The Relationship of Media Multitasking to Adolescents' Productivity and Executive Functions

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Abstract. This exploratory research addresses the phenomenon of media multitasking being widely spread among children and adolescents in the context of digital socialization. The switch between different digital environments requires attention with regard to studying the relation of a media multitasking strategy to cognitive strategies and productiveness of activity. To research this problem a quasi-experimental study, including digital tasks of various types on a computer and smartphone, the dots task for executive functions and a socio-psychological questionnaire, was conducted with adolescents aged 15-17 (N=33). The results show that media multitasking is not related to user activity level and time required to fulfill the quasi-experimental tasks. The positive correlations of media multitasking with productive fulfillment of the quasi-experimental tasks, including the productivity of determined actions, and negative correlations with executive function were also found. The data partially correspond with previous studies but appear to be rather contradictory and should be further explored.

Keywords: Media multitasking, Multitasking, Cognitive function, Adolescents, Executive function

Introduction

Modern children are developing in new conditions mediated by adopting digital technologies into everyday life which cannot but have transforming influence on different cultural practices. Thus, data on population studies indicate that user activity of coming generation is growing significantly which altogether changes their lifestyle [31, 32, 33]. The digital world's specific characteristics that allow to simultaneously perform different activities with electronic devices, or integrate media and common sources of information, or combine offline and online activities stimulate a wider promotion of such strategy as media multitasking. Even ten-year-old intergenerational studies show [5] that children and adolescents actively adopt media multitasking and easily incorporate it into their lives. For example, while doing their homework, at the same time adolescents listen to music and message on social media networks. At the same time older generation frequently see simultaneous performance of several tasks as an unnecessary problem and try to avoid doing like that [16]. It is also shown that a more advanced user activity is related to media multitasking.

Thus, while studying, pupils and students use at least two or more media flows within 7.5 - 10.45 hours [27]. In 2014 Korean scientists discovered that 90% of university students work in a multitasking mode [8]. The students' answers show that during classes 69% of students text on messengers, 28% use Facebook and check their email, and 21% do something not related to their studies on their computers.

Let us briefly discuss what phenomenon media multitasking is and some of its research directions. People have started to regularly use the term media multitasking since 1990s; information technology began to actively enter people's daily lives then. Recent studies identify the phenomenon of media multitasking from the three perspectives: 1) as the simultaneous use of several media technology tools; 2) as the combination of using media and traditional sources of information; 3) as the combination of using offline and virtual activities [2, 4, 6, 7, 8, 11, 28, 29]. In other words, different variations of the term media multitasking can be explained by combining sources of information environment that are used by a person. In accordance with the Milgram and Kishino's continuum, information environment can be completely virtual, or mixed, or real [19].

One of the significant research areas in this field is to study the correlation of media multitasking with various cognitive processes in adolescents and youth: volume and shifting of attention, low stability and concentration of attention as well as cognitive control and executive functions [3, 4, 15, 20, 22, 23, 30, 33]. Many studies have shown a negative effect of media multitasking on cognitive processes, yet a number of papers have presented reverse conclusions. Heavier media multitasking has been associated with worse performance on fluid intelligence measures [20], on demanding working memory tasks [4, 11, 23], on task switching [23]. On the opposite, the study of American youth has shown media multitaskers are characterized by a developed ability to switch attention and cognitive control [1]. Other studies have demonstrated that respondents who media multitask have a broader scope of attention [4, 14]. One of the few studies of adolescents' executive functions and media multitasking showed an association between heavier media multitasking and better inhibitory control [2].

The methodology of media multitasking research has some weaknesses. Most studies in this area rely on self-assessment methods, for example Media Multitasking Index [20, 30]. Quasi-experimental and experimental schemes are rarely used in media multitasking research. Media multitasking studies are more often conducted on a youth or student sample, and data on children and adolescents are presented in few studies [2, 3, 24, 35].

Although increasing digitalization and rapid changes in everyday life are relevant issues, there is a lack of research in the area of media multitasking and principally studying this phenomenon among adolescents during their daily digital activity. Hence, the purpose of our study is to examine specific characteristics of cognitive functions in adolescents with different levels of media multitasking.

The hypotheses of the study are the following: H1) a preferred level of media multitasking is connected with user activity; H2) a preferred level of media multitasking is connected with productivity; H3) a preferred level of media multitasking is connected with the time needed to perform the tasks; H4) a preferred level of media multitasking is connected with executive functions.

1 Methods and Procedure

1.1 Methods

The following methods were used in the study: 1) socio-psychological questionnaire on sociodemographic characteristics, intensity and features of online user activity; 2) quasi-experimental scheme of multitasking mode when using a computer and smartphone; 3) the Hearts and Flowers dots task in the modification of T.A. Akhutina, A.A. Korneyev, A.N. Gusev [10]; 4) by using the Entsefalan 131-03 (21/26 channels) electroencephalograph-analyzer, recording cognitive evoked potentials following auditory stimulation.

In the context of our study, we operationalized the concept of media multitasking as shifting among different types of digital tasks or their parallel performing. Unlike other studies that often use self-assessment tools (Media Multitasking Index) [17, 23, 28], we also developed and used a quasi-experimental scheme to reproduce the conditions of everyday media multitasking. The scheme comprised a number of tasks reproducing typical students' activities. The tasks included: 1) searching online for the definition of an unknown word; 2) solving several arithmetic tasks and tasks on rearranging syllables in several words in Google forms; 3) reading an online text; 4) watching a short video; 5) answering the questions from 3 messages sent to the mobile phone during the experiment.

To study executive functions and cognitive control, the dots task was used. This task required to press the response button in reaction to the signal. This task was performed on a computer and included 3 blocks with gradual increasing of complexity: a block of 20 congruent trials (with all the responses on the same side to a dot (heart) appeared); a block of 20 incongruent trials (with all the responses on the opposite side opposite to a dot (flower) appeared; a mixed block of 20 trials combining both congruent and opposite probes. The main parameters were the quality of performance (number of correct answers) and average response time.

1.2 Sample

The study sample comprised 33 adolescents aged 14 to 17 (mean=15,9) - 28 girls and 5 boys.

1.3 Procedure

The study procedure consisted of recording evoked potentials, quasi-experiment, performing dots task, and filling out a questionnaire. During the quasi-experiment, the participants were sitting with their own smartphones at the interviewer's computers. The participants used their own smartphones, which could differ in some technical characteristics. The main requirements were: Internet access and the devices' habitualness. The participants received printed instruction with a tasks list and the following oral instructions from the interviewer: "Now you will have to complete several tasks.

They are written on this paper. Please, read and remember what you will have to do. You will not have the opportunity to look at it again. You should complete them as quickly as possible in any order". Then, the printed instruction was taken. Four windows were opened on the screen. Every 2 minutes the interviewer sent a message with the question. During the experiment, five different music segments were played in the background (croaking of frogs, drums, guitar, chorus from a children's song, the sound of the surf). After completing the tasks, the interviewer asked several questions about the meaning of the text, a few details about the video, music, and then, after filling out the questionnaire, the definition of the word searched on the Internet. The data were collected in 2019.

1.4 Data processing

The data were processed using IBM SPSS Statistics 14. The correlation analysis of data was performed using the nonparametric Spearman correlation coefficient.

2 Results

2.1 Level of media multitasking

Level of media multitasking was measured following the number of switches while performing the tasks in the quasi-experiment. The number of switches was determined as follows: it has been recorded how many times a respondent returned to a task after he/she at first started the task and without finishing it, switched to the other tasks, and then returned to the original one again. The sum of such additional returns to all the tasks has been estimated. The mean value of the number of switches is 4.5; minimum is 0 (N=3) and maximum is 12 (N=3).

2.2 Media multitasking, time and productivity

For evaluating the results of performing the quasi-experimental tasks, three indices were used: general productivity, productivity of determined actions and productivity of undetermined actions. Depending on the quality of performing a task and its content, different number of points (min=0, max=4) was given. Thus, memory, analysis and comprehension tasks had a higher score than arithmetic and anagram tasks. General productivity of performing the quasi-experiment comprised the sum of points for all the task. The productivity of determined actions was evaluated based on the tasks clearly defined by the instruction (solving arithmetic tasks and anagrams, searching online for information, reading a parable). The productivity of undetermined actions was evaluated based on the tasks not given in the instruction (recognizing background audio pieces sounded during the quasi-experiment, answering to the questions about small details in the watched video, reproducing the definition of the term found online).

The nonparametric Spearman correlation coefficient between involuntary and voluntary components appeared to be insignificant (r=0.228, p=0.2) which may indicate certain independence of these indices.

Based on the general productivity index, the respondents can be divided into three groups: the group with the high level of general productivity consisted of 7 persons; the group with the moderate level consisted of 18 persons; the group with the low level consisted of 8 persons (mean±SD=4.5±3.3 points). In accordance with the productivity of determined actions, the group with the high level consisted of 5 respondents, with the moderate level consisted of 22 respondents, with the low level consisted of 6 respondents (mean±SD=6.5±1.9 points). In accordance with the productivity of undetermined actions, the group with the high level consisted of 6 respondents, with the moderate level consisted of 22 respondents, with the low level consisted of 5 respondents (mean±SD=8±2.6 points).

The time needed to perform the experiment positively correlates to general productivity (r=0.425, p<0.014) and productivity of undetermined actions (r=0.537, p<0.001). The productivity of determined actions does not correlate to overall time needed to perform the experiment. The number of switches positively correlates to general productivity (r=0.491, p<0.01) and productivity of determined actions (r=0.516, p<0.01). The correlations of number of switches with productivity of undetermined actions and time needed to perform the quasi-experiment are not found.

2.3 Media multitasking and user activity

User activity was calculated as an average time for time online on weekdays and weekend. Average time for user activity was 5.43 hours (min=1 h, max=12, SD±3.18). Significant correlations of user activity level with number of switches, overall time needed to perform the quasi-experiment, indices of general productivity, productivity of determined and undetermined actions are not found.

2.4 Media multitasking and executive functions

Three respondents were not included into data processing because they had given no right answers while had been performing the dots task. Upon analyzing the results of the dots task, the following was obtained: the number of switches between the tasks during the quasi-experiment negatively correlates to the number of correct answers in the second incongruent series of the dots task (r=-0.378, p=0.039). The index of general productivity correlates with the index of average time needed to perform the first congruent series of the dots task (r=0.447, p=0.013) and number of correct answers in the second incongruent series of the dots task (r=0.388, p=0.034). The productivity of determined actions correlates with the index of average time needed to perform the first congruent series of the dots task (r=0.4, p=0.028).

2.5 Media multitasking and evoked potentials

Upon analyzing evoked potentials, the negative correlation of amplitude N2 with the number of switches between the tasks of the quasi-experiment ($r=-0.457$, $p<0.013$) was shown. Amplitude P2 also negatively correlates to the number of switches between the tasks of the quasi-experiment ($r=-0.414$, $p<0.026$).

Discussion and conclusion

In accordance with the accepted definition of media multitasking, we regarded the number of switches as its main index [25]. The majority of the adolescents who took part in this study (91%) more or less prefer the media multitasking strategy. Such data correlate with existing studies showing high level of media multitasking among adolescents and youth [8, 27]. All the respondents demonstrate advanced digital activity, given that, in this sample, the correlation with the level of media multitasking is not found. Yet, foreign studies show the positive correlation between the level of media multitasking and advanced user activity [12, 16, 18]. Hence, hypothesis 1 was not confirmed in our empirical data. The obtained results of absent correlation can be determined by the sample size and its homogeneity in relation to user activity.

For analyzing the task performance productivity, three indices were used - general, productivity of determined actions and productivity of undetermined actions. Such approach allowed analyzing the obtained data at the quality level. It was assumed that, as a complicated process, multitasking is related to both voluntary and involuntary cognitive functions. The study shows that productivity of determined actions and productivity of undetermined actions are not related, that is, they are independent indices. In addition, productivity of determined actions more correlates with general productivity. Rather high indices of general productivity and productivity of determined actions are typical for adolescents choosing a more media multitasking strategy. However, in regard to productivity of undetermined actions, such tendencies are not revealed. Thus, we can assume that modern adolescents actively engaged in mixed reality, switching between offline and online, and different digital environments deliberately use the multitasking strategy and to a certain extent achieve a better result. Hence, hypothesis 2 was confirmed. Yet, the obtained data do not correspond with a number of studies [9, 15] which requires further more extensive research.

Hypothesis 3 was not confirmed. The speed of task performance in the format of our quasi-experiment did not depend on an adopted behavior (single-tasking or multitasking) strategy in digital environment.

Upon studying executive functions by using the dots task, it was shown that choosing a more single-tasking strategy stipulating sequential and thorough performance of the tasks given in the instruction during the quasi-experiment is related to the higher indices of executive functions. For single-taskers, smaller number of occurring mistakes in the incongruent series of the dots task is common, that is, a delay of an unsuitable answer. It may indicate a lower level of impulsivity. Thus, hypothesis 4 was partially confirmed.

It also correlates with the data of some studies linking adolescents' media multitasking with a lack of cognitive control and higher level of impulsivity effecting executive functions [14, 17, 19].

The results of analyzing evoked potentials show that the greater the amplitudes of N2 and P2, the more single-tasking strategy to solve tasks is chosen by a respondent. According to the study data, the spike of N2 is related to correct stimulus recognition and working memory processing [4, 21]. The spike of P2 is responsible for analyzing received information and its initial processing, that is, single-taskers analyze information more in depth while solving tasks [26].

Thus, the obtained data of our exploratory research indicates an ambiguous and complicated correlation of media multitasking with different adolescents' cognitive processes and some indices of their activity such as user activity, productivity and time needed to perform tasks. On the one hand, adolescents choosing media multitasking as a strategy in digital environment appeared to be more productive, including in the context of random task performance, though not faster than less media multitaskers. On the other hand, greater impulsivity and lower indices of executive functions, working memory, information processing are typical for media multitaskers. Sample size and unbalance by gender should be specified as research limitations. The obtained results require further more in-depth research in this field. Today's adolescents are to some extent forced to act in media multitasking mode in the context of the lifestyle digitalization. In this situation, it is important to understand the limitations and opportunities that media multitasking strategies offer.

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