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Research Article

THE RELATIONSHIP BETWEEN MEDIA MULTITASKING, WORKING MEMORY AND SUSTAINED ATTENTION*

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ABSTRACT

Using more than one device simultaneously is almost inevitable in our daily lives because we face an overload of information and digital devices. As a result, the effects of multitasking on working memory and sustained attention have become a popular research topic in the literature, even if with inconsistent results. The current study aims to examine the effects of media multitasking behavior on sustained attention and working memory with a sample of Turkish young adults. Continuous Performance Task (CPT) and Digit Span tasks were employed for sustained attention and working memory, respectively. The results showed that media multitasking correlated positively with digit span task performance and negatively with the reaction time of false response in the CPT task. That is to say, media multitasking may improve working memory performance but inhibit maintaining attention. The results are discussed in the light of theories of limited capacity, multiple resources, and neural plasticity.

Key words: *sustained attention, working memory, media multitasking, neuroplasticity, cognitive capacity*

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Çoklu Medya Görevi ile Çalışma Belleği ve Sürekli Dikkati İlişkisi

ÖZET

Teknoloji çağında doğan ve büyüyen gençler, dijital cihazları az bir çaba ile adeta uzman düzeyinde kullanabilmektedir. Öyle ki, birden fazla medya cihazının eş zamanlı veya aralarında geçişler yapılarak kullanımı olarak tanımlanan Çoklu medya görevi (ÇMG) davranışı özellikle gençler tarafından sıklıkla gerçekleştirilmektedir. Teknoloji tüketimi günden güne artış gösterirken, teknoloji kullanımının bilişsel düzeydeki sonuçları ile ilgili çalışmalar da artış göstermektedir. Ancak bu çalışma sonuçları özellikle çalışma belleği ve sürekli dikkat yetileri açısından karmaşık sonuçlar ortaya koymaktadır. Mevcut araştırma ise, daha önce çalışılmamış olan Türk gençleri örnekleminde çoklu medya davranışı ile sürekli dikkat ve çalışma belleği performansları arasındaki ilişkiyi incelemeyi amaçlamıştır. Çalışmada çalışma belleği ve sürekli dikkat yetilerini ölçmek için sırasıyla, Sayı menzili ve Sürekli performans testi (SPT) görevleri kullanılmıştır. Sonuçlar, daha yüksek ÇMG bildiriminin daha iyi çalışma belleği performansı ile ve daha kötü sürekli dikkat performansı ile ilişkili olduğunu göstermiştir. Elde edilen bulgular, kapasite ve çoklu kaynak teorileri ile nöroplastisite ışığında tartışılmıştır.

Anahtar kelimeler: *sürekli dikkat, çalışma belleği, çoklu medya görevi, nöroplastisite, bilişsel kapasite*

Introduction

The network era offers us an inevitable technological environment which is available at all hours of the day and night. Since almost all media devices have some common functions, they can be used interchangeably or simultaneously for the same or different purpose. This kind of media usage, which offers us opportunity for saving time is called "*Media multitasking*" (Ophir et al. 2009; Lang et al. 2015) and it is widespread especially among teenagers (Voorveld et al. 2013: 392; Van der Schuur et al. 2015: 204) who are growing up in the digital environment by adapting to it (Choudhury et al. 2013). The "screenagers" (Choudhury et al. 2013: 2) use many digital tools in this manner and can use their smartphones for social media networks while watching TV and using computers for reading news.

Turkey is a developing country that has a large young population who consume technology rapidly. Turkish Statistical Institute (TÜİK) reported that the internet (84,3 %) is the most common information and communication technology (ICT) followed by the computer (68,4 %), and overall usage statistics showed that while cell phone or smartphones (97 %) are most popular digital tools, notebook (36,4 %) and tablet (30 %) usage is increasing (TÜİK 2016). According to a large-scale online research in 37 countries, young people in Turkey spend 36 % of their online time with media multitasking. That is comparable with America (41 %) and some Europe countries (Spain, Italy, Germany, France, Czech Republic, Poland, Hungary, Romania and Slovakia) (average 32,5 %) where most of the studies on multitasking effects were executed (Kantar Millward Brown 2014a). Although, intensive media multitasking among young persons alerted researches to the possible cognitive effects of the media multitasking (e.g. Ophir et al. 2009; Colom et al. 2010; Cain et al. 2011; Minear et al. 2013; Yap et al. 2013; Unchapher et al. 2016), there is no research about media multitasking and its cognitive effects in Turkey, which has a large young population. Because of that reason, the main aim of the study is examining relationship between media multitasking intensity, working memory, and sustained attention in the Turkish young population.

In the literature participants are generally divided into two groups as heavy and light media multitaskers by their Media Multitasking Index scores (MMI, Ophir et al. 2009) according to cut-off scores that vary from study to study (see Ralph et al. 2017: 583). Although comparing heavy and light media multitaskers may be useful, this division loses some of the information in the data (see Cardoso-Leite et al. 2016). In the present study we considered media multitasking behavior as a continuum. Participants were asked to report their daily amount of media multitasking by giving estimates of how many hours they use media multitasking in a day. In addition to avoiding problems of Likert scales, such as the central tendency bias, this inventory provided information that could be used to investigate whether different device combinations have differential relations with cognition. We also measured media multitasking with an adapted and updated version of the MMI. The inventory was expanded by adding items including more current devices (smartphone, tablet, PC, etc.) and current functions of the devices (e.g., social media applications).

Literature Review and Hypotheses

MT studies date back to Telford's (1931) psychological refractory period (PRP) experiments (Meyer et al. 1997: 4). Telford (1931) named the delay in the response to one of two stimuli presented with a short inter stimulus interval a psychological refractory period. This finding was interpreted as meaning that the mind has a single channel. The low performance and increased task completion time during MT supports the limited capacity hypotheses (Broadbent 1958; Pashler 1994). Similarly, the bottleneck theory (Broadben 1958; Pashle 1994) suggests that the mind has a bottleneck inhibiting dual task performance. For instance, Pashler (1994) showed that participants failed in executing two simple tasks (e.g. stop-signal, flanker) simultaneously. Kahneman (1973: 182-185), claimed that the bottleneck view failed to account for PRP phenomena and suggested that since the mind has a one-limited resource for inputs and outputs, more than one task could not be executed simultaneously (Borst et al. 2010: 369). According to the limited capacity views MM can lead to low cognitive performance, since multiple media usage demands more cognitive resources than the mind has (Lang 2006: 59; Jeong et al. 2016: 2-3).

Some tasks can be done simultaneously (e.g. walking and talking), however. This is consistent with the possibility of *perfect time sharing* (Welford 1984) between resources. This idea fits in with the multiple resource theories, which assert that the mind has more than one resource and some tasks can be executed simultaneously by using different resource pools (Navon et al. 1979; Wickens 1984; 2002). MT can provide efficient use of the cognitive capacity (Jeong et al. 2016: 13) because preferring different media combinations while multitasking means using different mental resources (e.g. visual-auditory or visual-language etc.).

Working Memory and Media Multitasking

MM requires task switching and division of attention between devices (Ophir et al. 2013: 15585). Furthermore, information received from one device must be retained in memory until the next step during switching and different usage styles and functions of the devices must be retrieved from memory. Moreover, sometimes the information in memory has to be manipulated to respond on any task. Because of these reasons, it is assumed that working memory has active role in media multitasking (e.g. Ophir et al. 2009; Colom et al. 2010). Working memory is generally defined as a function for storing information for a short time, keeping going on target act, executing tasks, switching attention between tasks, monitoring relevant information, inhibiting irrelevant stimuli/information and manipulating information by retrieving temporary information from short term memory or permanent information from long term memory (Baddeley et al. 1974: 77-80; Cowan 1988: 8; Baddeley et al. 1999: 29-33; Goldstein 2011: 238). Some existing results showed that intense media multitasking is not related with working memory capacity (Minear et al. 2013; Baumgartner et al. 2014; Cardoso-Leite et al. 2015; Edwards et al. 2017; Wiradhany et al. 2017), while others found a negative relationship (Ophir et al. 2009; Sanbonmatsu et al. 2013; Uncapher et al. 2016; Cain et al. 2016; Cardoso-Leite et al. 2016; Ralph et al. 2017). Ralph et al. (2017: 583) suggested that the reason for the inconsistency in the literature might be the absence of a standard in the tasks used in the studies. However, most of the research showed that high amount of media multitasking usage is related low working memory capacity.

H1: High media multitasking usage amount will be associated with low working memory performance.

Sustained Attention and Media Multitasking

Sustained attention can be defined as the ability to maintain relevant information for prolonged periods of time, and to detect and not to respond to irrelevant information or stimuli (Sepede et al. 2014: 261-262). In other words, sustained attention ensures detecting and inhibiting irrelevant stimuli while focusing attention on relevant targets. Assessment of sustained attention generally involves tasks in which participants are required to be vigilant and to respond to predetermined stimuli while inhibiting irrelevant stimuli over extended periods of time (Sarter et al. 2001).

Since media multitasking requires switching frequently between devices, it is thought that it requires sustained attention ability (Ralph et al. 2015: 391). In the literature, some of the results showed that sustained attention and media multitasking are not related, (Ralph et al. 2015; Moisala et al. 2016) but other studies found a negative relationship (Ophir et al. 2009; Ralph et al. 2014, Cardoso-Leite et al. 2015). Ralph and colleagues (2015) used four different task measuring sustained attention and did not find any relation with MM. In the self-report study of Ralph et al. (2014), HMMs reported daily attentional lapses more than light media multitaskers (LMMs). Ralph and colleagues (2015) suggested that HMMs may prefer not to avoid distractors from their own digital environment. On the other hand, Cain and Mitroff (2011) suggested that HMMs might have wider attentional span and that can help them to maintain attention. They claimed that single tasks used in labs might not be sufficient to differentiate heavy and light media multitaskers in terms of sustained attention performance. According to Ophir and colleagues' (2009) research results, heavy media multitaskers had difficulties inhibiting distractors, detecting changes in the visual pattern and controlling their attention to use task-relevant information. Since during media multitasking many cognitive abilities become a part of the activity, cognitive load might be forced to sustain attention (Ophir et al. 2009). Cardoso-Leite and colleagues (2015) also replicated Ophir and colleagues' (2009) study and likewise found negative relationship. As a sum, it is supposed that media multitasking can disrupt sustained attention and the assumption supported by the literature predominantly.

H2: High media multitasking usage amount will be associated with poor sustained attention performance.

Method

Participants

One hundred and twenty undergraduate students (96 female) aged 18 to 33 (mean age = 21, 89 years, SD = 1.80*)* of Uludag University participated voluntarily to the study. One participant was removed from the sample because of an outlier was excluded from the study, the sample was 119 students. Target population of the study was from the faculty of science and letters and they were balanced in terms of departments to provide sample representativeness. The science students were from department of Math (14,2 %), Biology (21,7 %), Chemistry (11,8 %) and Physics (0,8 %) and they made up % 49 of the sample. Social sciences and humanities students were from department of Psychology (25,8 %), History (3,3 %), Sociology (0,8 %), Literature (7,5 %), Philosophy (6,7 %) and History of art (6,7 %) and they made up 51 % of the sample.

Materials

Media Multitasking Usage Inventory

To measure media multitasking usage amount of the participants, an inventory was adopted from MMI (Ophir et al. 2009) was formed by changing some of the items. MMI has 12 forms of media (TV, music, non-musical audio, video or computer games, video, telephone and mobile phone, instant messaging, SMS (text messaging), computer programs (word processing, storing data etc.), surfing on the net, and email). The inventory had two parts and 62 items in total (Cronbach's α = 69.5). The first part included questions on daily estimates (How many hours do you use the media devices below simultaneously in a day?) of media multitasking between media devices (TV, Notebook, Desktop PC, Tablet PC, Phone/Smartphone) and the second part included question about daily estimates of concurrent usage between the media device functions (Talking on the phone, Texting/reading SMS, Texting/Reading e-mail, Surfing on the net, using computer programs, playing computer game and listening to music). The devices and their functions were organized as a table separately. Daily mean media multitasking was the average of all the numbers of hours reported in these tables.

Continuous Performance Test (CPT)

CPT developed by Rosvold et al. (1956). Karamürsel (1994) computerized the Turkish version. The Turkish version uses Z in place of X, because X is not a letter in the Turkish alphabet (Zaimoğlu 1997). In the present study the stimuli consisted of letters presented for 160 ms and the Interstimulus Interval was 800 ms. Participants were told to press spacebar in the keyboard when they see letter "A" following letter "Z". Target stimuli "A" (following Z) were 20 % of total stimuli. Omissions, number and reaction time of false response were determined for each participant. Greater number of omission errors is thought to be a sign of inattention; false response reaction time gives information about inattention and impulsivity (Zaimoğlu 1997).

Forward and Backward Digit Span Tasks

Digit span tasks adapted from Wechsler Intelligence Scale for Children- Revised (WISC-R) standardized by Savaşır et al. (1995) were used for assessing working memory capacity. Digit span tasks measure short term memory, working memory and basic attention (Öktem 2004 in Tekeli 2013). The limits for normal Turkish people are 6 for forward and 4 for backward span (Peker et al. 2009).

Procedure

Participants first read the written informed consent and then filled the questions about their demographical information, technology ownership status and daily usage amounts of the technology which they have (How many years do you have the media devices below and How many hours do you use the devices in a day?) and average daily amounts of MM. After the Inventory participants ‘cognitive abilities were assessed via Continuous Performance Test (CPT) and Forward and Backward Digit Span respectively. Before the tasks all participants informed about the procedure and provide short practice in the CPT task. Also, participants were given verbal fluency task and they were asked their average daily and yearly amounts of using ICT. Since the data was collected as part of another study, examining relationship between technology use status and memory, executive functions and attention, the results do not given in the current study.

Open sesame 2.9.5 software (Mathôt et al. 2012) was used in the study and stimuli were presented on a notebook with 15.6 inch screen, 2.6 GHz, and Windows 10 operating system. Participants were tested in the psychology department laboratory individually and completing the entire study took approximately 20 minutes.

Results

Descriptive statistics and correlations between media multitasking and the cognitive task parameters can be seen in Table 1. According to the Kolmogorov Smirnov test (Table 2), data were not normally distributed ($p < .001$). Therefore to test whether there is any relationship between cognitive measurements and amounts of using MM, the data were analyzed with Kendall’s tau correlation (r_τ).

Table 1. Descriptive statistics and correlations of MMI, Digit span and CPT task

	M	*SD*	**1**	**2**	**3**	**4**	**5**
1. Daily MM	.34	.32	–	.07	.08	.01	-.14
2. Digit Span	5.69	1.04		—	**-.17***	-.02	-.05
3. CPT Omission	.31	.99			—	-.03	.04
4. CPT RT of False responses	.43	.78				—	**.52****
5. CPT Number of False responses	348.62	142.25					—

Table 2. Kolmogorov-Smirnov Normality test for the dependent variables

	Kolmogorov-Smirnov [a]	
Dependent variables	Statistic	*p*
CPT omission	.47	< *.001*
CPT RT for false responses	.43	< *.001*
CPT number of false responses	.42	< *.001*
Digit span	.13	< *.001*

Working Memory

Daily mean media multitasking and WM were not related significantly (p = .273) (Table 3). However, working memory performance was related with concurrent texting/reading SMS and playing game (r_τ = .16, p = .039), TV and Tablet PC (r_τ = .19, p = .020), TV and phone/smartphone (r_τ = .21, p = .004), Tablet PC and phone/smartphone (r_τ = .17, p = .028) positively (Table 3).

Table 3. Media multitasking with device, functions and WM

r_T		1	2	3	4	5	6	7	8	9	10
1.	Digit Span	—	.10	-.10	**.19***	**.21****	.06	-.03	-.02	**.17***	**.16***
2.	TV & Notebook			.16	.09	.46**	-.04	**.20***	.02	-.11	-.09
3.	TV & Desktop PC				.10	.20*	-.04	-.01	**.35****	.10	-.01
4.	TV & Tablet PC					.16	.10	-.05	.12	**.33****	.09
5.	TV & Phone/Smartphone						-.14	-.00	.11	-.08	-.10
6.	Notebook & Tablet PC							.08	-.06	.12	.05
7.	Notebook & Phone/Smartphone								.02	.09	.10
8.	Desktop PC & Phone/Smartphone									**.20***	-.03
9.	Tablet & Phone/Smartphone										**.16***
10.	SMS & Game										—

**p< .01
*p< .05

Sustained Attention

Daily mean media multitasking and CPT performance (omission (p = .302), number of false responses (p = .855), RT for false responses (p = .906)) were not related significantly (Table 4). However, concurrent TV watching and Notebook/Netbook use were significantly and positively correlated with CPT task reaction time of false response performance (r_τ = .29, p = .013). There was no relationship between media multitasking with functions of the devices and sustained attention task parameters.

Table 4. Media multitasking and Sustained Attention

	1	2	3	4	5	6	7	8	9	1
1. CPT RT for false responses	—	**.52****	-.16	**.29***	.13	-.01	.08	-.15	.14	.
2. CPT number of false responses			.04	.07	.06	-.04	-.04	-.11	.01	.
3. CPT omission				-.06	.09	-.12	.02	-.08	-.03	.
4. TV & Notebook					.16	.10	**.46****	-.04	**.20***	.
5. TV & Desktop PC						**.10**	**.20***	-.04	-.01	.
6. TV & Tablet PC							.16	.10	-.05	.
7. TV & Phone/Smartphone								-.14	.00	.
8. Notebook & Tablet PC									.08	-
9. Notebook & Phone/Smartphone										.
10. Desktop PC & Phone/Smartphone										
11. Tablet & Phone/Smartphone										

** p < .01
* p < .05

Discussion

The current study aimed to examine the effects of media multitasking intensity on working memory and sustained attention. It was hypothesized that greater media multitasking would be associated with low working memory and low sustained attention performance. The results partially supported the hypotheses. However, the current results present some new and surprising information.

Discussion on the Working Memory Results

It has been hypothesized that working memory can overcome the cognitive load which results from switching between media devices. However, that hypothesis could not be supported to date (Ophir et al. 2009; Cain et al. 2011; Minear et al. 2013; Baumgartner et al. 2014). The current results showed that there are positive relationships between working memory and some kinds of media multitasking behaviors. According to the results, working memory, thought as an important function in terms of executing simultaneous tasks, was not related with the daily average amount of MM. Other researchers (Ophir et al. 2009; Cain et al. 2011; Minear et al. 2013; Edwards et al. 2017; Wiradhany et al. 2017) obtained similar results. However, the results showed that concurrent use of some functions of media devices were related with working memory performance. Concurrent TV watching and using phone or tablet PC, texting/reading SMS and playing computer game, Tablet PC and phone/smartphone were positively related with working memory performance. TV and smartphone are most common media devices used in Turkey and also they are generally used simultaneously (Kantar Millward Brown 2014b). Since TV is not an interactive device, people may prefer to use other handheld smart devices for communication, checking on their social media accounts, reading news or any other reason simultaneously with watching TV. Concurrent use of tablet PC and smartphone is an interesting result, because they have similar functions and generally the same software (e.g. Android). However, this similarity may provide switching facility and cause intense use of working memory. Some studies on the relationship between video games and working memory (Blacker et al. 2013; Colzato et al. 2013; McDermott et al. 2014) found positive relationships, while other studies did not (e.g. Ballesteros et al. 2018; Bediou et al. 2018; Boot et al. 2008; Unsworth et al. 2015). Thus, the result seems inconsistent with the literature. Jeong and Hwang (2016) examined cognitive outcomes of MM as a function of user control, number of the shared modalities, task contiguity, task relevance, task hierarchy. They found that whether the user has control of MM activity, tasks have related content and MM devices have spatial contiguity can affect the cognitive outcomes. The results of higher WM correlated with the SMS and game multitasking may reflect that content of the tasks or the user having control while multitasking may be relevant as suggested by Jeong and Hwang (2016).

The results are also consistent with the neuroplasticity account. Multitasking should require practicing working memory because it involves switching between devices or their functions. Working memory performance may increase with practice and daily activities may provide cognitive improvement because of the plasticity of the brain (Jak 2012: 284; Choudhury et al. 2013: 16; Loh et al. 2016). Although it is debated whether working memory training transfers to different working memory and other cognitive tasks (Melby-Lervåg et al. 2012; Shipstead et al. 2012; Harrison et al. 2013; Hsu et al. 2015; Cardoso-Leite et al. 2015; Hsu et al. 2017; Linares et al. 2017; Clark et al. 2017; Blacker et al. 2017), multitasking might provide practice or training for working memory performance (Anguera et al. 2013: 98; Van der Schuur et al. 2015: 206).

Discussion on the Sustained Attention Results

Since media multitasking involves switching and allocating attention between devices, maintaining attention is needed for avoiding any possible mistakes during MM. In the present study, no relationship was found between average daily media multitasking and sustained attention scores. However, simultaneous TV and notebook usage is related positively with CPT reaction time of false response. That is, the more multitasking with TV and notebook people do, the more they experience lapses on attention and make mistakes. As in online surveys, the current sample showed that simultaneous use of TV and notebook is the second most preferred media multitasking behavior (the first one is simultaneous use of TV and smartphone) (Kantar Millward Brown 2014b). Maintaining attention may become difficult during simultaneous use of TV, which presents a large number of stimuli, and notebooks, which are used interactively. The results were consistent with Ralph and colleagues' (2014) self-report study, but not with Ralph and colleagues' (2015) performance based study. That might result from how media multitasking measured and the different tasks that were used. In the current study sustained attention was measured with a single task and the task may have been more difficult to maintain for multitaskers, because it was simple but monotone. Therefore, participants would find it difficult to focus constantly to catch the target stimulus. Also, Ralph et al. (2015: 400) suggested that media multitasking effect might be seen more explicitly in daily life by heavy multitaskers. However, the current study showed media multitasking intensity effect also in a laboratory setting. As a result, some forms of media multitasking might make sustaining attention difficult because that requires focusing on one task (Gunzelmann et al. 2010). Therefore, multitasking with media devices may impair focusing ability by distorting the prolonged performance.

Conclusions

Overall, it was seen that media multitasking was related positively with working memory and negatively with sustaining attention. Both the limited capacity and the multiple resources theories may account for these results. MM may reduce attentional performance as a result of limited mental capacity because TV- Notebook multitasking requires different kinds of resources at the same time and also Notebooks need more intensive hand use (for keyboard and mouse or touchpad) than touchscreen devices. It can be inferred that if mental capacity is limited, TV-Notebook as an attention demanded kind of MM may distort attention performance.

On the other hand, working memory has different components for different kinds of input (visual-spatial sketchpad, phonological loop, etc.) and as suggested by the multiple resource hypothesis, that can enable efficient cognitive performance via the resources. That is to say, some kinds of MM, that need different input resources, might be executed easily due to working memory components enabling multiple input processing.

WM results may also reflect a training effect (Anguera et al. 2013: 98; Van der Schuur et al. 2015: 206) on working memory via neuroplasticity (Jak 2012: 284; Choudhury et al. 2013: 16; Loh et al. 2016). However, that needs to be supported by neuropsychological data. For sustained attention, on the other hand, switches between devices might cause unintended lapses on attention. Although the relationships are weak and some possible limitations might be affecting the results as argued before, the findings present new and essential information to the literature which is including studies that are reported negative or no relationships between MM and attention, memory. Also, this is the first study measuring MM with a daily metric measurement. It is thought that the multitasking level may differ day to day and the results showed that how many time students spend with multitasking is an essential variable. Another contribution of the study is that the study based on theoretical background on the contrary to the studies in the related literature.

The study has some limitations. The first limitation of the study is non-parametrical statistical analysis of the data. The distribution may result from the study sample, which was thought be highly representative but heterogeneous. Another limitation was the measurement of daily media multitasking amounts by self-report. Self-report studies have some risk about reflecting reality (see more information, Fan et al. 2006). It may be an improvement to test media multitasking in lab setups that are arranged similarly to a real-life media environment. In addition, the different results for the attention and working memory may reflect individual differences in cognitive capacity and MM preference. That is to say, individuals with low sustained attention may prefer MM with cognitively demanding tasks such as TV-Notebook while individuals with high WM prefer other kinds of MM.

As a final evaluation, the surprise findings might be reflecting differences in the technological history of the populations of current study. Although Turkey as a developing country has a large proportion of young population, ICT usage is still behind the developed countries. The results may have to do with the fact that Turkey has a short but fast history of ICT technology. Media multitaskers in Turkey may need time to deal with the negative effects of media multitasking on attention. It is possible that the positive effects of media multitasking may not last over the long term. Therefore, effects of media multitasking on cognition should better be studied longitudinally with larger sample sizes to get more reliable information about its long-term effects. For future studies, the media multitasking usage amount can be measure objectively. Also, if studies can ensure real life media multitasking environment to participants even in labs as much as possible, it can provide greater validity of the results.

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EXTENDED ABSTRACT

Introduction

The network era offers us an inevitable technological environment which is available at all hours of the day and night. Since almost all media devices have some common functions, they can be used interchangeably or simultaneously for the same or different purpose. This kind of media usage, which offers us opportunity for saving time is called "Media multitasking" (Ophir et al. 2009; Lang et al. 2015) and it is widespread especially among teenagers (Voorveld et al. 2013: 392; Van der Schuur et al. 2015: 204) who are growing up in the digital environment by adapting to it (Choudhury et al. 2013). The main aim of the study is examining relationship between media multitasking intensity, working memory, and sustained attention in the Turkish young population.

It is assumed that working memory has active role in media multitasking (e.g. Ophir et al. 2009; Colom et al. 2010). Some existing results showed that intense media multitasking is not related with working memory capacity (Minear et al. 2013; Baumgartner et al. 2014; Cardoso-Leite et al. 2015; Edwards et al. 2017; Wiradhany et al. 2017), while others found a negative relationship (Ophir et al. 2009; Sanbonmatsu et al. 2013; Uncapher et al. 2016; Cain et al. 2016; Cardoso-Leite et al. 2016; Ralph et al. 2017).

***H1:** High media multitasking usage amount will be associated with low working memory performance.*

Since media multitasking requires switching frequently between devices, it is thought that it requires sustained attention ability (Ralph et al. 2015: 391). In the literature, some of the results showed that sustained attention and media multitasking are not related, (Ralph et al. 2015; Moisala et al. 2016) but other studies found a negative relationship (Ophir et al. 2009; Ralph et al. 2014, Cardoso-Leite et al. 2015).

***H2:** High media multitasking usage amount will be associated with poor sustained attention performance.*

Method

Participants

One hundred and twenty undergraduate students (96 female) aged 18 to 33 (mean age = 21, 89 years, SD = 1.80) of Uludag University participated voluntarily to the study. One participant was removed from the sample because of an outlier was excluded from the study, the sample was 119 students.

Materials

Media multitasking usage inventory

To measure media multitasking usage amount of the participants, an inventory was adopted from MMI (Ophir et al. 2009). The inventory had two parts and 62 items in total (Cronbach's α = 69.5).

Cognitive tasks

Continuous Performance Test (CPT) was used to measure sustained attention performance and Forward and Backward Digit Spans were used to measure working memory performance.

Procedure

Participants first read the written informed consent and then filled the MMI ınventory. After the Inventory participants' cognitive abilities were assessed via Continuous Performance Test (CPT) and Forward and Backward Digit Span respectively.

Results

Daily mean media multitasking and WM were not related significantly (p = .273). However, working memory performance was related with concurrent texting/reading SMS and playing game (r_τ = .16, p = .039), TV and Tablet PC (r_τ = .19, p = .020), TV and phone/smartphone (r_τ = .21, p = 004), Tablet PC and phone/smartphone (r_τ = .17, p = .028) positively. Concurrent TV watching and Notebook/Netbook use were significantly and positively correlated with CPT task reaction time of false response performance (r_τ = .29, p = .013).

Discussion

Overall, it was seen that media multitasking was related positively with working memory and negatively with sustaining attention. Both the limited capacity and the multiple resources theories may account for these results. MM may reduce attentional performance as a result of limited mental capacity because TV- Notebook multitasking requires different kinds of resources at the same time and also Notebooks need more intensive hand use (for keyboard and mouse or touchpad) than touchscreen devices. It can be inferred that if mental capacity is limited, TV-Notebook as an attention demanded kind of MM may distort attention performance. On the other hand, working memory has different components for different kinds of input (visual-spatial sketchpad, phonological loop, etc.) and as suggested by the multiple resource hypothesis, that can enable efficient cognitive performance via the resources. That is *to say, some kinds of MM, that need different input resources, might be executed easily due to working memory components enabling multiple input processing.*

For future studies, the media multitasking usage amount can be measure objectively. Also, if studies can ensure real life media multitasking environment to participants even in labs as much as possible, it can provide greater validity of the results.