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Are Individual Differences in Media Multitasking Habits Associated with Changes in Brain Activation: An ERP Investigation of Multitasking and Cognitive Control

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Are Individual Differences in Media Multitasking Habits Associated with Changes in Brain Activation: An ERP Investigation of Multitasking and Cognitive Control

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Abstract

As the number of mobile phone users grows, understanding the impact of multiple streams of media on media multitasking and related neural correlates is especially pertinent. This research aims to understand the association between media multitasking tendencies on the neural correlates underlying cognitive control using event-related potentials (ERPs). Specifically, we were interested in the N2 and P3, ERPs that measure neural activation underlying aspects of cognitive control. Based on the literature, we predicted that participants who have high media multitasking scores would show more negative N2 activation and more positive P3 activation than their low media multitasking counterparts during an AX-CPT task, indicating less efficient neural processing. However, we did not find the expected pattern of results. It is possible that reactive and proactive control are not related to digital media multitasking or it may be that some potential design issues impacted our results. The current paper will explore these issues.

Keywords: *cognitive control, media multitasking, ERPs, self-regulation*

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Introduction

Media Use Today

The use of digital media has been steadily on the rise over the last decade, with smartphone ownership reaching a nearly ubiquitous level. A study conducted in 2018 by the Pew Research Center found that up to 96% of Americans aged 18 – 65+ own a cell phone and up to 81% of Americans own a smartphone (Pew Research Center, 2018). This study also found that for people aged 18-24-years, 94% used YouTube to watch videos, 80% were on Facebook, 78% were using Snapchat, and 71% were using Instagram. Of these smartphone users, 57% of them felt distracted by their phones, while 36% of users reported feelings of frustration related to smartphone use. In addition to the aforementioned effects of frustration or distraction, many studies have shown that use of digital media and social media is negatively correlated with academic performance (e.g., Jacobsen et al., 2011; Lau, 2017) For example, Jacobson and Forste (2011) found that in a college aged sample for every hour spent exposed to electronic media, GPA was lower on average between 0.05 and 0.07 points. The same study also found that there was an inverse relationship between GPA and time spent using cellular phone communication, video and online gaming, and TV watching. In a similar study, college students who used social media multitasking (using social media while studying) negatively predicted academic outcomes as measured by cumulative GPA (Lau, 2017). Digital media use has become a far-reaching part of our daily lives, but the impacts of these levels of usage along with that of using multiple streams of digital media are not clear.

Media multitasking, or the concurrent use of two or more media forms, has been on the climb in recent years (e.g., Carrier, Cheever, Rosen, Benitez, & Chang, 2009; Rideout, Foehr, & Roberts, 2010). Carrier and colleagues (2009) found that when presented with 66 combinations of media tasks, Baby Boomers (born between 1946 and 1964) had engaged in 23.2 combinations on average and younger generations (1965 -1978; after 1978) averaged between 32.4 combinations and 36.5 combinations. In a similar study focused on 7th to 12th graders, Rideout et al. (2010) found that a majority of teenagers multitask "most" or "some" of the time. These statistics include respondents listening to music (73%), using a computer (66%), watching TV (68%), and while reading (53%). The same study also found that media multitasking has increased between 2004 and 2009. Similarly, to digital media use, the upward trending prevalence of media multitasking has resulted in negative impacts on users (Becker, Alzahabi, & Hopwood, 2013: Armstrong & Chung, 2000; Furnham, & Bradley, 1997: Rosen, Carrier, & Cheever, 2013). For example, Becker and colleagues (2013) found that an increase in media multitasking is associated with higher rates of depression and social anxiety in a college aged sample (Becker et al., 2013). Additionally, Rosen and colleagues (2013) conducted a correlational study and found that students who accessed Facebook one or more times while studying also showed lower GPAs than their unitasking counterparts. Similarly, Armstrong and Chung (2000) found that when given a reading task with TV playing in the background, participants had a harder time recalling what they had read in a multiple-choice test. Interestingly, even listening to music while learning has been shown to effect recall (Furnham, & Bradley, 1997). Thus, the literature suggests that media multitasking acts more as a distractor than the portrayed productivity booster. While the deleterious impact of multitasking is relatively evident, the neurocognitive mechanisms underlying these effects are still being researched, especially in the context of cognitive control.

Cognitive Control & Distraction

Cognitive control refers to one's ability to attend to relevant events while ignoring distracting events (Braver, Gray, Burgess, 2007). Researchers have attempted to explain the impact of distractors on cognitive control, often in the form of multitasking research (e.g., Dux, Ivanoff, Asplund, & Marois 2006; Foerde, Knowlton, & Poldrack, 2006: Chun & Potter, 1995; Vogel, Luck, & Shapiro, 1998; Raymond, Shapiro, & Arnell, 1992). Functional imaging research has indicated that when humans try to perform two tasks, the execution of the first task limits the processing of the second task due to a bottlenecking of the neural network of the frontal lobe (Dux et al., 2006). This bottlenecking is often discussed in the context of a dual task model, where two actions are required. It can be thought of as dual task model, because when two tasks need the same brain mechanism at the same time, a bottle neck occurs. This bottleneck in turn either slows down both tasks, or requires one task to be completed before the other -or sequentially processed (Pashler, 1994). Many of these studies use the attentional blink paradigm, which presents two events sequentially (e.g., Chun & Potter, 1995; Vogel et al., 1998; Raymond et al., 1992). Studies have consistently shown that when the second event is presented roughly 200-400 ms after the first one, the second event is "blinked" or missed; however, if the second event is presented at a later time, for example 600 ms after the first, the second event is not blinked (Shapiro, Raymond, & Arnell, 1997; Marois, Chun, & Gore, 2000). Some studies using this paradigm have shown that the second stimulus is "blinked" due to insufficient neural resources to perceive the second event (Chun & Potter, 1995; Vogel, Luck, & Shapiro, 1998; Raymond, Shapiro, & Arnell, 1992). In other words, perceiving a stimulus does not mean you have processed the meaning or context of the stimulus. It is possible that the same problems associated with deficits in cognitive control due to immediate sequential presentation could be a driving force in the adverse impacts of media multitasking on cognitive control.

The impact of multitasking on cognitive control also extends to media multitasking (e.g., Ophir, Nass, & Wagner, 2009). A study by Ophir and colleagues (2009) found that participants who were high multimedia users (HMM) were more susceptible to interference (or distractors) from irrelevant stimuli than low multimedia (LMM) users using a modified AX-Continuous Performance Task (CPT) that also presented irrelevant distractor stimuli. More specifically, they found that in the presence of distractors the HMM were slower and less accurate than the LMM. Interestingly, they found no difference in accuracy or response times for LMMs or HMMs in non-distractor trials, indicating that the effects of media multitasking were not global in nature. To explain the performance deficit in the distractor trials, the authors argued that HMM had worse cognitive control than the LMM that led to an inability to filter out distractors.

Another explanation might be that HMM take "breadth-biased" approach to consuming media that is reflected in a "breadth-biased" profile of cognitive control. In other words, HMM sacrifice focus on a singular task to let outside information in, often at the expense of information processing. For example, Cain and Mitrof (2011) used a task that minimizes reliance on memory (singleton distractor task) to isolate attention processes and found slower reaction times for the HMM than LMM. The HMM seem to have paid more attention to distractors than the LMM even when instructions specified otherwise. In line with the theory on breadth-based processing, individuals who score high on measures of impulsivity and low on measures of cognitive control have been found to be high multitaskers, indicating an inability to block out distractors (Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013). While high levels of media multitasking do not indicate the ability to process two streams of information concurrently, research also suggests that heavy media multitaskers are better able to switch between discrete tasks (Alzahabi, & Becker, 2013). In a study that used four measures of cognitive control (AX-continuous performance, N-back, task-switching, and filter tasks) researchers found that high levels of media multitasking resulted in a global reduction in performance in terms of speed and accuracy (Cardoso-Leite, Kludt, Vignola, Ma, Green, & Bavelier, 2016). Hence, current research suggests that multitasking could have a negative impact on cognitive control.

Neural Mechanisms Underlying Cognitive Control

Many regions of the brain have been implicated in the mechanisms underlying cognitive control, including most consistently areas of the prefrontal cortex (PFC) and the parietal cortex (Braver et al., 2007; Blassi et al., 2006; Ridderinkhof et al., 2004). Areas of the PFC that are commonly implicated are the dorsolateral prefrontal cortex (DLPFC), the ventrolateral prefrontal cortex (VLPFC), the dorsal cingulate (dACC), and the parietal cortex (PC; e.g., Blassi et al., 2006; Ridderinkhof et al., 2004). Research has indicated that higher DLPFC activation is associated with less conflict and better reaction times in a Stroop task, suggesting the DLPFC is involved in aiding one's ability to ignore interference or distractors (MacDonald et al., 2000). A similar study using the Stroop task and fMRI aimed to determine if distinct areas of the brain were activated in either response conflict during responses or in semantic conflict at the level of conceptual encoding (Van Veen, & Carter, 2005). Response conflict elicited brain activity specifically from the superior temporal cortex and thalamus while semantic conflict elicited activity in the parietal cortex. There was no overlap in these distinct areas. Additionally, they found that both forms of conflict prompted activity in DLPFC and ACC. Taken together this research points to the large roll of the PFC (especially the DLPFC) in the context of cognitive control.

The posterior medial frontal cortex (pMFC) and the dorsal anterior cingulate cortex (ACC) also play a role in cognitive control within the framework of conflict monitoring, or when a task concurrently activates a response tendency for both the correct and incorrect response (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Matsumoto, & Tanaka, 2004). The ACC has been shown to have more activation in a Stroop task during the incongruent trials compared with congruent trials, an indication that the ACC contributes to one's ability to override prepotent responses. This pattern of results indicates that the ACC appears to be involved in resolving response conflict (Botvinick et al., 2001; Pardo, Pardo, Janer, & Raichle, 1990; Carter, Mintun, & Cohen, 1995). A related study also found ACC activation during incongruent trials of a Stroop task. The ACC on these high conflict trails was followed by an increase in activity in the prefrontal cortex that could reflect post-conflict behavioral corrections (Kerns, Cohen, MacDonald, Cho, Stenger, & Carter, 2004). Another task used to study conflict monitoring elicits "The Simon Effect," in which a stimulus is presented either on the left or right side of a computer screen in two different colors (Simon, and Wolf, 1963). The participant is required to respond to the color of the stimulus by pressing a specific response button, either left or right, and ignoring the location. On some trials, the response requiring color and location are congruent eliciting faster reaction times while on other trials they are incongruent eliciting slower reaction times. A study by De Pellegrino and colleagues (2007) found similar reaction times for congruent and incongruent trials for patients with rACC lesions compared with healthy adults, suggesting a failure to moderate their performance based on the conflict level (Di Pellegrino, Ciaramelli, & Làdavas, 2007). All in all, the ACC has a well-established body of literature that points to its importance in moderating performance during situations with high conflict levels.

The ventral lateral prefrontal cortex (VLPFC), specifically the right VLPFC, is thought to play a critical role in motor inhibition, a feature of cognitive control (Aron, Robbins, & Poldrack, 2004; Corbetta, Patel, & Shulman, 2008). In a meta-analysis Aron and colleagues (2004) isolated Go/No-go studies where participants respond (press a button) quickly to letters except for a designated stop letter (do not click the button), a way to measure response inhibition. They found that response inhibition (not clicking the button) was consistently associated with right lateralized VLPFC activation in fMRI studies. In a similar study, a modified Go/No-go using arrows rather than letters, also found that successful response inhibition was associated with the right inferior prefrontal cortex (Rubia, Smith, Brammer, & Taylor, 2003). Thus, this research indicates that the VLPFC plays a critical role in inhibiting motor responses.

Another region of the brain linked to cognitive control, often in context of goal directed cognitive processes, is the parietal cortex (Merian, 2000; Sohn, Ursu, Anderson, Stenger, & Carter, 2000). Goal directed cognitive processes can be understood as a deliberate application of intention to achieve a goal (Sohn et al., 2000). In order to start a task or switch between them to achieve a goal, Cognitive control is needed (Meiran, 2000). In a task switching paradigm participants were asked to classify letters and numbers while undergoing an MRI. In some trials, repetitions of either letters or numbers were the same (task repetition) and in other trials the letters were different (task switching). Participants were either informed or uninformed that there would be task switching. Foreknowledge about the task seemed to involve the lateral prefrontal cortex and the superior parietal cortex during preparation for the task. When adjusting and changing strategies (task switching) with no foreknowledge the superior prefrontal cortex along with the posterior parietal had more activation, implicating these regions in tasking switching (Sohn et al., 2000). The idea of task switching can also be thought of as selective attention, a process whereby some input is preferentially selected for focus (Behrmann, Geng, & Shomstein, 2004; Yantis, Schwarzbach, Serences, Carlson, Steinmetz, Pekar, & Courtney, 2002). In a review of the role of the parietal cortex in attention by Behrmann et al., (2004), the parietal cortex and tempo parietal junction (TPJ) were implicated by many studies as the area of the brain that aids selective attention. In a study using event related fMRI to detect the brain regions sensitive to novel stimuli, the TPJ region was found to be highly active in response to a variety of novel visual, auditory, and tactile (brushing patterns) stimuli (Downar, Crawley, Mikulis, & Davis, 2002). A similar study using a modified rapid serial visual presentation task (RSVP), found activation within the parietal cortex when participants shifted attention from a consistent stimulus to a novel one, further evidence that the parietal cortex plays a role in selective attention (Yantis et al., 2002). All in all, these studies indicate that the parietal cortex is involved in the ability of the brain to switch between tasks and use selective attention to reorient to a more salient stimuli or task.

Event Related Potentials and Cognitive Control

Electroencephalography (EEG) is a non-invasive method that allows researchers to directly measure neural function with millisecond precision. Repeated similar trials are often presented and averaged together to increase the signal to noise ratio (Jung, Makeig, Westerfield, Townsend, Courchesne, & Sejnowski, 1999) generating event-related-potentials (ERPs). The N2, a mediofrontal ERP, that occurs around 200ms post-stimulus (Patel, & Azzam, 2005), is frequently associated with conflict monitoring and response conflict (Nieuwenhuis et al., 2003;

Donkers and van Boxtel, 2004; Bartholow et al., 2005; van Veen and Carter, 2002; Dimoska et al., 2006). Linear inverse modeling suggests that the N2 has a number of generators in the PFC, including the ACC, an area known to play a role in cognitive control (Nieuwenhuis et al., 2003; Yeung, Botvinick, & Cohen, 2004).

Another ERP associated with cognitive control is the P3, a frontal component associated with attention (Polich, 2007). The P3 has also been associated with better performance in terms of accuracy and reaction time in an N – Back task (Saliasi, Geerligs, Lorist, & Maurits, 2013), a task in which, participants are presented with a sequence of stimuli, and are asked to indicate if a stimulus is the same as a stimulus presented "N" trials ago (Kirchner, 1958). An association between the P3 and better performance on an N-Back task could indicate that the P3 is sensitive to individuals who pay more attention to the task (Saliasi et al., 2013). The P3 was also found to have larger amplitudes in the presence of novel sounds, indicating its role in attentional orienting (Barcelo, Escera, Corral, & Periáñez, 2006). Given the sensitivity of ERP and their ability to capture different aspects of cognitive control, the use of ERP technique may provide an appropriate measure of the underlying neural differences between those who are high and low media multitaskers.

Another task that is often used to elicit ERPs and investigate the neural correlates underlying cognitive control is the AX-CPT (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). The AX-CPT yields two aspects of cognitive control: reactive control, which incorporates last minute environmental information to change an action strategy, and proactive control, the active maintenance of information in the face of distracting events (Braver et al., 2009). Past research has found that the N2 component has been associated with both reactive and proactive control (Lamm, Pine, & Fox, 2013; van Wouwe, Band, & Ridderinkhof, 2011). A 2009

ERP study using the AX-CPT found that when participants responded to cue conditions, they exhibited clear P3s (van Wouwe et al., 2011), indicating that this task can elicit P3 activation. Furthermore, they found greater N2s for trials that required last minute action change than for trials that executed planed action strategies. Additionally, Lamm and colleagues (2013) found that in trials that required proactive control (i.e., actively maintaining a planned action strategy), participants who used a proactive style of responding showed smaller N2s than participants who used a reactive style of responding, suggesting neural efficiency. Similarly, in trials that required reactive control (i.e., changing action strategies in the face of new information), participants who used a reactive style of responding showed smaller N2s (more efficient neural processing) than participants who used a proactive style of responding. Taken together, these students indicate that the N2 and P3 could be useful measures of the neural resources underlying proactive and reactive control.

Impact of multitasking on the neural correlates underlying cognitive control

Though the cost of multitasking on performance has been well documented in research (Rogers, & Monsell, 1995; Monsell, & Driver, 2000), the impact of multitasking on the neural correlates underling cognitive control are less clear. Many studies have indicated that a neural locus of multitasking can be found both in the prefrontal and inferior parietal cortex (Collette, Olivier, Van der Linden, Laureys, Delfiore, Luxen, & Salmon, 2005; Dux, et al., 2006; Wu, Liu, Hallett, Zheng, & Chan, P, 2013). In a dual task study using positron emission tomography study (PET), participants were asked to indicate the position of a specific stimulus (a cross) presented on a screen or indicate the pitch of a tone. In the baseline condition, the participants were either shown the cross or presented with the tone, and asked to press a button either indicating the positioning of the cross, or indicating if the tone was a high or low tone. In the dual task condition the participants saw a cross and heard the tone, and were cued to respond to only one of the stimuli and thus ignoring the other. When comparing the dual task to the single tasks, greater left sided activity in the frontal gyrus, inferior parietal gyrus, and cerebellum was shown. This indicated that the prefrontal gyrus was implicated during dual task processing (Collette et al., 2005). In a similar study using a dual task paradigm, researchers found evidence that the frontal lobe, specifically the posterior lateral prefrontal cortex and the superior medial frontal cortex were associated with multitasking related deficits. These results suggest that these areas of the PFC might contribute to the bottlenecking that underlies multitasking related deficits (Dux et al., 2006). Some authors interpret these findings to reflect a central locus of multitasking, while other authors argue that cognitive factors, such as memorization might be associated with this pattern of activation (Erickson, Colcombe, Wadhwa, Bherer, Peterson, Scalf, & Kramer, 2005; Just, Keller, & Cynkar, 2008). To explore these conflicting views, Erickson et al. (2005) used 4 computerized discrimination tasks that presented two different trial types: 1) participants had to indicate if they saw the letter “B” or “C” by pressing two different buttons and 2) indicate if an “X” was colored yellow or green by pressing two different buttons. In the single task, participants had to only respond to one of the trial types. In the mixed trials, participants had to respond to all the aforementioned trial types. These trials were intended to remove the possibility of memorization as trials varied within blocks. They found that the mixed task trials activated the same areas as the single task trials, but to a greater magnitude. More importantly though, in the mixed task trials they found activation in areas that were not evident in the single task trials, suggesting that previous multitasking-related brain activation might be in part due to task memorization rather than to the existence of a multitasking neural locus. In a related study, participants played a driving game either undisturbed or while listening to sentences that they needed to determine to be true or false. The dual task condition (driving while listening to sentences) decreased driving accuracy and saw a decrease in bilateral parietal and superior extrastriate secondary visual areas, indicating that the neural resources needed to listen to sound took resources away from driving (Just et al., 2008). This study indicates there may be a capacity limit, but does not point to a specific area of the brain as a locus for multitasking. Taken together this research indicates that there may not be a neural locus of multitasking, rather a capacity limit on the brain when a second task is introduced. Activation in areas outside of the frontal cortex point towards the task specific neural resources of multitasking. Overall, the literature regarding the impact of multitasking on the neural correlates of cognitive control are unclear. Furthermore, to the best of our knowledge, no one has explored how multitasking specifically relates to the neural correlates underlying reactive and proactive control. Determining if the neural correlates underlying reactive and proactive control are differentially impacted by multitasking could inform educators and guide best practices. Therefore, the current study explores the relationship between multitasking and the N2 and P3 amplitudes in the context of an AX-CPT task. More specifically, we examined the relationship between multitasking and the patterns of neural activation underlying proactive and reactive control.

Hypothesis 1: Though the findings of Ophir et al., (2009) did not find behavioral differences (reaction time and performance accuracy) between low and high media multitaskers in an AX-CPT without distractors, we hypothesize that the use of ERPs will provide more sensitivity and thus will show differences between high and low media multitaskers. We believe that participants who have high media multitasking scores will show more negative N2 activation (less efficient) when compared to their low media multitasking counterparts. We expect that the N2 activation will be more negative in the AY probe condition (reactive control) and in the BX cue condition (proactive control) compared with the respective control conditions.

Hypothesis 2: Consistent with hypothesis 2, we expect that participants who have high media multitasking scores will show more positive P3 activation (less efficient) when compared to their low media multitasking counterparts. We expect that the P3 activation will be more positive in the AY probe condition (reactive control) and in the BX cue condition (proactive control) compared with their respective control conditions.

Method

Participants

Participants (N = 155) were undergraduate students enrolled in general psychology at the University of Arkansas for course credit (SONA). Participants were 51.6% female, 47.1% Male, 1.3% other, and were aged 18-47. Participants were asked questions in an online pre-screener to allow us to exclude participants based on self-reports of 1) current psychiatric diagnoses, 2) current use of any psychoactive medication, 3) uncorrected visual impairments, and 4) hair styles not conducive to clean EEG data. These hair styles include but are not limited to: extremely thick hair, thick tight braids, dreadlocks, sewn in hair, or any hair style that would not allow an electrode to be directly placed on the scalp. Additionally, a small number of participants with incompatible hair styles attended lab testing sessions and had to be excluded upon arrival. Finally, after data collection, 9 participants were excluded from analyses due to insufficient artifact free correct ERP data. Another 59 participants were excluded from analyses due to insufficient correct trials. There were no significant differences in age, gender, or media multitasking between the included and excluded participants. Approval for the study was obtained through the University of Arkansas' Institutional Review Board (Approval Number: 1708026820).

Procedure

As described in Rawls et al. 2018, participants were brought into the lab and familiarized with the testing environment and experimenters. After consent was obtained, participants completed questionnaires, including the demographic questions and the media multitasking questionnaire. Participants then had the electrode sensor net applied. The participants were given instructions to minimize facial movement and were seated 67 centimeters in front of a computer monitor. They were then given task instructions and completed two practice blocks of 10 trials to ensure proficiency within the AX-CPT task. Participants then completed 8 blocks of 58 pseudo randomized trials of the AX-CPT. Additional questionnaires and tasks were also administered but these were not part of the current project.

Measures & Tasks

Media Multitasking Scale

Media multitasking was measured using a media use and multitasking scale adapted from Ophir (2009). The scale is comprised of 10 questions asking total hours spent doing a particular kind of activity including: face-to-face conversation, print media, texting/instant messaging/emailing, social site usage, non-social text-oriented sites, telephone/video chatting, listening to music, watching TV/movies or playing video games. Each of the ten questions have sub-questions asking how long an individual spends doing one of the aforementioned activities while simultaneously doing another one of the aforementioned activities. The sub-questions were answered using a slider to indicate the percentage of time they spent doing one activity while simultaneously doing another activity (See supplementary material 1). For the purpose of this research we focused on the six questions pertaining to digital media only. All missing values in the data set were set to "not applicable." Next, to calculate the digital media multitasking score we first identified each participant's maximal value for each sub-question and then averaged across all these maximal values. For example, in Figure 2, shows 2 questions (of the 6 we used) and their sub-questions. For question 4.2, you will see that the maximal value is 40 for playing video games or online games (highlighted grey) and for question 9.2 the maximal value is 55 for talking on the telephone or video chatting (also in grey). We then averaged across these maximal values, in this case averaging to 47.5.

Q4.2 While you are Using social sites (e.g., Facebook, Twitter, etc., except games), what percentage of time are you also doing each of these other activities?

24 Texting, instant messaging, or emailing
NA Using a second social site (e.g., Facebook, Twitter, etc., except games)
1 Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
5 Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
11 Watching TV and Movies (online and off-line) or YouTube
40 Playing video games or online games

Q9.2 While you are watching TV and Movies (online and off-line) or YouTube, what percentage of time are you also doing each of these other activities?

34 Texting, instant messaging, or emailing
NA Using a second social site (e.g., Facebook, Twitter, etc., except games)
NA Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
55 Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
21 Watching TV and Movies (online and off-line) or YouTube
42 Playing video games or online games

Figure 1. *Two example questions from the media multitasking scale. In this example the gray highlighted area represents the maximal values from the questions. These values would then be*

averaged to create a media multitasking scale from 2 questions, in the analyses we used 6 questions.

Cognitive Control Task

The task was an AX continuous performance task (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956). A 17-in monitor was used to present images using E-prime Software (Psychology Software Tools, Inc., Pittsburgh, PA; Schneider, Eschman, & Zuccolotto, 2002). Stimuli was presented on black screen and single letters were presented in either blue (cue, first letter) or white (probe, second letter). Participants were first presented with either an "A" or a "B" as the cue to which they were required to press the "1" button. However, if an "X" (probe) followed the "A" cue, the participant pressed the "5" button. In all other scenarios the participants pressed "1" for both cue and probe. A fixation "*" was presented before the cue, between the cue and the probe, and after the probe (see Figure 1).

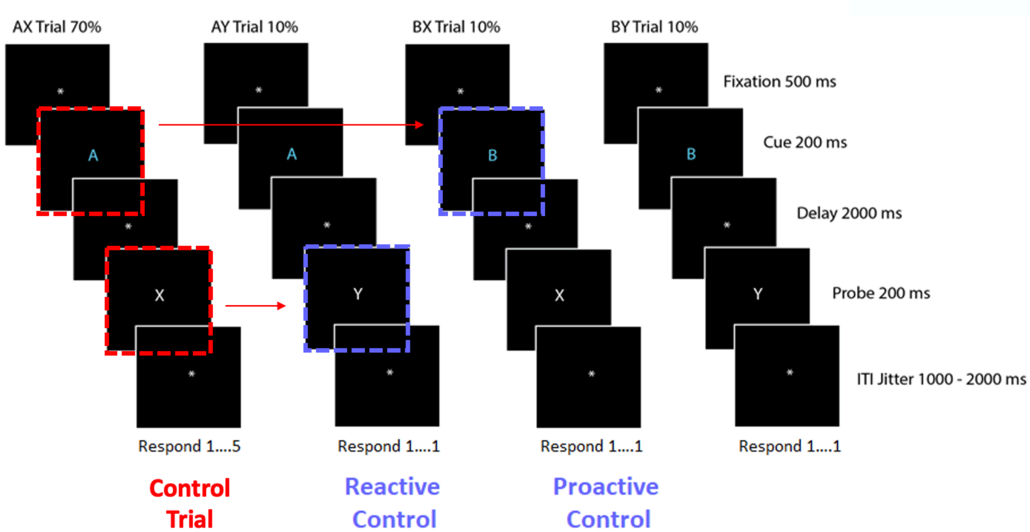

Figure 2. *Task diagram of the AX-CPT task. The dashed boxes indicate the time-locked stimuli used for ERP analysis. The target condition stimuli are shown in purple and the control condition stimuli are shown in red. Here, "B" of B-X trials was the target stimulus for proactive control and its respective control trial was the "A" of A-X trials. The "Y" of A-Y trials was the target stimulus for reactive control and its respective control trial was the "X" of A-X trials.*

Analyses

EEG data collection and analyses

EEG data collection and processing procedures were consistent with Lamm et al. (2013). EEG was recorded using a dense array 128-channel Geodesic Sensor Net and sampled at 1000 Hz, using EGI software (Net Station; Electrical Geodesic, Inc., Eugene, OR [data was processed using Net Station]). The impedance values for all EEG channels were reduced to below 50 kΩ before data collection began. During data collection, all channels were referenced to Cz. Participants were excluded if they were missing data or if the EEG contained too much artifactual data. Consistent with Meyer et al. (2013), participants were excluded if they had less than 10 correct artifact free responses for each trial type.

Data Processing

Using a processing pipeline developed by Dr. Eric Rawls and Stephanie Long, EEG data was pre-processed in EEGLAB, a MATLAB toolbox used for EEG processing (Delorme & Makeig, 2004; http://www.sccn.ucsd.edu/eeglab). A bandpass filter from 0.1-35 Hz was applied to the data, and it was downsampled to 125 Hz. EEG channels that were four standard deviation above the mean of the dataset were removed and later interpolated. The data was then segmented from -300 – 900ms and stimulus-locked around each of the relevant stimuli associated with proactive (cue) and reactive (probe) control. Proactive control target segments were time-locked to the presentation of the "B" cue in B-X trials, while the control condition segment was time-locked to the presentation of the "A" cue of the A-X trials. Reactive control target segments were time-locked to the "Y" probe stimuli of the A-Y trials, while the control condition segment was time-locked to the presentation of the "X" probe on A-X trials. Each of the time-locked segments was baseline corrected across the entire segment. Infomax ICA was then applied on the cleaned data set using the *runica* function (Makeig, Jung, Bell, Ghahremani, & Sejnowski, 1997) coupled with the ADJUST plugin (Mognon et al., 2011) to identify and remove components containing eye blinks and eye movements. The cleaned segments were then examined for any remaining artifacts (such as fast transits) and were rejected with a threshold of ±140 µV (peak-to-peak). Finally, all removed channels were interpolated and all segments were re-referenced using an average reference. To avoid biasing the data, grand average waveforms were created for proactive and reactive control by averaging across target conditions and control conditions to select the N2 (Figure 2) and P3 (Figure 3) component windows (with 0 ms indicating stimulus onset). Scalp distributions were created across all 128 electrodes to assess which electrodes the N2 (Figure 2) and P3 (Figure 3) components were maximal.

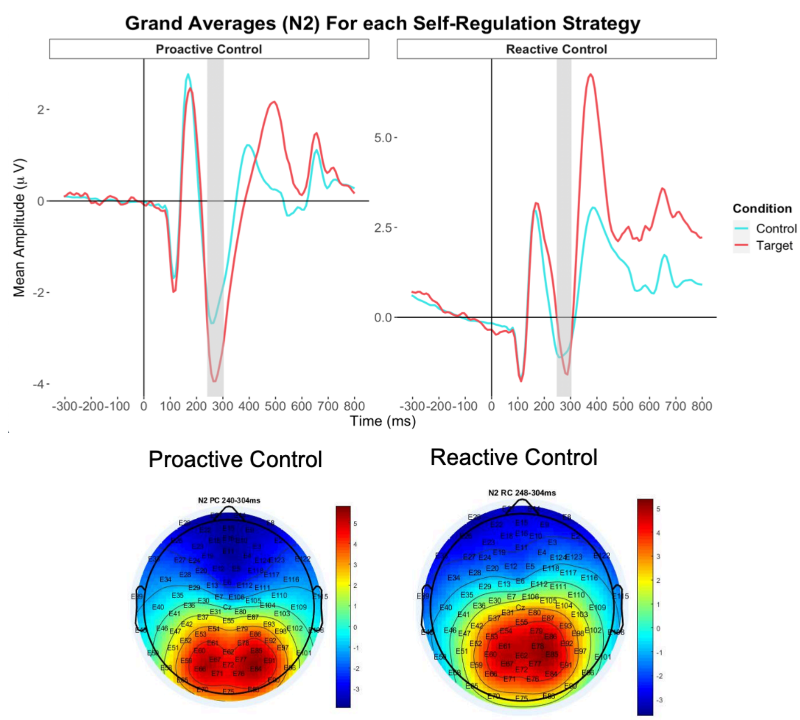

Figure 2. *Grand averaged waveforms were created for the N2 during each self-regulatory strategy. For visualization purposes, the target condition is shown in red and the control condition is shown in blue. Each N2 time window (shown in gray) was extracted from electrode FCz (electrode 6) , to align with the literature (Lamm et al., 2013; Jonkman, Sniedt, & Kemner, 2007; Munro, Dywan, Harris, McKee, Unsal, & Segalowitz, 2007).*

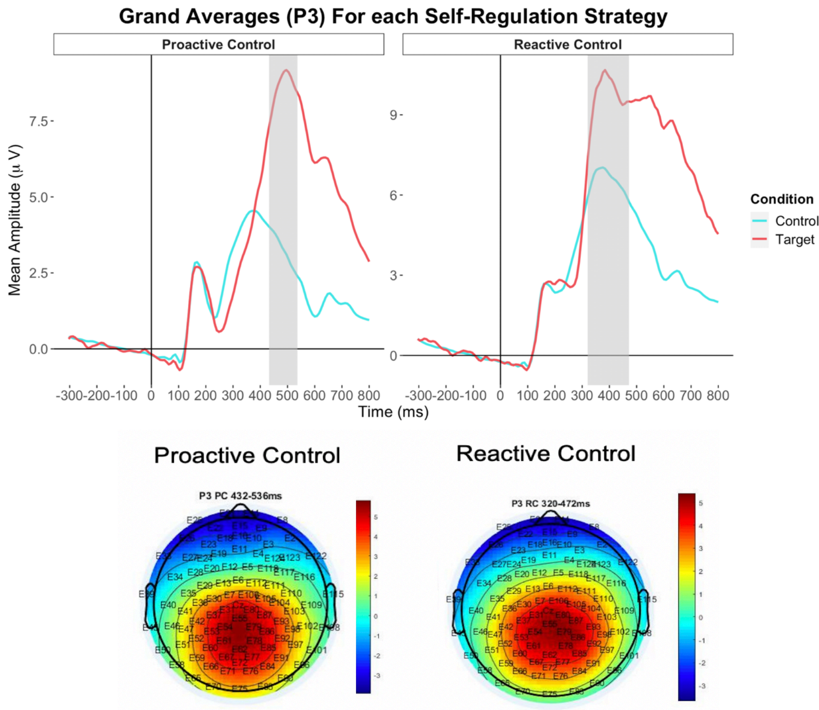

Figure 3. *Grand averaged waveforms were created for the P3 during each self-regulatory strategy. For visualization purposes, the target condition is shown in red and the control condition is shown in blue. Each P3 time window (shown in gray) was examined at the electrode where it showed maximum amplitude based on the scalp topography (Electrode 55 = between REF and COM)*

Statistical Analyses

The analysis was conducted in R Studio (RStudio Team, 2016). A hierarchical linear regression analysis using the lm () function, a function used to fit linear models, such as regressions, was used to test each hypothesis. For the ERP analyses, the dependent variables were either the N2 or P3 amplitudes time locked to either the BX Cue (proactive control) or the AY Probe (reactive control) events. Gender, trial count (number of trials that make up the ERP), and the AX Probe serve as covariates that were treated as nuisance variables in the reactive control model (in step 1). Gender, trial count, and the AX Cue serve as covariates that were treated as nuisance variables in the proactive control model (in step 1). Digital media multitasking was added to step 2 of the models. Change in R2 was assessed to determine if digital media multitasking better explained variance in N2 or P3 activation over and above the nuisance variables. This analysis was run separately for reactive and proactive control. Similar regression analyses were also conducted to determine the effect of the digital media multitasking on a participant's performance accuracy and reaction times.

Results

Behavioral Results

Consistent with the Ophir et al. (2009) study, we found no main effect of digital media multitasking on accuracy for both AY trials (reactive control), $F\ (5,147) = 83.27,\ p = 0.97,\ R^2 = 0.74,\ \Delta R^2 = 0.00$, and BX trials (proactive control), $F\ (5, 147) = 19.71,\ p = 0.11,\ R^2 = 0.41,\ \Delta R^2 = 0.10$ (See Table 1 for more information). There was also no main effect of digital media multitasking on reaction time in both the AY trials, $F\ (5, 147) = 30.05,\ p = 0.32,\ R^2 = .507,\ \Delta R^2 = .003$, and the BX trials, $F\ (5, 147) = 35.48,\ p = 0.68,\ R^2 = .549,\ \Delta R^2 = .001$ (See Table 2 for more information).

Table 1: Regression Model Summary for Accuracy on Reactive Control (AY) and Proactive Control (BX) Trials with Digital Media Multitasking Score added as the IV of Interest

Dependent Variables											
	Reactive Control (AY) Accuracy						***Proactive Control (BX) Accuracy***				
	Predictor	*b*	*b* 95% CI [LL, UL]	Fit (R2)	Change in R2		Predictor	*b*	*b* 95% CI [LL, UL]	Fit (R2)	Change in R2
Step 1						**Step 1**					
	Control Trials (AX)	0.23	[-0.12, 0.57]				Control Trials(AX)	0.70**	[0.45, 0.95]		
	Trial Count (AY)	0.02**	[0.02, 0.02]				Trial Count (BX)	0.01**	[0.00, 0.01]		
	Male	-0.02	[-0.05, 0.01]				Male	-0.01	[-0.03, 0.02]		
	Other Genders	-0.06	[-0.18, 0.07]				Other Genders	-0.03	[-0.12, 0.07]		
				R^2 = .739** 95% CI[.66,.78]						R^2 = .391** 95% CI[.26,.48]	
Step 2						**Step 2**					
	Control Trials	0.23	[-0.12, 0.58]				Control Trials(AX)	0.70**	[0.45, 0.95]		
	Trial Count (AY)	0.02**	[0.02, 0.02]				Trial Count (BX)	0.01**	[0.00, 0.01]		
	Male	-0.02	[-0.05, 0.01]				Male	0	[-0.03, 0.02]		
	Other Genders	-0.06	[-0.18, 0.07]				Other Genders	-0.03	[-0.12, 0.07]		
	Media Mulitasking Scale	0	[-0.00, 0.00]				Media Mulitasking Scale	0	[-0.00, 0.00]		
				R^2 = .739** 95% CI[.66,.78]	ΔR^2 = .000 95% CI[-.00, .00]					R^2 = .401** 95% CI[.26,.48]	ΔR^2 = .010 95% CI[-.01, .04]

Note. A significant b-weight indicates the semi-partial correlation is also significant. b represents unstandardized regression weights. LL and UL indicate the lower and upper limits of a confidence interval, respectively.
** indicates p < .05. ** indicates p < .01.*

Table 2: Regression Model Summary for Reaction Time on Reactive Control (AY) and Proactive Control (BX) Trials with Digital Media Multitasking Score added as the IV of Interest

Dependent Variables										
	Reactive Control (AY) Accuracy					*Proactive Control (BX) Accuracy*				
	Predictor	*b*	*b* 95% CI [LL, UL]	Fit (R2)	Change in R2	Predictor	*b*	*b* 95% CI [LL, UL]	Fit (R2)	Change in R2
Step 1						**Step 1**				
	Control Trials (AX)	0.23	[-0.12, 0.57]			Control Trials(AX)	0.70**	[0.45, 0.95]		
	Trial Count (AY)	0.02**	[0.02, 0.02]			Trial Count (BX)	0.01**	[0.00, 0.01]		
	Male	-0.02	[-0.05, 0.01]			Male	-0.01	[-0.03, 0.02]		
	Other Genders	-0.06	[-0.18, 0.07]			Other Genders	-0.03	[-0.12, 0.07]		
				R^2 = .739** 95% CI[.66,.78]					R^2 = .391** 95% CI[.26,.48]	
Step 2						**Step 2**				
	Control Trials	0.23	[-0.12, 0.58]			Control Trials(AX)	0.70**	[0.45, 0.95]		
	Trial Count (AY)	0.02**	[0.02, 0.02]			Trial Count (BX)	0.01**	[0.00, 0.01]		
	Male	-0.02	[-0.05, 0.01]			Male	0	[-0.03, 0.02]		
	Other Genders	-0.06	[-0.18, 0.07]			Other Genders	-0.03	[-0.12, 0.07]		
	Media Mulitasking Scale	0	[-0.00, 0.00]			Media Mulitasking Scale	0	[-0.00, 0.00]		
				R^2 = .739** 95% CI[.66,.78]	ΔR^2 = .000 95% CI[-.00, .00]				R^2 = .401** 95% CI[.26,.48]	ΔR^2 = .010 95% CI[-.01, .04]

Note. A significant b-weight indicates the semi-partial correlation is also significant. b represents unstandardized regression weights. LL and UL indicate the lower and upper limits of a confidence interval, respectively.
** indicates p < .05. ** indicates p < .01.*

ERP Results

Results indicated there was no main effect of digital media multitasking scores on the *N2, (F (5,147) =9.90, p = 0.35,* R^2 *=0.25,* ΔR^2*= 0.004)* or P3, *(F (5, 147) = 35.76, p = 0.49,* R^2 *= 0.55,* ΔR^2*=.001)* amplitudes of the correct trials in the AY Probe condition (reactive control), as shown in Table 3. There was also no main effect of digital media multitasking on N2, *(F (5,147)*

=40.53, p = 0.21, R^2 *=0.58,* $\Delta R^2 = 0.005$*)* or P3, *(F (5, 147) = 15.51, p = 0.46,* $R^2 = .34$*,* $\Delta R^2 = .002$*)* amplitudes on the correct trials in the BX Cue condition (proactive control), as shown in Table 4. Put simply, digital media multitasking was not associated with ERP amplitudes commonly associated with proactive or reactive control.

Table 3: Regression Model Summary for Reactive Trials with Digital Media Multitasking Score added as the IV of Interest

Dependent Variables

	N2 Reactive Control					***P3 Reactive Control***				
	Predictor	*b*	*b* 95% CI [LL, UL]	Fit	Difference	Predictor	*b*	*b* 95% CI [LL, UL]	Fit	Difference
Step 1						**Step 1**				
	Correct Trial Count	0.03	[-0.05, 0.11]			Correct Trail Count	0.03	[-0.04, 0.11]		
	Control Trials	0.73**	[0.51, 0.94]			Control Trials	1.05**	[0.88, 1.22]		
	Male	0.27	[-0.75, 1.29]			Male	0.54	[-0.44, 1.51]		
	Other Genders	0.11	[-4.29, 4.51]			Other Genders	-3.66	[-7.78, 0.46]		
				R^2 = .245** 95% CI[.12,.34]					R^2 = .544** 95% CI[.43,.62]	
Step 2						**Step 2**				
	Correct Trial Count	0.03	[-0.05, 0.11]			Correct Trail Count	0.04	[-0.04, 0.11]		
	Control Trials	0.72**	[0.51, 0.94]			Control Trials	1.05**	[0.88, 1.23]		
	Male	0.24	[-0.78, 1.27]			Male	0.51	[-0.47, 1.49]		
	Other Genders	0.22	[-4.19, 4.62]			Other Genders	-3.6	[-7.73, 0.53]		
	Digital Media Mulitasking	-0.02	[-0.06, 0.02]			Digital Media Mulitasking	-0.01	[-0.05, 0.03]		
				R^2 = .249** 95% CI[.12,.34]	ΔR^2 = .004 95% CI[-.01, .02]				R^2 = .545** 95% CI[.43,.61]	ΔR^2 = .001 95% CI[-.01, .01]

Note. A significant b-weight indicates the semi-partial correlation is also significant. b represents unstandardized regression weights. LL and UL indicate the lower and upper limits of a confidence interval, respectively.
** indicates p < .05. ** indicates p < .01.*

Table 4: Regression Model Summary for Proactive Trials with Digital Media Multitasking Score added as the IV of Interest

Dependent Variables									
N2 Proactive Control					*P3 Proactive Control*				
Predictor	*b*	*b* 95% CI [LL, UL]	Fit	Difference	Predictor	*b*	*b* 95% CI [LL, UL]	Fit	Difference
Step 1					**Step 1**				
Correct Trial Count	0	[-0.04, 0.05]			Correct Trial Count	0.11*	[0.02, 0.19]		
Control Trials	0.81**	[0.69, 0.93]			Control Trials	0.91**	[0.69, 1.12]		
Male	0.35	[-0.21, 0.92]			Male	1.31*	[0.23, 2.39]		
Other Genders	0.76	[-1.70, 3.22]			Other Genders	-1.8	[-6.56, 2.96]		
			R^2 = .572**					R^2 = .340**	
			95% CI [.46,.64]					95% CI[.21,.43]	
Step 2					**Step 2**				
Correct Trail Count	0	[-0.04, 0.05]			Correct Trail Count	0.11*	[0.02, 0.19]		
Control Trials	0.82**	[0.70, 0.93]			Control Trials	0.92**	[0.70, 1.13]		
Male	0.37	[-0.19, 0.93]			Male	1.29*	[0.21, 2.37]		
Other Genders	0.68	[-1.77, 3.14]			Other Genders	-1.74	[-6.51, 3.03]		
Digital Media Mulitasking	0.01	[-0.01, 0.04]			Digital Media Mulitasking	-0.02	[-0.06, 0.03]		
			R^2 = .576**	ΔR^2 = .005				R^2 = .342**	ΔR^2 = .002
			95% CI [.46,.64]	95% CI [-.01, .02]				95% CI[.20,.43]	95% CI[-.01, .01]

Note. A significant b-weight indicates the semi-partial correlation is also significant. b represents unstandardized regression weights. LL and UL indicate the lower and upper limits of a confidence interval, respectively.
** indicates p < .05. ** indicates p < .01.*

Discussion

The current study's aim was to determine if the amount of media multitasking a participant engages in would impact the activation of brain regions underlying cognitive control, specifically, two aspects of cognitive control: reactive and proactive control. Participants were asked to perform an AX-CPT while EEG was recorded. ERP data was computed from the EEG data for the N2 and P3. Given that previous research found no differences in behavioral data (i.e., reaction times and performance accuracy) between HMM and LMM (Ophir et al., 2009), we did not predict any behavioral differences. It is likely that behavioral data is not sensitive enough to show individual differences in multitasking. However, we did expect brain differences because ERPs tend to be more sensitive to effects than behavioral data. We were specifically interested in individual differences in multitasking on two ERPs, the N2 and P3. Amplitude variation in these ERPs have been shown to reflect efficiency in utilizing reactive and proactive control (Lamm et al., 2013).

Contrary to our hypotheses, we did not find any N2 or P3 effects associations with digital media multitasking for either reactive or proactive control. One explanation for the lack of findings could be that the design of the research was largely based on the Ophir (2009) study, but was not a direct replication. Our data was evoked using the canonical AX-CPT task that did not include any distractors, and the behavioral effect of media multitasking that Ophir and colleagues found was in a condition that included distractors. Thus, it may be that avoiding of distractors is influenced by media multitasking but not proactive and reactive control. This argument is supported by a study that found high media multitaskers were actually better at ignoring the distractors compared with low media multitaskers using a classic Erickson Flanker task, a task where participants have to focus on the direction of a central arrow while ignoring the direction of the flanking arrows (Baumgartner, Weeda, van der Heijden, & Huizinga, 2014). Additionally, Wiradhany and Nieuwenstein (2017) did a meta-analysis of media multitasking and found only a weak association between media multitasking and distractibility in cognitive control, an effect that was no longer evident after controlling for studies with small effect sizes. In a related study about the impact of media multitasking on executive function, authors found that executive functions related to processing information, while holding other things in working memory, were related to media multitasking (Cain, Leonard, Gabrieli, & Finn, 2016). However, they also found that measures of cognitive processing speed were not related to higher levels of media multitasking. These mixed results could point towards media multitasking having task specific impacts on cognitive control; thus, reactive and proactive control may not be associated with individual differences in media multitasking.

It is also important to consider that the media multitasking scale of interest was a self-report measure. Many studies have called the accuracy of self-report measures into question indicating that participants may answer in a socially desirable ways, they may exaggerate their response, and their responses could simply reflect that they cannot describe their behaviors that accurately (Lucas, 2018). In the case of smartphone use in particular, multiple studies have found that self-report measures were not accurate compared to an application that logged the amount of time devices were used (de Reuver, & Bouwman, 2015; Boase, & Ling, 2013; Vanden Abeele, Beullens & Roe, 2013; Kobayashi, & Boase, 2012). It is possible that using a self-report measure might not capture the true behavioral aspect of media multitasking habits, and a tracking device would be better suited to capture that behavior. Taken together, the mixed perspectives of the impact of media multitasking on cognitive control and the problematic nature of self-reports points to the need for future research to unpack how media multitasking is related to cognitive control. Future researchers could integrate the use of phone usage data to better reflect the true behavioral aspect of media multitasking.

Limitations and Future Directions

The current study has a number of limitations. First, the data collected using the modified media multitasking scale had many instances of missing data. This is likely due to the way that the data was presented in Qualtrics. More specifically, our Qualtrics measure did not differentiate between true missing data and instances in which the participant did not actually partake in that type of media multitasking. This problematic design was different than how Ophir and colleagues (2009) scored the questionnaire; thus, our data had a restriction of range that was not present in the original publication. Another difference in the scoring between the current study and the original Ophir et al. (2009) paper is that the amount of time spent using different forms of technology was not included in our study. Our scale only captures the amount of multitasking, but not how often they actually used media generally. Furthermore, the scale was trimmed to only include items that could be considered forms of digital or electronic media. The original scale included other items such as print media. Future studies could use the media multitasking scale in its original form to help potentially avoid these problems.

Another limitation of the current study is that we did not include any distractors in our task. The original study by Ophir et al. (2009) included a distractor condition; interestingly, this condition was the only one that revealed group differences in media multitasking. Future studies could use a larger array of cognitive control tasks to determine which tasks are most effective for understanding the relationship between digital media multitasking and cognitive control.

Finally, the use of EEG in the current study prevents the inclusions of any person whose hair might limit the collection of clean EEG data. This issue primarily impacts Black persons who often wear their hair in styles that include, but are not limited to, braids, cornrows, hair extensions, or wigs. However, it would also prevent participation for a person with very thick hair or someone who uses a lot of hair product (e.g., hair gel). We recognize that due to the nature of EEG data collection, our data (as well as most EEG data) is biased and would make conclusions about our data impossible to generalize to a larger more diverse population. Future research should be done to determine how to prevent these hair-style-related exclusions so that we can study these previously understudied populations within the field of EEG.

Conclusions

This study attempted to understand the neural differences underlying cognitive control in the context of digital or electronic media multitasking. However, we found no association between multitasking and both reactive and proactive control. Future research should replicate this study but use multiple tasks to evoke various cognitive-control strategies, as it may be that reactive and proactive control are not influenced by media multitasking but that other cognitive-control strategies might be. Drilling down and understanding which cognitive-control strategies are associated with media multitasking can set the stage for designing guiding principles on screen time use for parenting and teaching.

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Appendix

UNIVERSITY OF ARKANSAS

Office of Research Compliance
Institutional Review Board

January 30, 2017

MEMORANDUM

TO:	Connie Lamm
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	17-01-386
Protocol Title:	*Differential Neural Correlates Underlying Various Self-Regulation Strategies*
Review Type:	☐ EXEMPT ☒ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 01/25/2017 Expiration Date: 01/24/2018

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (https://vpred.uark.edu/units/rscp/index.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 120 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.

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The University of Arkansas is an equal opportunity/affirmative action institution.

To:	Connie Lamm BELL 4188
From:	Douglas James Adams, Chair IRB Committee
Date:	01/27/2020
Action:	**Expedited Approval**
Action Date:	01/23/2020
Protocol #:	1708026820R003
Study Title:	Differential Neural Correlates Underlying Various Self-Regulation Strategies
Expiration Date:	01/24/2021
Last Approval Date:	01/25/2020

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Michelle Gray, Key Personnel
Stephanie M Long, Key Personnel
Morgan Middlebrooks, Key Personnel
Arooj Abid, Key Personnel
Eric Logan Rawls, Key Personnel
Carroll Gene Bentley, Key Personnel
Andrew Wilton Jennings, Key Personnel
Ebony A Walker, Key Personnel
Emily Brianne Tolar, Key Personnel
Erik Lyle Abramson, Key Personnel
Jahnavi Kodali, Key Personnel
Gabriel Keifer Bernardo, Key Personnel

Supplemental 1: Media Multitasking Scale

Q3.1 On an average day, how many hours do you spend texting, instant messaging, or emailing? Please feel free to use decimals. If you do not do this activity on the average day, please enter 0.

Q3.2 While you are texting, instant messaging, or emailing, what percentage of time are you also doing each of these other activities? Please use the sliders to indicate the percentage of time.

- Using print media (including print books, print newspapers, etc.)
- Texting, instant messaging, or emailing
- Using social sites (e.g., Facebook, Twitter, etc., except games)
- Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
- Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
- Listening to music
- Watching TV and Movies (online and off-line) or YouTube
- Playing video games or online games
- Doing homework/studying/writing papers
- Talking face-to-face with a second person

Q4.1 On an average day, how many hours do you spend using social sites (e.g., Facebook, Twitter, etc., except games)? Please feel free to use decimals. If you do not do this activity on the average day, please enter 0.

Q4.2 While you are Using social sites (e.g., Facebook, Twitter, etc., except games), what percentage of time are you also doing each of these other activities? Please use the sliders to indicate the percentage of time.

- Using print media (including print books, print newspapers, etc.)
- Texting, instant messaging, or emailing
- Using social sites (e.g., Facebook, Twitter, etc., except games)
- Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
- Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
- Listening to music
- Watching TV and Movies (online and off-line) or YouTube
- Playing video games or online games
- Doing homework/studying/writing papers
- Talking face-to-face with a second person

Q5.1 On an average day, how many hours do you spend using non-social text-oriented sites (e.g., online news, blogs, eBooks)? Please feel free to use decimals. If you do not do this activity on the average day, please enter 0.

Q5.2 While you are using non-social text-oriented sites (e.g., online news, blogs, eBooks), what percentage of time are you also doing each of these other activities? Please use the sliders to indicate the percentage of time.

- Using print media (including print books, print newspapers, etc.)
- Texting, instant messaging, or emailing
- Using social sites (e.g., Facebook, Twitter, etc., except games)
- Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
- Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
- Listening to music
- Watching TV and Movies (online and off-line) or YouTube
- Playing video games or online games
- Doing homework/studying/writing papers
- Talking face-to-face with a second person

Q6.1 On an average day, how many hours do you spend talking on the telephone or video chatting (e.g., Skype, iPhone video chat)? Please feel free to use decimals. If you do not do this activity on the average day, please enter 0.

Q6.2 While you are talking on the telephone or video chatting (e.g., Skype, iPhone video chat), what percentage of time are you also doing each of these other activities? Please use the sliders to indicate the percentage of time.

- Using print media (including print books, print newspapers, etc.)
- Texting, instant messaging, or emailing
- Using social sites (e.g., Facebook, Twitter, etc., except games)
- Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
- Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
- Listening to music
- Watching TV and Movies (online and off-line) or YouTube
- Playing video games or online games
- Doing homework/studying/writing papers
- Talking face-to-face with a second person
- Talking face-to-face with a second person

Q9.1 On an average day, how many hours do you spend watching TV and Movies (online and off-line) or YouTube? Please feel free to use decimals. If you do not do this activity on the average day, please enter 0.

Q9.2 While you are watching TV and Movies (online and off-line) or YouTube, what percentage of time are you also doing each of these other activities? Please use the sliders to indicate the percentage of time.

- Using print media (including print books, print newspapers, etc.)
- Texting, instant messaging, or emailing
- Using social sites (e.g., Facebook, Twitter, etc., except games)
- Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
- Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
- Listening to music
- Watching TV and Movies (online and off-line) or YouTube

- Playing video games or online games
- Doing homework/studying/writing papers
- Talking face-to-face with a second person

Q10.1 On an average day, how many hours do spend playing video games or online games? Please feel free to use decimals. If you do not do this activity on the average day, please enter 0.

Q10.2 While you are playing video games or online games, what percentage of time are you also doing each of these other activities? Please use the sliders to indicate the percentage of time.

- Using print media (including print books, print newspapers, etc.)
- Texting, instant messaging, or emailing
- Using social sites (e.g., Facebook, Twitter, etc., except games)
- Using non-social text-oriented sites (e.g., online news, blogs, eBooks)
- Talking on the telephone or video chatting (e.g., Skype, iPhone video chat)
- Listening to music
- Watching TV and Movies (online and off-line) or YouTube
- Playing video games or online games
- Doing homework/studying/writing papers
- Talking face-to-face with a second person