

After having studied the current state of the problem of the educational environment informatization (Afanasyeva Yu.V., Zuev N.A., Ivanov A.V., Levkina N.N., Petrova A.S., Saykov B.P., Suslova I.A., Tolstova N.S., Shakuto E.A. and others), we came to the conclusion that the point of view of S.G. Kanane can be considered as the basic one. It allows us to trace the following peculiar features of information. The first feature lies in the fact that information today has a special resource - knowledge. The newest information model has been formed due to a significant increase in the quantitative indicators of the absorbed information. The second feature: informatization causes a change in value orientations, socially significant rules and legal standards have changed (and will keep changing), since there is a need to provide free and equal access to information for any interested member of society. This aspect cannot but affect the life of each specific personality.

Speaking of a virtual educational environment, many researchers (Andreev A.A., Weindorf-Sysoeva M.E., Kalmykov D.A., Makarova E.E., Miroshin D.G., Tikhomirov V.P., Uvarov A.Yu., Khachaturov L. A., Khutorskoy A.V., Kholodkova I.V., Kholodova G.B., Weller M., Demian P, Kaszap M., Lemire G., Morrice J., Reese S, Senteni A., Taurisson A. , Jeffrey D. etc) mean a system-telecommunication environment that serves the entire educational process. This is needed for information support and documentation in electronic networks, since educational institutions of any professional specialization and different level of education use the standard technological means.

In the modern world, the "virtual learning process" means "an integral set of educational situations replacing each other in the virtual space, during the resolution of which the education, upbringing and development of the student take place" [4].

Interaction [7] means coordinated action, this interaction is carried out at several levels:

1) human-machine interface - interaction through commands and manipulations; standard tool - keyboard, mouse, remote control;

2) exchange of various kinds of data (audio, video, graphic, etc.).

Video conferencing is one of the most modern types of work for network users in video communication today (programs such as Zoom, NetMeeting, CU-SeeMe, iVisit, Skype are used). This technology appeared in the public domain in 1994 thanks to the release of Connectix Quickcam. In modern society in general and in terms of education in particular, this technology has become a natural form of knowledge transfer, like a traditional lesson.

Thus, we can draw a conclusion that the unconditional advantage of digitalization is a significant, even (in a way) global expansion of the consumer information market, almost all information has become available to users of Internet services.

It is necessary to understand that the use of information in the educational environment has some peculiarities, and, "speaking about the education and socialization of modern youth, one cannot be limited only to the exchange of information" (the opinion of A.A. Kalmykov) [1,2,3]. In his opinion, "a virtual educational environment cannot become an educational

environment if it is limited only to information exchange." In the process of educational activity, only the transfer of some knowledge cannot be sufficient, the main meaning of education is that the task of the individual is to develop, recreating in himself the image transmitted to him by the educational system. Only due to some kind of control element, at least at the initial stages of working with that huge flow of information that a modern young person faces, various negative manifestations of digitalization can be avoided.

One of the inevitable consequences of the observed technological progress is Internet addiction. It arouses the interest and attention of researchers in various fields of knowledge, due to the ambiguous impact, which includes both positive and negative aspects of the direct impact on a person.

The worldwide use of the Internet, which in one way or another has conquered almost the entire part of the population, causes irreparable damage to various spheres of society: social, economic, psychological and physical. The problem of internet addiction is multifaceted.

First of all, it directly affects the health of society in physical and psychological terms (the immune system weakens, problems in the musculoskeletal system arise as well as weight problems, various eye diseases, anxiety and depression and general mental exhaustion of the body). Internet addiction also affects social interactions: long-term Internet use separates a person from real social interactions; problems arise in various spheres of life: family, education, profession.

According to K. Young, one of the leading researchers of Internet addicted behavior, "the degree of addiction is determined not by the amount of time spent on the Internet, but by the amount of losses in the present time" [9].

Internet addiction is currently an acute problem that harms the mental state of a person and requires to be studied more thoroughly. It is easy to notice that the majority of young people prefer "virtual reality" to being involved in various spheres of public life.

This phenomenon has been studied by scientists from different countries, including K. Young, A. Goldberg, D. Greenfield, M. Orzak, O. Egger and M. Rauterberg - abroad, as well as A.E. Voiskunsky, O.E. Smyslova, L.N. Yuryeva, O.D. Babaeva, G.L. Smolyan, Ts.P. Korolenko in Russia. The general features of computer addiction as one of the types of Internet addiction according to A. Goldberg are:

- 1) the emotional background rises while the computer is being used;
- 2) the amount of time spent on the network increases;
- 3) there is no possibility to stop;
- 4) "couldn't care less" attitude towards family and friends is traced;
- 5) lying to superiors or family members about their activities;
- 6) difficulties with work or study increase.

The presence of this kind of conditions, affecting a person who seeks to refuse the Internet or reduce the amount of time spent in it, indicates the occurrence of psychological dependence.

As it was stated above, the problem the Internet addiction worries many foreign and domestic researchers. With all the positive influence of worldwide networks, as well as the unconditional need for active use of the designated resources, it is noted that in a number of cases there is a pathological dependence on the Internet. There are many reasons for this addiction. Yet, in our point of view, the psychophysiological mechanisms that can affect the consolidation (or, more precisely, the development of a certain blocking) of the unconstructive, but habitual and, to some extent, socially approved behavior model, have not been studied sufficiently. Inhibitory control can serve as such a psychophysiological mechanism.

According to our previous theoretical analysis of studies aimed at studying this psychophysiological mechanism of behavior control [5], we can point out the following characteristics. Inhibitory control is carried out due to neuronal activation (the prefrontal

cortex is the place of its localization), which is interconnected with the developing specialized neural pathways, which, in turn, cross many functional areas of the brain that affect the inhibitory control. Thereby, the prefrontal, basal ganglia, the anterior cingulate gyrus and the parietal region get activated, and as a result (the connection between the prefrontal cortex, the subcortical and posterior regions of the brain), the inhibitory control is enhanced, because there is a relationship between areas that control sensory input and areas designed for higher cognitive functioning [1, 11]. Gradually, starting from the birth (localized in the prefrontal cortex), neural activation occurs, which is necessary for solving the tasks of the inhibitory control; from the age of three, this zone is activated in children under the influence of performing the tasks of the inhibitory control [5, 14]. Activation occurs throughout preschool childhood and continues into adolescence, thanks to the relationship that is formed, developed and strengthened between the prefrontal region and other functional areas of the inhibitory control [13]. Thus, it can be stated that the neural basis of the thoracic control makes the transition sequentially: generalized neural activation, localized prefrontal activation, activation of specialized networks. Consequently, the inhibitory control provides and determines, in general, the main direction of attention, and it is also the foundation for supporting a deliberate orientation of human behavior in solving various problems and achieving various goals [1,9]. According to researchers of the inhibitory control (Nelson, T.D., Nelson, J.M., Mason, W.A. Nikolaeva E.I., Vergunov E.G. and others), poor inhibitory control is likely to have an impact on the leading behavioral characteristics of a person's personality [15].

All of the mentioned above allows us to assert that inhibitory control can be considered as a kind of psychophysiological marker, which signals the presence of the danger of the addiction formation to the Internet a modern young person can have. And although the realities of modern society are as follows - young men and women (especially those receiving higher education) need to "keep pace with the times" and actively use information technologies and Internet resources in the course of their life, the following aspect must still be taken into account: individual typological characteristics of a young person (including those of a psychophysiological nature). This will make it possible to timely neutralize the potential negative influence, even if it is a progressive element of modern culture. Our research was aimed at identifying these features.

2 Materials and methods

100 respondents - students of the Yelets Bunin State University – took part in the study. Diagnostic study of these young people was carried out basing on the following diagnostic tool: "The method of screening diagnostics of computer addiction" (by L.N. Yurieva, T.Yu. Bolbot). This technique makes it possible to conduct effective screening diagnostics of computer addiction not only among individuals, but also in a group of users of computer technologies. The second component of the diagnostic data obtained is assessment of the individual emotional state, their willing properties, self-control ability, physical and psychological condition. The "Internet addiction" test created by K. Young (adapted by V.A. Loskutova), aimed at self-diagnosis of pathological addiction to the Internet (regardless of the form of this addiction), was also used.

The original method by K. Young allows us to record the presence of three main symptoms, indicating that addiction exists. The first symptom: increasing of the dose (the time spent on the Internet increases); the second symptom: a change in the form of behavior (Internet activity begins to replace the forms of real life); third symptom: withdrawal syndrome (deterioration of emotional well-being outside of Internet activity). Adapted by V.A. Loskutova, this tool makes it possible to identify the level of Internet addiction: low (an ordinary Internet user), average (risk of addiction) and high (Internet addiction) in particular.

To assess the inhibitory control of the respondents, we used the reflexometric technique called "ReBOS" (author-developer: E.G. Vergunov). With its help, we assessed not only the parameters of a simple and complex sensorimotor reaction, but also the level of formation of the inhibitory control. The research procedure consists of demonstrating stimuli in the form of circles of different colors on the monitor screen at a certain frequency. By pressing the spacebar, the subject must react to the appearance of the stimulus, the speed of the reaction to the stimulus is estimated. The research took place in several stages: at the first stage, respondents should respond to the appearance of a stimulus (circle on the screen) by pressing always, without any restrictions; at the second stage, it is necessary to react to the appearance of circles of any color, except for red (this restriction in the instructions allows us to diagnose the level of one's inhibitory control). Evaluation depends on the average time of a simple and complex sensorimotor reaction, the number of reactions that do not correspond to the instructions (errors of the type I are recorded - pressing the spacebar before the appearance of the stimulus - false start, errors of the type II- pressing the spacebar when a red circle appears, as well as missing stimuli) [6]. Based on the number of mistakes of the first and second kind, a diagnostic opinion is formed about the level of formation of the inhibitory control.

3 Results

The first stage of the study was the diagnosis of computer and Internet addiction, based on which the following results were obtained.

According to the data obtained as a result of carrying-out of the "Method for screening diagnostics of computer addiction", the authors are L.N. Yuriev and T.Yu. Bolbot [8], it was revealed that the vast majority of students are at risk of acquiring a computer addiction. It shows us that this category of people is at risk and they need to pay attention to the amount of time they spend online, to the extent of interaction with friends and the environment, and also to reduce the time spent at the computer to a minimum.

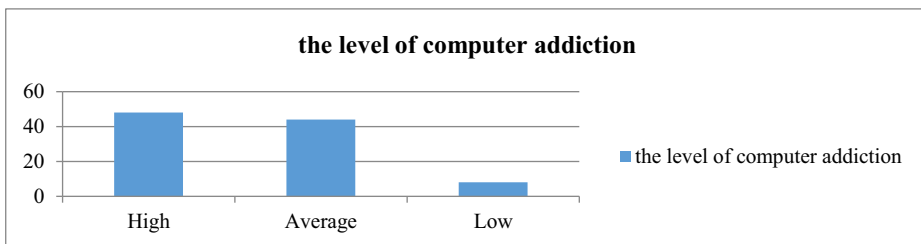


Fig. 1. Results of the "Method of screening diagnostics of computer addiction".

Similar results were obtained during the "Internet addiction" diagnosis basing on K. Young's methods (adapted by V.A. Loskutova). The results are presented below.

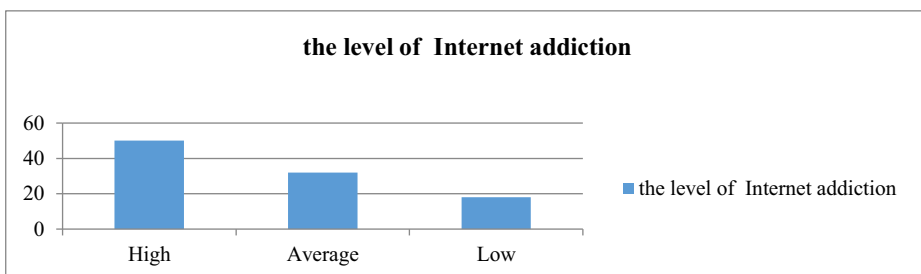


Fig. 2. Results of the "Internet addiction" test.

Figure 2 represents an increased interest to the Internet among the students participating in the study. This is manifested both in the increased amount of time spent online and in the decreased emotional state offline, which lead to the availability of various kinds of information with possible protection of anonymity.

If the Internet user is trying to reduce the time spent online, it can lead to poor health condition, which can last from several weeks to a month.

The results obtained during the first stage of the study allowed us to divide the participants of the experimental study into two groups:

- young men and women with a high level of computer dependence on the Internet;
- young men and women with an average and low level of computer addiction to the Internet.

For perception convenience of the results obtained in the course of the next stage of the study, we notionally named the groups highlighted above as: "addicted" and "addiction free".

The next component of the diagnosis was the evaluation of the inhibitory control by means of the reflexometric technique "ReBOS". A comparative analysis of the average reaction time in a simple and complex sensorimotor reaction is presented in Table 1.

Table 1. Comparative analysis of the average reaction time in a simple and complex sensorimotor reaction.

Subjects	simple sensorimotor reaction		complex sensorimotor reaction	
	1st half	2nd half	1st half	2nd half
addicted	282.2 ±37.5	297.3 ±41.6	328.8 ±33.4*	351.1 ±41.5*
addiction free	297.6 ±24.9	300.6 ±35.8	362.7 ±37.7*	379.6 ±41.6*

* - The threshold value, $p \leq 0.05$ according to Student's t-criterion. Statistical significance between the first and second halves of sensory flow.

Analyzing the results, we can state an increase in the reaction time from the first half to the second, both in a series of a simple sensorimotor reaction, and in a complex one. We also note an increased reaction time from a series of simple sensorimotor reactions to a complex one; this may be due to the complication of instructions (the appearance of a stimulus to which it is prohibited to react). Although the increase was recorded both among young men and women addicted to the Internet, it was also traced among representatives of the group, who did not have this addiction. We consider it important to note the following fact that the students of the second group have a higher reaction time, both in comparison with Internet addicted students as well as when comparing simple and complex series.

Table 2. Comparative analysis of errors in the form of a gap in simple and complex sensorimotor reactions.

Subjects	simple sensorimotor reaction		complex sensorimotor reaction	
	1st half	2nd half	1st half	2nd half
addicted	2.03 ±3	2.5 ±4	2.8±2.6	2.2±3.9
addiction free	2.08±2.8	2.3±2.9	2.6±1.9	2.1±1.8

According to the results presented in Table 2, it is obvious that young men and women of both groups (with and without addiction) have demonstrated constant stability. The data shown in the table clearly demonstrates that the number of errors in both series of a simple sensorimotor reaction and a complex one is virtually identical in the first and second half of the test. This means that the students who took part in the study were able to reflect the pattern set by the program and were not mistaken (that means they did not miss the stimuli). The instructions were followed correctly, that is, the respondents pressed the spacebar each time circles of different colors appeared on the monitor screen. The simplicity of the instructions may have affected the study, therefore we assume that these results require some additional verification.

Table 3. Comparative analysis of the Type I error rate in simple and complex sensorimotor reactions.

Subjects	simple sensorimotor reaction		complex sensorimotor reaction	
	1st half	2nd half	1st half	2nd half
addicted	1.7 ±2.8	2.8 ±5.1*	3.1±8.7	3.5±10.2
addiction free	4.8±15.2	3.1±7.2*	1.1±3.2**	1.6±5.6**

* - The threshold value, $p \leq 0.05$ according to Student's t-criterion. Statistical significance between the first and second halves of sensory flow. ** - The threshold value, $p \leq 0,05$ according to Student's t-criterion. Statistical significance between the first and second groups of respondents.

According to the data presented in Table 3, fixing the number of errors of the type I showed a discrepancy between the results and the analysis of the presence of gaps in a simple and complex sensorimotor reaction. Revealed significant differences in the results obtained during the demonstration of the first and second parts of the sensory flow. And also the obvious differences between the indicators of the first and second groups of respondents.

Table 3 demonstrates that the subjects of the first group, having shown good results at the beginning of the series, increased the number of errors of the type II in the series of a simple sensorimotor reaction (pressing the spacebar before the appearance of the stimulus - false start); By contrast, the non-addicted group made more mistakes at the beginning of the trial and made fewer mistakes towards its end.

The results of the diagnostic study indicate a higher level of formation of the inhibitory control among young men and women from the second group, we can assume that their nervous system is more plastic, and representatives of this group possess better adaptive capabilities.

Special attention should be paid to such an indicator as the stable number of type I errors in the subjects from the first group: young men and women from the second group significantly reduced the number of errors in a series of complex sensorimotor reactions. We believe that this indicates that the subjects of the group, in which the dependence on the Internet was not recorded, were able to reflect the regularity of the appearance of stimuli on the monitor screen and "learned" to perform the task almost flawlessly.

Table 4. Comparative analysis of the Type II error rate in complex sensorimotor reactions.

Subjects	complex sensorimotor reaction	
	1st half	2nd half
addicted	7.2±3.9	10.5±4*
addiction free	7.7±3.7	5.8±4.1

* - The threshold value, $p \leq 0,05$ according to Student's t-criterion. Statistical significance between the first and second halves of sensory flow.

Analyzing errors of the type II in a complex sensorimotor reaction, we came to the conclusion that the respondents of the 1st group increased the number of errors in the second half of the stream of a complex sensorimotor reaction. This pattern was not found in the subjects of the second group (addiction free). That is, the subjects of the second group demonstrated a decrease in the number of pressing the spacebar when a forbidden stimulus appeared (a red circle). This demonstrates that they reflected the regularity of the appearance of stimuli in the second half of the sensory flow, and they were able to adapt to the translation of cyclically changing stimuli. And the respondents, who were registered as being addicted to the Internet, continued to press the space bar while demonstrating a forbidden stimulus - a red circle.

4 Discussion

The significance and unconditional usefulness of digitalization is undeniable. It does not require any proofs that society keeps developing and technical progress enters into all spheres of human life. It is also necessary to pay great attention to the fact that modern youth considers the Internet to be an important part of the professional development process and it can also serve to obtain additional information for self-education. But thinking about the necessity and importance of digital technologies, we risk forgetting that even the most useful and important inventions, which are used uncontrollably, can cause not only benefit, but also significant harm, especially to immature minds.

Talking about how important the Internet is for the modern young generation, we should not forget that the Internet can also be a kind of "trap" that gives an opportunity to "escape" from the real world where a person is able to find a solution to his specific problems. Whether the modern youth really can "stop" in time, get out of the "networks", change their views, choose a more constructive model of behavior - we will be able to understand, having studied in time not only the psychological characteristics of a person, but the psychophysiological characteristics as well. It should be noted that it is impossible to draw any large-scale conclusions on the basis of the pilot study carried out. However, the obtained results will allow us to think about the need for an individual approach to solving any significant tasks on the agenda.

5 Conclusions

Thus, on the basis of the conducted research, we can conclude:

- at the present stage of development of society, taking into account the current trends in its development, it is very important not to forget that informatization can have not only a positive, but also a negative impact;
- it is possible to assess a person's ability to build a constructive model of behavior minding modern trends only by comprehensively studying their individual and typological characteristics;
- the results obtained indicate that the young people who took part in the pilot experimental study, to one degree or another, have computer addiction and are addicted to the Internet;
- respondents with a higher degree of dependence demonstrate a low level of the formation of the inhibitory control, young people who have a lower degree of dependence both on a computer and on the Internet have a more flexible nervous system, which is indicated by a higher level of formation of the inhibitory control. It can be assumed that students, who are less addicted to the Internet, have more vivid adaptive capabilities in a changing environment.

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