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**Psychology of subculture: Phenomenology and Contemporary  
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**FEATHERS OF THE COGNITIVE SPHERE IN ADOLESCENT  
INTERNET USERS**

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***Abstract***

This paper explores cognitive functions of adolescents with various online activity on the Internet. The study involved 100 adolescents (Moscow, Russia). The adolescents were divided into groups: 11–13 years old (N = 50), and 14–16 years old (N = 50). Specially selected neuropsychological methods were used to study cognitive functions. All the adolescents were divided into groups according to the criterion of varying degrees of online activity's intensity: low (33%), medium (31%), controlled high (19%) and uncontrolled high (17%) intensity of Internet use. The adolescents with the average level of Internet use in comparison to the other groups showed better results in such neuropsychological characteristics as programming and control, visual spatial memory, selectivity of auditory verbal memory, verbal intelligence and erudition. The lowest results in these characteristics were shown by the adolescents from the groups with the high level of online activity. When comparing the younger and older adolescents, the same pattern remained in the younger group. When undergoing neuropsychological tests, the adolescents aged 11-13 years with the average level of user activity were more productive than the adolescents with low and high online activity. In the group of the older adolescents, this pattern was absent. In this regard, it can be concluded that the younger an adolescent is, the more the development of his/her cognitive functions depends on the amount of time he/she spends online. In this study, some optimum time spent by the adolescents on the Internet was observed. When that optimum time frame provided, higher rates of certain cognitive functions' development are present, especially among the adolescents from the younger age group.

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**Keywords:** Digital technologies, neuropsychological assessment, cognitive functions, user activity.



## **1. Introduction**

Information and communications technologies and above all the Internet are increasingly entering the life of modern children and adolescents. The new cultural and psychological phenomenon - digital childhood - is determined by the certain social situation of the modern child's development. This situation changes the forms of the child's interaction with the external world (Soldatova, 2018). Appearing empirical facts confirm that information and communications technologies as cultural tools of modern times not only form new values and social practices but also influence the personal and cognitive development of children (Soldatova, Rasskazova, & Nestik, 2016).

## **2. Problem Statement**

Despite the growing number of works about the impact of digital devices on personal and mental development of children (Jackson et al., 2012; Barr, Pennycook, Stolz, & Fugelsang, 2015; George & Odgers, 2015, etc.), there is a lack of systematic studies of such important mental functions as memory, attention, thinking and speech and their qualitative changes determined by the intensity of Internet use. In the modern world it is impossible to fully protect a child from digital technologies; therefore, the issues not only about the content of children's online activities but also determining the optimal amount of time they could spend on the Internet not only harmlessly but, on the contrary, for the benefit of their personal and cognitive development are becoming burning ones. By using a range of neuropsychological methods, some aspects of memory, attention and verbal functions of adolescents with different intensity of Internet use are analyzed in this study. The level of voluntary regulation and serial organization of activity is also examined as a necessary basis for the successful functioning of these cognitive processes. This study is a continuation of the work on studying the impact of Internet use on the cognitive functions of children and adolescents, which was began in 2017 (Soldatova, Vishneva, & Chigarkova, 2018).

## **3. Research Questions**

The relation between the intensity of Internet use and a number of characteristics that reflect the development of cognitive functions of children aged 11 to 16 years are analyzed in this study. In this regard, it is assumed, firstly, that there is some optimum time spent by adolescents on the Internet, which contributes to a more harmonious development of higher mental functions, especially the voluntary regulation of activity. Secondly, the younger an adolescent is, the more prominent will be the relation between successful undergoing neuropsychological tests and the optimal time spent online.

## **4. Purpose of the Study**

The main objectives of this study were: division of adolescents into groups depending on the intensity of their user activity, identification and description of differences in cognitive functions of adolescents with different user activity, study of the interrelation between user activity and cognitive functions of the adolescents from the two age groups: the group of younger adolescents (11-13 years old), the group of older adolescents (14-16 years old).

## 5. Research Methods

### 5.1. Samples

The study involved 100 adolescents: younger adolescents (11–13 years old, 53 people) and older adolescents (14–16 years old, 47 people). The sample of children was balanced by gender and age.

### 5.2. Methods

For carrying out this study, a methodological complex was developed and tested: 1) a neuropsychological evaluation, 2) a sociopsychological questionnaire that included several blocks of questions and special psychological methods and methodological techniques.

The study was conducted at home in families in the form of an individual interview with each adolescent where the parents filled out the sociopsychological questionnaire.

The range of neuropsychological tests included the following methods (Akhutina, 2016): 1) Dynamic praxis; 2) Auditory verbal memory (immediate and delayed memorization of 2 groups with 3 words each); 3) Counting operations, serial counting; 5) Visual spatial memory (immediate and delayed memorization of 4 difficult verbalized patterns); 6) Making up a story based on a series of plot pictures; 7) Hedge graphic test; 8) Dots test (on the computer); 9) Subtests from the children's version of the Wechsler test - Knowledge and Comprehension.

Methods of neuropsychological testing were aimed at the study of the following neuropsychological indices: 1) programming and control (skills of analyzing the conditions of the task being undertaken, developing and mastering the algorithm of actions, monitoring their implementation); 2) serial organization of movements and actions (smoothness of interchanging from one program component to another, including when undertaking intellectual tasks); 3) auditory verbal memory; 4) visual spatial memory; 5) maintaining tone and concentration. The subtest Knowledge tests verbal intelligence (level of knowledge, scope of interests and erudition and the ability to store this information in long-term memory). This subtest has high correlations with overall intelligence. The subtest Comprehension determines the ability to model your own behavior in different situations.

The obtained results were processed using the statistical software IBM SPSS Statistics 22. The following procedures were carried out: correlation analysis, single factor analysis of variance (ANOVA), multivariate analysis of variance (MANOVA), which revealed the interrelation of age and online activity factors and their effect on neuropsychological results.

## 6. Findings

Based on the frequency distribution, all the adolescents were divided into the following groups according to their user activity of digital devices and the Internet:

- Low user activity (33%) – up to 3 hours on weekdays and weekends;
- Medium user activity (31%) – adolescents who spend no more than 5 hours on the Internet on weekdays and about the same amount on weekends, and three persons who compensate for low user activity on weekdays (1-3 hours) by weekends (6-8 hours);
- Controlled high user activity (19%) - adolescents who spend 4-5 hours on the Internet on weekdays and 6-12 hours on weekends or no more than 6-8 hours both on weekdays and weekends;

- Uncontrolled high user activity (17%) - adolescents who spend at least 6-8 hours online on weekdays and more than 9 hours on weekends.

Time online includes not only using social networks, searching for information, publishing posts, but also chatting in messengers (WhatsApp, Viber, Twitter etc.), viewing photos on Instagram.

### **6.1. Differences in the results of the neuropsychological tests for the adolescents with different user activity**

According to the results of single factor analysis of variance (ANOVA), the maximum number of significant differences was obtained with the respect to the following neuropsychological indices: programming and control, visual spatial memory, verbal intelligence and erudition following the Knowledge subtest.

On average the adolescents with medium user activity (no more than 5 hours on weekdays and weekends) performed counting operations better, made no mistakes, or made one mistake when in their heads solving six tasks that included the addition, subtraction, multiplication and division operations ( $r = 0.55$ ,  $p \leq 0.05$ ). While avoiding repetition of words within the 1st and 2nd groups ( $r = 0.19$ ,  $p = 0.052$ ) and also transfer of the word to another group ( $r = 0.48$ ,  $p = 0.067$ ), they made less regulatory errors in the method for auditory verbal memory than the others, and they remembered more accurately the word relation to the group than the other respondents. In the computer test Dots aimed at evaluating the function of programming and control, on average the adolescents with medium user activity gave answers to stimuli in all the three series faster than the others (average reaction time is 0.49 second). This time period differed significantly from the reaction time of the adolescents with low online activity (0.56 second). The adolescents of the “medium” group showed the best results when memorizing five difficult verbalized patterns (visual spatial memory) at their first-time reproduction ( $r = 3.44$ ,  $p \leq 0.05$ ). No significant differences were observed at the second, third and delayed reproduction. However, they had more inaccuracies when reproduced patterns and added more non-existent patterns than the others ( $r = 0.35$ ,  $p \leq 0.05$ ). This indicator is included in the programming and control index. On average the adolescents from this group scored more on the subtest Knowledge ( $r = 15.00$ ) which significantly differed from the performance of the adolescents from groups with high online activity ( $r = 13.21$ ,  $r = 12.24$ , significance of differences is  $p \leq 0.05$ ). In the other methods, no significant differences between the groups were found.

The adolescents with low user activity (up to 3 hours on weekdays and weekends) showed average results in many methods. Thus, they slightly worse performed counting operations in their heads ( $r = 0.94$ ,  $p \leq 0.05$ ) than the adolescents with medium user activity but significantly better than the adolescents from the groups with high activity. The same patterns were observed in the method for visual memory; the adolescents with low online activity showed quite high scores when they reproduced patterns the first time but had lower scores than the adolescents with medium activity (significance of differences is  $\leq 0.05$ ). In the Wechsler subtest Knowledge, the adolescents from this group showed better scores than the adolescents from the groups with high online activity but slightly worse than the adolescents with medium activity ( $r = 14.52$ ,  $p \leq 0.05$ ). In the method for studying auditory verbal memory, the adolescents from this group had more inaccuracies, repetitions of words and transfers to another group of words to be

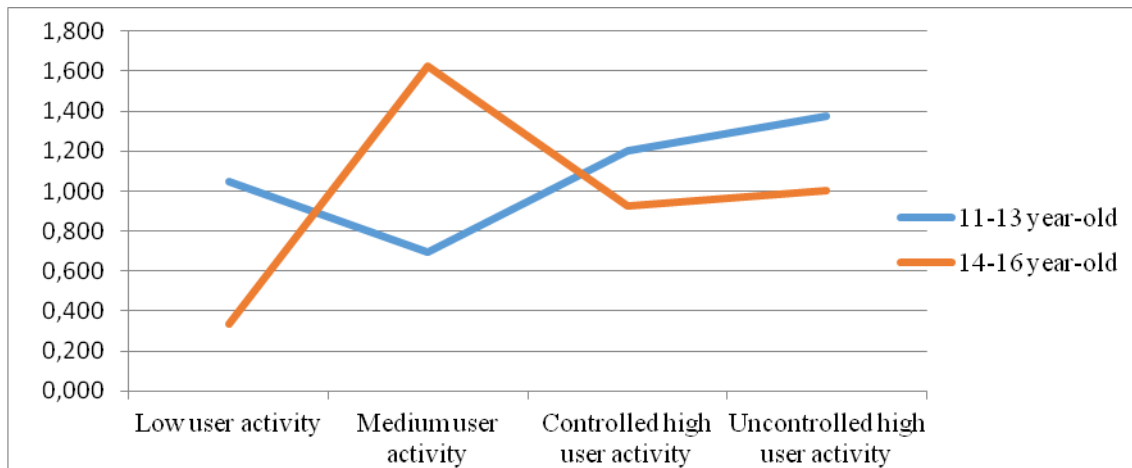
memorized (significance as a trend) than the others. In the Dots test, they responded slower than the others to the presented stimuli, that is on average they had the longest reaction time in all the three series of tasks (0.56 second, significance of differences is  $p \leq 0.05$ ).

On average the adolescents from the groups of controlled and uncontrolled high online activity coped worse with the proposed tasks than the others, with the exception of the reaction time in the computer test Dots where their performance was the same as the performance of the “medium” group (0.50 second). They worse performed counting operations in their heads than the other adolescents and on average made 1-2 errors without self-correction (controlled high user activity  $r = 1.11$ , uncontrolled high activity  $r = 1.47$ , significance of differences  $p \leq 0.05$ ). The effectiveness of memorizing patterns in the method for visual spatial memory of the adolescents with high user activity during the first-time reproduction of patterns differed significantly. At the first-time reproduction, they memorized 2-3 patterns from the series of five patterns (controlled high activity  $r = 2.95$ , uncontrolled high activity  $r = 2.75$ ). Despite the low performance of visual memory, the adolescents from these groups rarely had inaccuracies and added non-existent patterns which indicates a good selectivity of their visual memory while it has small capacity. In the Wechsler verbal subtest Knowledge, on average the adolescents from these groups got lower score than the adolescents from the other groups. This indicates insufficient erudition and verbal intelligence of the adolescents with this intensity of online activity.

Thus, some optimum time spent by adolescents on the Internet was observed in our study. The adolescents who spend from 3 to 5 hours online are better oriented in conditions of tasks, have better control over the implementation process, make less mistakes, have better immediate visual memory capacity and good selectivity of auditory verbal memory. They show greater knowledge and erudition, demonstrate better awareness. The adolescents with low online activity demonstrate an average level of cognitive development comparing to the adolescents from the other groups, except for the reaction time in the computer test where they reacted more slowly than the others. The adolescents from the groups with high online activity coped worse with the proposed methods which indicates a reduced level of cognitive development comparing to the other groups.

## **6.2. Differences in the results of the neuropsychological tests for the two age groups with different online activity**

According to the results of the multivariate analysis of variance MANOVA, differences in neuropsychological indices were observed depending on the age and online activity of the respondents, which examined functions of programming and control, serial organization, including in verbal functions (in storytelling), and visual spatial functions. The greatest number of differences related to the type of online activity and age of the respondents was presented in the method Story Based on a Series of Plot Pictures under the following parameters: programming the story, average phrase length, grammatical structure of the story.

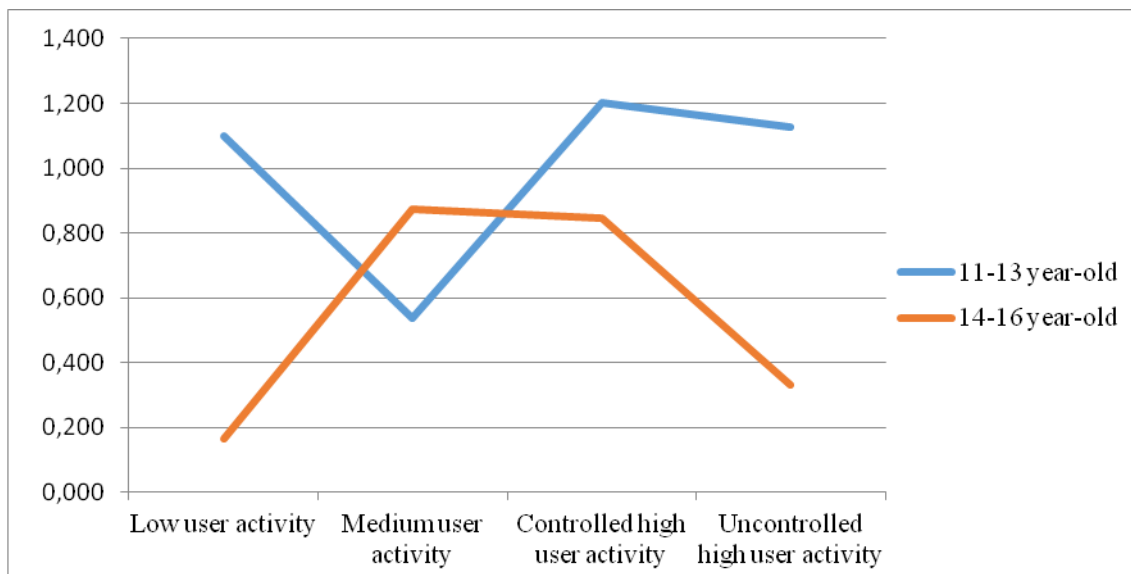


**Figure 01.** Programming the story. Error scale.

Figure 01 shows the differences in the two age groups depending on online activity in accordance with the Programming Story Scale. The Programming Scale shows how complete and informative the story is. The absence of errors is when all semantic units and their correct sequence are present (0 points are given). The maximum number of errors is coded by 4 points and indicates the failure to create a coherent text. Among the adolescents from the younger age group, the adolescents with medium online activity had the smallest number of programming errors: usually their story included all semantic units in the correct sequence and had reasonable links. The adolescents with low online activity coped slightly worse. The adolescents from the groups with high online activity had significantly more errors in programming a story (significance of differences is  $p \leq 0.01$ ). This means that when creating an oral story, they missed semantic links, had repetitions and made breaks in the narrative, their story was more like a listing of the details of pictures.

The older adolescents had a different pattern: the adolescents with low online activity programmed a story much better than the others ( $r = 0.33$ ); on the contrary, the adolescents with “medium” activity made more programming errors comparing to the others ( $r = 1.62$ ); the adolescents from the groups with “high” activity showed average results (see fig.01).

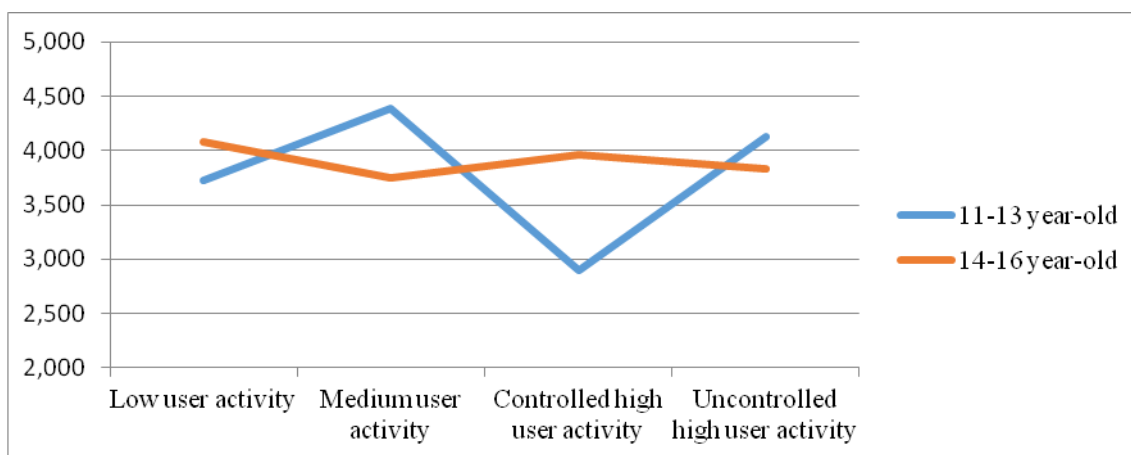
The index with a large number of differences was also the scale Grammatical Structure of the Story, which tests the functions of serial organization. The absence of errors is coded as 0 points; the maximum number of errors is 3 points (agrammatism and multiple syntactic errors, omissions of the verbal predicate). In the two age groups, the opposite trend is observed.



**Figure 02.** Grammatical structure of the story by the adolescents from the two age groups with different user activity

Among the adolescents from the younger age group, the adolescents with medium online activity better structured the story grammatically than the others. The adolescents with low activity and adolescents with high activity made significantly more errors of this kind (see Fig. 02). In the older age group, the adolescents with both low and uncontrolled high activity better than the others grammatically structured the story (significance of differences is  $p \leq 0.05$ ). In this age group, the adolescents with medium and controlled high activity made more grammatical errors than the others.

Significant differences were also noted in the results of the method for visual spatial memory. This method tests visual memory capacity and maturity of visual spatial functions.

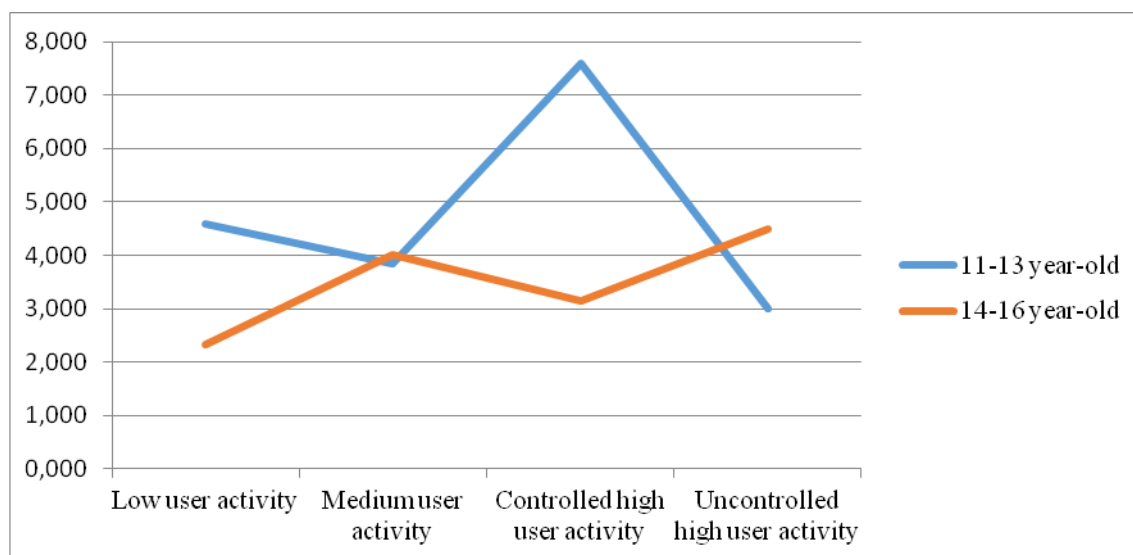


**Figure 03.** Efficiency of visual memory of the adolescents from the two age groups with different user activity

In the group of younger adolescents, the largest visual memory capacity was demonstrated by the adolescents with medium activity (on average, 4.38 patterns at the second time reproduction). Slightly worse were the results of the adolescents with uncontrolled high and low activity. The smallest visual memory capacity was demonstrated by the adolescents with controlled high activity (2.90 words on

average, significance of differences is  $p \leq 0.05$ ). For the older adolescents, there is no such variation in performance of the groups with different levels of online activity (see Fig. 03). The adolescents with medium and high user activity showed average results (3 - 4.5 figures on average); the adolescents with low online activity performed worse than the others.

Significant differences were observed on the scale Right Hemisphere Errors in the visual spatial memory.

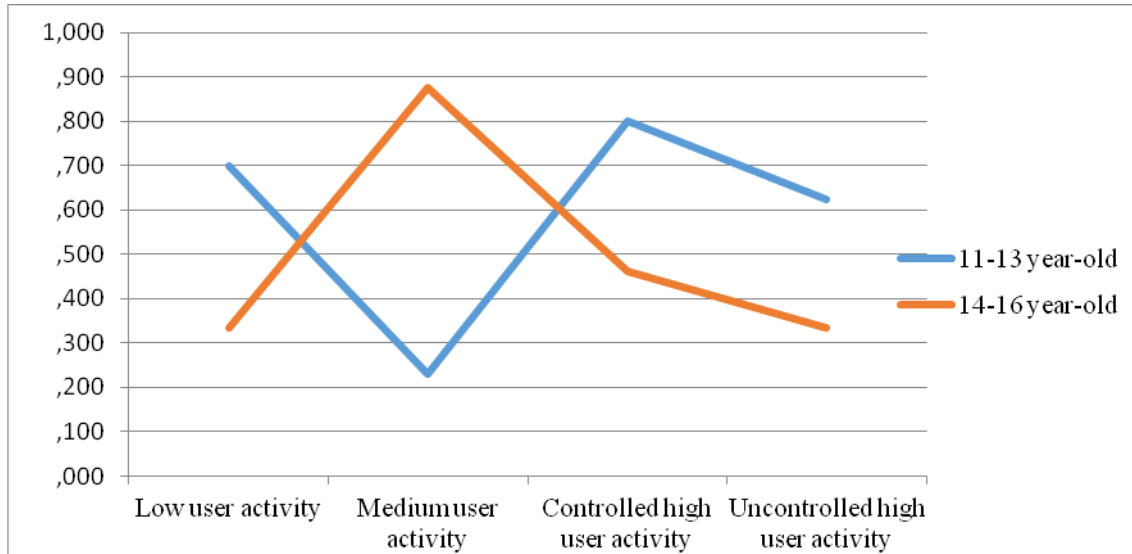


**Figure 04.** Right hemisphere errors by the adolescents from the two age groups with different user activity

For the younger adolescents, the following trend was observed: the adolescents with medium activity and adolescents with uncontrolled high activity made the least number of right hemisphere errors. The maximum number of this kind of errors was observed in the adolescents with controlled high online activity (significance of differences is  $p \leq 0.05$ ). In the older group there was no such variation in performance, and a different pattern was observed. The adolescents with low online activity had the smallest number of these errors ( $r = 2.33$ ). The adolescents with medium and high activity had higher number of right hemisphere errors (see Fig. 04).

Differences as a trend were observed in the background components of movements when undertaking a manual test in the two groups of the adolescents with different activity. This index tests the energy block of functions which includes hand muscle tone (background components of movements), performance, pace of activity, fluctuations of attention. The absence of tonic errors is 0 points; the presence of errors (incomplete clenching of the fist, unfinished movements, excessive amplitude of movements, increased tone) is 1 point.





**Figure 05.** Background components of movements by the adolescents from the two age groups with different user activity

In the younger age group, the smallest number of errors of this kind is observed in the adolescents with medium activity. The adolescents with low and high online activity have high scores (see Fig. 05). In the older age group, an inverse trend is observed - the adolescents with medium activity often have hand muscle tone and make inaccurate movements, and the adolescents with low and high user activity much rarely have these kinds of errors.

Thus, according to the results of this study, various profiles of the cognitive productivity of neuropsychological tests for the younger and older adolescents were obtained depending on the duration of Internet use per day. The pattern obtained throughout the sample is retained in the group of the younger adolescents. In this age group, such higher mental functions of the adolescents with medium online activity as voluntary regulation and control, serial organization of movements and actions, verbal functions, visual spatial memory were better developed than the ones of the adolescents with low and high activity. This was demonstrated by the better performance when undergoing neuropsychological methods. In the group of the older adolescents, this pattern was absent; the indicators of cognitive success depended less on time spent on the Internet. On average in the group of the older adolescents, the adolescents with low activity were better at storytelling and used better grammatical structures. At the same time, the adolescents from the group with high activity showed almost the same good results. Significant differences in the performance of visual memory depending on the online activity by the older adolescents was not observed.

## 7. Conclusion

In this study, differences in cognitive functions of adolescents with different online activity are identified and described. When analyzing the entire sample of the adolescents, the adolescents with medium online activity (from 3 to 5 hours per day) turned out to be the most productive in undertaking the neuropsychological tests. They showed the best performance in programming and control, visual spatial memory, and verbal intelligence. This gave us the opportunity to assume that 3-5 hours online,

including chatting in messengers and chats, is the optimum time that combined with offline activity contributes to the cognitive development and erudition of adolescents. When the adolescents were divided into age groups, the pattern of cognitive functions depending on online activity turned out to be slightly different comparing to the pattern when the adolescents were not divided. In the group of the younger adolescents, the obtained pattern preserved: the most successful in programming in terms of verbal functions and visual memory were the adolescents with medium online activity. But in the group of the older adolescents, this pattern following the main indices was absent or opposite. Thus, it can be proposed that the younger an adolescent is, the more the development of his/her cognitive functions depends on the time he/she spends online. It can also be proposed that for older adolescents the optimum time spent on the Internet is different. The obtained phenomena and patterns require further deeper analysis.

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