Influence of Media Multitasking, Cognitive Load and Smartphone Addiction on

Divided Attention Performance

by

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ABSTRACT

Mixed results have been found for effects of media multitasking frequency on divided attention ability. In addition, there is a lack of evidence to support cognitive differences in those who qualify for a usage disorder concerning their mobile device. In the current study, performance was measured using the Sustained Attention to Response Task (low cognitive load) and a letter number sorting task (high cognitive load). Participants completed both tasks with and without a video presented simultaneously. Eye tracking data was used to evaluate when each participant was looking at each area. Speed, accuracy, and number of fixations on each stimulus were analyzed for each participant. Results demonstrated no cognitive differences among heavy and light media multitaskers, or those who qualified for social media disordered use criteria compared to those who did not. In addition, no differences were observed between the control condition and the experimental condition with the video present.

DEDICATION

I'd like to dedicate this thesis to my Mom and my Dad, for always believing in me and

never failing to encourage me, and to my sister Cara for serving as the inspiration for my

project.

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Finally, thank you to Taylor Swift.

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List of Symbols, Nomenclature or Abbreviations

HMM = Heavy Media Multitaskers

LMM = Light Media Multitaskers

MMI = Media Multitasking Index

SNS = Social Networking Site

SMD = Social Media Disorder

Influence of Media Multitasking, Cognitive Load and Smartphone Addiction on

Divided Attention Performance

Smartphone usage has become an integral part of society and its functioning, with heavy influence on individuals. Ninety-five percent of individuals aged 13–17 used a smartphone in 2018 (Anderson & Jiang, 2018). Usage habits have also evolved significantly in short periods of time; in 2015, Pew Research Center reported Facebook to be the most prevalent social media source among young adults (Lenhart, 2015), however in 2018 only 51% of users report using the application, behind YouTube, Instagram, or Snapchat (i.e., 85%, 72%, and 69% respectively; Anderson & Jiang, 2018). In 2021, the most common applications for adults aged 18–24 were Instagram, Snapchat and TikTok, with the majority of users for each indicating they visit the applications daily (Auxier & Anderson, 2021).

With this increased usage, potential risks have also become more prevalent. Texting while driving has increased 102% from 2010 to 2019 among Canadians (Lyon et al, 2021). Seventy-five percent of young adults aged 12-25 admit to checking their mobile device at least once an hour (Rosen, Carrier, & Cheever, 2013), and 45% admit to being "online on a near-constant basis" (Anderson & Jiang, 2018, para. 2). Smartphones have become an integral element of society, becoming an extension of an individual's personal identity (Harkin, 2003).

Although smartphones have been studied extensively, there is less research focused on the cognitive effects of chronic mobile device usage, such as the influence smartphones may have on components of functioning such as attention. The current study aims to explore the effects of media multitasking and disordered social media use on

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divided attention, by measuring performance on tasks of media multitasking as well as using eye tracking data, to better understand the influences of smartphone use on cognition, and differences between high and low media multitaskers.

Attention

Attention refers to "taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought" (James, 1890, pp. 403–404). More attentional resources are available when an individual is more engaged with the task, and many factors influence how much attention is available at any time, such as the influence of drugs or alcohol and task demands (Kahneman, 1973). Goal-directed behaviour can be defined as "focusing attention on goal-relevant stimuli while ignoring relevant distractors" (Lavie et al., 2004, p. 339) and is important in focusing attention. Attention can be categorized as focused (i.e., attending to one stimulus channel at a time), or divided (i.e., dividing attention between two or more sources at one time; Nebel et al., 2005). Individuals completing tasks of divided attention are more likely to exhaust their attentional resources more quickly, because of limited resources (Castro et al., 2019).

Two predominant mechanisms for understanding how attention works are top-down attention and bottom-up attention. Bottom-up attention is driven by a stimulus, and top-down attention is goal-based (Liu et al., 2009). Bottom-up attention occurs when a stimulus is prominent in some way (e.g., colour or presentation style), capturing attention and delaying the individual from considering other stimuli (Yantis & Jonides, 1984). This process employs exogenous processes, pulling attention even when the individual is directed to focus on other tasks (Theeuwes, 1994). This phenomenon is observed both in

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singletons (i.e., a unique visual stimulus; Hsieh et al., 2011) and in changes in luminance (Irwin et al., 2000). Notifications are an example of a bottom-up stimulus in smartphones (Stothart et al., 2015). Top-down processing is driven by individual goals. When attention is directed in one area, individuals are more likely to focus attention to that task and can filter out distracting stimuli (Bacon & Egeth, 1994). This may also be contingent on task demands (Folk et al., 1992). However, visual search is hindered by the onset of abrupt stimuli leading to slower reaction times than when focus is directed, even when participants were instructed not to pay attention to exogenous cues (Posner et al., 1980; Remington et al., 1992).

However, a more reasonable theory may be a combination of both top-down and bottom-up processing. According to hybrids of these theories, attention is drawn to a stimulus initially, and the individual decides how to proceed based on endogenous considerations such as goals and motivations (Rogers & Monsell, 1995; Yantis, 2000).

Failures in Attention

Failures in attention are defined as "temporary shifts of attention away from the task at hand" (Unsworth et al., 2012, p. 1765). The causes of these failures can be external (e.g., exogenous attentional cues, for example, while receiving a notification on a smartphone) or internal (e.g., thoughts or ruminations; Unsworth et al., 2012). In university students, the most common failure in attention reported was feeling distracted while studying (Unsworth et al., 2012). The ability to hold attention for longer periods of time led to fewer failures in attention, and have also been linked to improved academic performance (i.e., SAT scores; Unsworth et al., 2012).

On average, individuals focus on one task for three minutes in work settings before switching to another task based on observational data, and once attention has been switched or diverted by exogenous stimuli, it takes on average 30 minutes for the individual to resume the original task (González & Mark, 2004). Rosen, Carrier, and Cheever (2013) demonstrated individuals were able to focus on studying for approximately six minutes before disengaging and switching to a different task, typically to an application such as Facebook. In addition, those who reported texting more often were more likely to switch to the distractor task after a shorter period of time (Rosen, Carrier, and Cheever, 2013). Higher media multitasking has been demonstrated to cause increased failures of attention in everyday life (Ralph et al., 2014).

Bottleneck Theory of Attention

Broadbent (1958) hypothesized attention as a bottleneck. The theory includes three systems; 1) the S system, known as the short-term memory system, where all information is entered without capacity limits; 2) the selective filter, that decides which information is selected from the vast amount of information in the S system; 3) and the P system, also known as the limited capacity channel, where most perceptual analyses are carried out. Information in the S system that is not selected to be processed decays.

This theory posits the brain cannot focus on two or more tasks at one time, as the P system is not capable of processing two streams of information at one time. This means attention cannot be truly divided between two tasks, but is moderated by continual task switching.

What is chosen for selective filtering has been debated. Theories include early (i.e., when attention is directed and opposing stimuli are filtered out; Broadbent, 1958)

and late selection (i.e., when all stimuli are processed whether they are paid attention to or are not paid attention to; Deutsch & Deutsch, 1963). Broadbent's theory conforms to early selection models, however this theory does not explain exogenous attentional cues, as if the individual is focused intently on the task at hand, they would be less likely to be distracted by external cues. Moray (1959) furthered this critique by demonstrating participants were not able to focus on the stream of audio presented to one ear as instructed, when the other stream said the participants name.

Treisman (1960) introduced Attenuation theory to expand upon Broadbent's theory. Attenuation theory posits the filter does not block other stimuli, rather attenuates them. Other stimuli are processed, but not as strongly as the stream being attended to. This means if a stimulus is salient enough, it may draw the attention of the individual, causing a switch in attention (Yiğit-Elliott et al., 2011).

A more modern approach to understanding early versus late selection theory is that both processes interact, and both can be seen under different experimental conditions (Pohl et al., 2010). Both attenuation and blocking have been shown to be used in different circumstances; for example, when spatial selection is low, blocking is more likely to be used, and when special selection is broad, attenuation is used (Yiğit-Elliott et al., 2011).

Attention and Effort

Kahneman's theory of attention describes goal-directed attention as a limited workspace (Kahneman, 1973). This theory also includes effort into the attentional framework: Kahneman proposes the more effort individuals put into a task, the more attention they can dedicate to the task at hand (Kahneman, 1973). When effort is

increased, this theory posits attention is more selective, leading to the individual ignoring irrelevant cues and improving focus (Kahneman, 1973).

Cognitive Load

Cognitive load is defined as anything that takes up working memory capacity (Lovell, 2020). Cognitive load theory consists of three types of load: 1) intrinsic load, known as load imposed by the task or task difficulty (i.e., task demands); 2) extraneous load, known as the load imposed by the surrounding environment; 3) and germane load, characterized by individual factors (i.e., individual motivation; Gwizdka, 2010; Plass et al., 2010). Ideal levels of productivity are when external load is reduced, and internal load is optimal (Lovell, 2020). Task switching increases cognitive load (Paivio, 1990), as the more resources are required to complete the primary task, the fewer cognitive resources are available to complete a secondary task (Gwizdka, 2010). Chunking pieces of information that are similar is an effective strategy to minimize cognitive load, and can help to maximize the amount of information the individual can retain (Paas et al., 2003).

In internet search tasks, generating search terms and viewing content exhibits higher cognitive load than viewing relevant result lists and scanning pages for relevant information (Gwizdka, 2010). Specifically concerning smartphones, scrolling on social media or the internet is considered low cognitive load, while sending messages and composing content are considered high cognitive load (Oh & Lapointe, 2017).

Individuals report higher cognitive load when their phone is in their presence, a phenomenon that increases the more dependent the individual is on their smartphone (Ward et al., 2017). This is because the more the individual is preoccupied with thoughts

of their smartphone, the more space is occupied by intrinsic factors, thereby reducing availability for external tasks (Nason & Wilbiks, 2022).

Load Theory

Lavie & Tsal (1994) introduced load theory to combine the effects of cognitive load and perceptual load, and to provide a theory for why early and late selection are both possible. This theory posits both processes have independent and opposite effects on cognition (Fitouski & Wegner, 2011). Perceptual load is defined as the amount of perceptual processing that is required for the task at hand, or when observing a scene (Greene et al., 2017). High perceptual load is known to cause cases of inattentional blindness and can also cause difficulty in identifying peripheral details (Greene et al., 2017). Early selection of selective attention happens when perceptual load reaches attentional capacity (Lavie & Tsal, 1994). While high perceptual load eliminates distractor processing, higher cognitive load encourages distractor processing (Lavie et al., 2004). This theory posits distractors will not be processed due to cognitive load when perceptual load is also high (Lavie et al., 2004). With low perceptual load, the remainder of attention will be split over peripheral distractors (Lavie et al., 2004). This theory explains early and late selection, as early selection is high perceptual load, and late selection would be due to lower perceptual load (Lavie et al., 2004).

For example, because the Sustained Attention to Response Task (SART) consists of a number presented on a blank background, perceptual load is low as well as cognitive load, and the individual will be more likely to facilitate other stimuli because of this. Using the random SART, where stimuli are presented in a random order, increases cognitive load, and therefore the individual is less likely to consider additional stimuli. In

comparison, when completing a letter-number classification task, perceptual load is still low (i.e., a number or a letter on a blank background), but cognitive load is high as the individual will be likely to consider external stimuli because of this. If perceptual load was increased, by using dots instead of a number and increasing the number of stimuli the individual needs to process, they will be more likely to remain engaged on the task, as counting dots remains a task of low cognitive load. If the individual were to count dots, then assign a classification of odd or even, cognitive load is increased, and the individual may consider additional distractors due to this effect.

However, this theory is not without criticism. Researchers argue load theory is too simplistic and ignores crucial elements such as spatial proximity and stimulus salience (Fitouski & Wegner, 2011; Khetrapal, 2010). Studies have also found evidence for selective attention in low-load conditions, where distractors did not affect participant performance (Paquet & Craig, 1997). Low load conditions also were found to eliminate distractors when cuing was used (Johnson et al., 2002). Khetrapal (2010) argues this theory may account for perceptual load, however it needs to be further developed to encompass all elements of selective attention, although the theory is robust and has had success in predicting many conditions.

Task Motivation

Task motivation, or the drive to finish one task, influences overall cognitive load. If individuals are more motivated, they will be more likely to focus their attention to meet these guidelines. Students assigned to a primary task were less likely to dedicate attention to the second task to protect the first task (Ralph et al., 2021). They were also more likely to eliminate additional distractors (e.g., an optional video the participant could turn on or

off) to focus on the primary task. Instructions to focus on one task or another may also motivate individuals; in a 1996 study by Craik et al., when participants were instructed to focus on fast responses or accuracy, these effects were observed during the encoding stage of memory.

Motivation can also be influenced by reward. Although rewards can be subjective (Berridge et al., 2009; Lebreton et al., 2009), research demonstrates both subliminal as well as supraliminal rewards increase performance when offered to a participant (Zedelius et al., 2014).

Divided Attention

Divided attention is defined as splitting attention between two or more tasks (Nebel et al., 2005). Performance costs in tasks of divided attention are prevalent in both concurrent tasks and continual task switching.

Adler et al., (2015) gave participants control over a multi-tabbed interface, with one containing the target task (i.e., studying for a quiz), while the others included amusing tasks. When individuals are reminded to return to the task at hand following one minute of off task activity, reminders were not useful in returning the individuals to productive behaviour in males (Adler et al., 2015).

Dual Task Performance

Performing two or more tasks at one time is associated with switch costs, or the time associated with switching from one task to another while completing multiple tasks (Rogers & Monsell, 1995). Switch costs can be measured by calculating the difference between switch (i.e., switching from task A to task B) and non-switch trials (i.e., completing two presentations of task A; Wylie & Allport, 2000). Reaction time with

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switch trials is higher than reaction time for repeat trials when completing tasks involving task switching (Richter & Yeung, 2012). Practice can reduce switch costs (Rogers & Monsell, 1995). Alternating from one task to another (e.g., switching from task A to task B back to task A) causes switch costs to be uniform, although reaction time is slower in switching between two tasks (Allport et al., 1994).

Dual task performance has been shown to lower attentional capacity compared to single task conditions (Wahn & König, 2015). To illustrate this point, engaging in a conversation over a messaging network while scrolling social media would be more difficult compared to scrolling on social media with no ongoing conversations. Dual task performance has been shown to differ in attentional resource allocation, due to factors such as task demands (Wahn & König, 2015) as well as perceived importance (Law et al., 2006), or directions (Schumacher et al., 2001). Both executive control as well as working memory are involved in favouring one task over another, based on elements such as difficulty and motivation (Lavie et al., 2004). In addition, switching tasks led to impaired recognition memory for task irrelevant information, but increases performance for task irrelevant items, aligning with theories of high cognitive load (Richter & Yeung, 2012). In a 2015 study by Wahn and König, task performance was impaired increasingly for multiple objects tracking tasks than for localization tasks. It was reasoned the individual devoted additional resources to the localization task, at the expense of the multiple objects tracking task. Individuals who are committed to one task are more likely to favour that task over secondary tasks, and are more likely to eliminate distractors (such as background content) to focus on the primary task (Ralph et al., 2020). In addition, those completing tasks with a higher memory demand (i.e., completing a 2-back task rather

than a 0-back task) were more likely to remove the video, indicating increased difficulty focusing in a high cognitive load condition. In this task, 83% of participants reported being distracted by the video (Ralph et al., 2020).

While performance typically suffers in one task when an individual is completing dual tasks, expertise can remedy this in both dual task (Hirst et al., 1980; Schumacher et al., 2001), and independent task performance (Yantis & Jonides, 1984). Task switching is also improved when switching from an experimental task that has been practiced to a similar task (Alzahabi & Becker, 2013).

Executive Control

Executive control, or the high-level mental processes in place when deciding behaviour, is an important decision-making mechanism, which helps the individual decide what to focus on (Gilbert & Burgess, 2008). Both executive control as well as working memory are involved in switching between tasks, based on elements such as difficulty and motivation (Lavie et al., 2004). In tasks of divided attention, availability of executive function is important "to ensure that task performance remains in accordance with current priorities" (Lavie et al., 2004, p. 352). Switching tasks reduces cognitive control, resulting in decreased memory ability (Richter & Yeung, 2012).

Media Multitasking

The present study aims to examine multitasking in order to observe differences in multitasking among task types. Media multitasking is defined as the use of two or more sources of media at one time (Uncapher & Wagner, 2018). Media Multitasking is measured using the Media Multitasking Index (MMI; Ophir et al., 2009), where participants indicate how much time they spend on each medium, and how much time

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they spend on two of the mediums at the same time, forming a correlational matrix. Average media multitasking scores are equal to 3.82 (Lui & Wong, 2012), and can include print media, television, computer-based video (e.g., YouTube or Netflix), music, non-music audio (e.g., podcasts), video or computer games, smartphone calls, instant messaging, SMS (text messaging), email, web surfing, and other computer-based applications. Examples of media multitasking include listening to music while scrolling social media, making a call while playing a video game, or surfing the web while listening to a podcast. Scoring typically divides participants into Heavy Media Multitaskers (HMM) and Light Media Multitaskers (LMM; Uncapher & Wagner, 2018) although scores are sometimes assessed as a continuous variable (e.g., Elbe et al., 2019).

HMMs, across a variety of cognitive domains, typically report deficits compared to LMMs despite some conflicting evidence, according to a review by Uncapher & Wagner (2018). These authors speculate this may be due to HMMs adopting a more exploratory nature than LMMs, as they have the tendency to consider more external stimuli not related to the original task (Elbe et al., 2019; Uncapher & Wagner, 2018).

Heavy media multitasking has been shown to lead to increased distractor processing, as well as a broader focus of attention (Cain & Mitroff, 2011). HMMs are found to be more likely to allow themselves to be distracted compared to lower media multitaskers who maintain focus on a singular task (Ralph et al., 2015). Those who report lower media multitasking scores report a unitary mode of focus and can focus on a singular task without incorporating outside information more easily (Yap & Lim, 2013). This leads to increased productivity. Heavier media multitasking also predicts impulsive

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behaviour (Baumgartner et al., 2014). In addition, it has a negative relationship with executive function (Baumgartner et al., 2014).

There is no significant relationship between media multitasking and working memory, meaning it most frequently impacts attention (Ralph et al., 2014). Media multitasking frequently reports negative effects of media multitasking on measures of attention, however it is recommended the frequency and intensity be further researched to be fully understood (Uncapher & Wagner, 2018). In addition, conflicting results suggest younger generations may not multitask as much as expected, with results from experimental studies suggesting multitasking in young adults is not as high as expected based a 2011 study (Judd & Kennedy, 2011). While most students participated in multitasking behaviours, results were not as high as hypothesized when observing computer login information (Judd & Kennedy, 2011). It is hypothesized by the authors that due to different computer uses (e.g., educational purposes, or personal reasons) multitasking may be observed more frequently under some conditions than others. However, differences were observed even between first-year university students and second-year university students, indicating vast differences between age groups, hypothesized to be due to technology familiarity (Judd & Kennedy, 2011). Because smartphones have grown in prevalence since this time, it is unclear whether this effect would persist over smartphones as well.

However, higher media multitaskers report more positive effects on well-being than low media multitaskers (Xu et al., 2016). In addition, conversations while media multitasking had different effects on well-being; while higher media multitaskers report lower social success while having a synchronous conversation (i.e., face-to-face), there

were no effects found with asynchronous conversations (i.e., instant messaging; Xu et al., 2016).

With increased technology usage, it is evident individuals will turn to additional media multitasking, for example, 75% of users complete schoolwork while listening to music (David et al., 2014). However, this may not be an asset as those who reported higher tendency to multitask also reported additional symptoms for disorders such as mania, depression, narcissism, and antisocial disorder (Rosen, Whaling, et al., 2013). This result calls researchers to wonder if multitasking ability has evolved beyond its benefits with the addition of media, because of the ease of multitasking (Rosen, Whaling, et al., 2013). Results from a 2018 meta-analysis indicate overall negative effects of media multitasking in academic contexts, including Grade Point Average, comprehension, as well as self-regulation (May & Elder, 2018).

Media Multitasking and Switch Costs

Media multitasking requires dividing attention between two or more tasks (Cain et al., 2016). Ophir et al. (2009) found higher media multitaskers reported poorer switch costs than lower media multitaskers, because of their broad filters and inability to filter distractors. However, other authors have found opposing results. Minear et al. (2013) found no differences between high and low media multitaskers in task switching ability or working memory by comparing reaction time for switch versus non-switch trials, but did find HMM's reported higher motor impulsivity. Due to these faster reaction times, it was hypothesized individuals became more impulsive as they attempted to ignore distracting stimuli (Minear et al., 2013).

Alzahabi & Becker (2013) found switch costs were the cause of improved performance of task switching ability, concluding HMM's were more capable of reconfiguring their task set at rapid paces. Elbe et al. (2019) demonstrated media multitaskers have lower switch costs than low media multitaskers, improving divided attention ability. Further work indicated active anticipation of a new task as well as passive decay were most prominent in viewing these switch costs (Alzahabi et al., 2017). These findings were consistent with previous theories of task switching (Sohn & Anderson, 2001), indicating these two factors specifically may be important in observing these switch costs. In addition, active anticipation was also related to heavier media multitasking as well as fluid intelligence (Alzahabi et al., 2017).

However, many studies that report a positive effect have been criticized due to low statistical power producing a false positive result (Schneider & Chun, 2021). When task switching paradigms are used with a larger sample, there is the absence of a relationship (Schneider & Chun, 2021). Evidence of a null result has been found in many studies (Alzahabi et al., 2017, Baumgartner et al., 2014, Cardoso-Leite et al., 2016, Minear et al., 2013), even when individuals report additional attentional difficulty (Baumgartner et al., 2014).

Media Multitasking with Videos

Using a smartphone while watching television is one of the most prevalent forms of media multitasking today, with approximately 35% of individuals using their smartphone during television according to a 2015 study (Holz et al., 2015). This media multitasking combination is reported to be the most common form of media multitasking (Segijn et al., 2017). Individuals frequently use their smartphones or other electronic

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devices when television is playing in the background for many reasons, including sitting

in a room with family while television is on and being disinterested in the program, or

completing tasks (i.e., answering emails or responding to messages) on a smartphone

while watching television (Holz et al., 2015). Use of tablets to watch television is also

common, enabling individuals to watch television even when they do not have access to a

television (Greer & Ferguson, 2015). Using a tablet to watch television is positively

correlated with watching television on a device itself, meaning tablet devices allow

individuals to continue watching television when only a tablet is available, increasing

overall media consumption (Greer & Ferguson, 2015). While this does not necessarily

constitute media multitasking, a second device facilitates both increased media usage as

well as more opportunities to engage in media multitasking. Tablets also allow users to

split the screen, meaning media multitasking can take place using a single device.

Smartphones

Many individuals have the tendency to see physical reality as fundamentally

different than the digital world, a phenomenon referred to as digital dualism (Jurgenson,

2011). However, using social networking sites (SNS; e.g., Facebook) has been shown to

increase feelings of social connectedness, yet not for sites such as Twitter or YouTube

(Alloway & Alloway, 2012). This is due to sharing personal information on Facebook

more frequently than other applications (Alloway & Alloway, 2012). However, 44% of

individuals feel they do not spend time with others as they are distracted by their

smartphones (James et al., 2018). This influence has been shown in addition to social

interaction in a variety of situations, such as danger on the road while driving through

lack of self-awareness and missing critical information on the road (Mccart et al., 2006;

Sanbonmatsu et al., 2016; Strayer & Johnson, 2001; Strayer et al., 2003) and financial issues (Billieux et al., 2008) in addition to influences on mental (Lee et al., 2018) and physical health (e.g., Clayton et al., 2015; Fu et al., 2020; Gutiérrez et al, 2016). Young individuals are more prone to overuse and problematic use (Bianchi & Phillips, 2005). Dangerous smartphone use, prohibited smartphone use, dependence on one's smartphone as well as financial problems due to one's smartphone can each be predicted by how long the individual has owned a smartphone (Billieux et al., 2008).

As with primary caregivers or transitional objects (Winnicott, 1991), individuals can show attachment to smartphones. Individuals who are attached to an object may demonstrate proximity-seeking behaviours and may have anxiety when not exposed to the stimulus they are attached to (Bowlby, 1969). Behavioural and physiological stress were demonstrated in relation to smartphones in a study by Konok et al. (2017), as well as proximity-seeking behaviours when separated. However, in relation to original theories of attachment, there are crucial differences when being attached to smartphones. Individuals exhibit these same emotions when exposed to an unfamiliar device, meaning it is not the mere presence of their smartphone, rather the content that is accessible on any smartphone that is appealing to users (Konok et al., 2017). Individuals with insecure attachments were more likely to meet smartphone addiction criteria to a 2022 meta-analysis (Zhang et al., 2022). This attachment is important when considering diagnosis with smartphone addiction, as attachment does not mean an individual is addicted.

Individuals may be attached to their smartphones because of the perceived cognitive elements related to one's smartphone, including "serving as a technological reminder of the network of friends and loved ones within its phonebook" (Harkin, 2003,

p.16). Because of these positive elements, many individuals would not want to change any potential negative influences from their smartphone; for example, when students reported experiencing phantom vibration syndrome (i.e., "perceived vibrations from a device that is not really vibrating;" Drouin et al., 2012, p. 1490), they did not care for intervention of any sort, with only 9% of students reporting this sensation as bothersome (Drouin et al., 2012). In a 2018 study, 31% describe the effects of social media in a mostly positive manner, 45% describe its effects as neutral, and 21% describe its effects as mostly negative, despite disconfirming evidence (Anderson & Jiang, 2018). Because of this, these results demonstrate heterogeneity, and illustrate the idea that many individuals do not feel negatively impacted by their smartphone usage.

It is hypothesized by Kuang-Tsan and Fu-Yuan (2017) that excessive smartphone usage may be due to unpleasant situations in real life romantic or academic stress. Smartphones have been shown to have a significant effect on relationships; using the smartphone of a significant other has been shown to increase feelings of mistrust (Haranto & Yang, 2016), and partially mediates the relationship between emotional instability, conflict, and intention to break up in couples (Arikewuyo et al., 2021). In addition to difficulties in relationships, there are also cognitive effects that may arise because of excessive smartphone usage. Although excessive usage has been shown to result in lower wellbeing, some usage is better than no usage, suggesting the relationship between the two variables is not linear (Przybylski & Weinstein, 2017).

Cognitive Effects

Research has provided mixed results on the effects of smartphones on cognition. Chronic usage has not been shown to have detrimental effects on cognition (Mohan et al.,

2016). In addition, more frequent SNS usage was associated with higher working memory ability (Alloway & Alloway, 2012).

Boredom has been shown to lead to excessive social media use, leading to information overload (Zhang et al., 2016) and fatigue (Whelan et al., 2020). Social overload has the largest effect on social network fatigue, and men are more likely than women to demonstrate this phenomenon (Zhang et al., 2016).

The inability to answer one's phone while it rings can cause poor task performance as well as increased heart rate and unpleasantness (Clayton et al., 2015). More impulsive smartphone users have been demonstrated to use social media more frequently and to access public internet more often (Jeske et al., 2016). Billieux et al., (2008) hypothesized individuals reporting higher levels of urgency would also report additional difficulty in restraining from using their smartphone especially in emotional situations, leading to increased usage. In addition to these feelings of anxiety because of separation and impulsive use, the relationship between separation anxiety and switch costs can be moderated by smartphone addiction, leading to changes in divided attention performance (Haranto & Yang, 2016).

Academic Performance. One area smartphones have proven to be distracting is in academic settings (End et al., 2010). Because the sample for the current study is comprised of university students, it is important to consider the specific circumstances that students may experience that renders performance fundamentally different from other adults. For example, attempting to navigate social communication while studying has become increasingly difficult because of endogenous individual control as well as exogenous cues, such as the arrival of notifications. While many individuals report

instant messaging and social media during learning and while studying, although these students also believe it to be detrimental to their learning (Junco & Cotton, 2011). Individuals who heard a phone ringing during an instructional video performed worse on a recall test than those who did not. Students also use this technology while studying; a study by Rosen, Carrier, and Cheever (2013) revealed students were able to focus on studying for approximately six minutes before switching to another task. Texting and boredom were the most common reasons for task switching (Rosen, Carrier, and Cheever, 2013). In addition, individuals who reported checking Facebook recently had lower Grade Point Averages than individuals who checked the application less frequently (Rosen, Carrier, and Cheever, 2013). Students with more refined study strategies were also able to focus on studying for longer than other students (Rosen, Carrier, and Cheever, 2013).

Smartphones have also been shown to negatively impact sleep quality (Fu et al., 2021). Screen use specifically before sleeping has been found to lead to a shorter duration of sleep, leading to slower reaction times and lapses in sustained attention the following day (Oliviera et al., 2020).

Students seem to be aware of the cost of engaging in smartphone behaviours, as 75% of individuals believed texting during a lecture to negatively affect academic performance, but 40% admit to still engaging in these behaviours despite this knowledge (Rosen, Carrier, and Cheever, 2013). When given the option to multitask during a lecture, students performed worse on a test of recall compared to students told to focus on the lecture with only a pen and paper (Demirbilek & Talan, 2017). This led to consideration for how technology policies are policed, and in some cases restricted, in academic

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settings for ease of students and educators (Demirbilek & Talan, 2017). Rosen et al.,

(2011) state "we should be teaching our students metacognitive strategies that focus on

when it is appropriate to take a break and when it is important to focus without

distractions" (p. 174). It is important to understand the effects of using smartphones in

learning environments because of the effects they have demonstrated to have on learning

(Rosen et al., 2011).

Notifications. The average individual receives 151 notifications per day (Nason

& Wilbiks, 2022). These notifications are disruptive because the arrival of a new

stimulus, especially an abrupt one, has the tendency to capture attention (Yantis, 1993).

Because notifications are exogenous attention cues, this means attention may be diverted

from a task hundreds of times per day, whenever these may occur. Receiving

notifications leads to poorer performance in tasks of sustained attention than receiving no

notifications, even when individuals did not respond (Stothart et al., 2015). This is

hypothesized to be because the notifications are important to the individual, causing mind

wandering to ponder what the message may be (Stothart et al., 2015). In an online

experiment with no notification manipulation, increased notifications were a predictor of

poorer sustained attention performance, meaning these effects may be due to the lasting

effects of notifications typically received during the day, or due to the individual's

receiving notifications while completing the experimental task (Nason & Wilbiks, 2022).

Individuals receiving 16 or more messages during a lecture period reported worse

performance on a test than those who received four or less, or no messages (Rosen et al.,

2011). In addition, those who waited to answer the message rather than attending to it

immediately indicated improved performance on the test, leading to a recommendation

for the individual to find more appropriate times to engage with their smartphone as opposed to attending to it immediately (Rosen et al., 2011).

In addition to notification costs, 89% of students report phantom vibration syndrome (Drouin et al., 2012). Of these students, 11% report experiencing these sensations daily, and 33% report receiving them at least once per month (Drouin et al., 2012). As well, individuals who have stronger emotional reactions to text messages (i.e., feeling disappointed when they feel a vibration to see no message) report feeling additionally bothered by these phantom vibrations (Drouin et al., 2012).

Smartphones and Attention

Alloway & Alloway (2012) tested individuals who frequently used SNS's using a task of sustained attention, to examine differences in those who engage more frequently compared to those who do not choose to engage. Active users (i.e., those who spent most time engaging with others) reported higher performance in block one than passive users (i.e., those who use SNS to browse, but did not engage during most of their time on their smartphone), however with practice, passive users were able to eliminate this effect. Active SNS users report the improved ability to process parallel forms of media at one time. Passive users assigned attention to one task and had the tendency to filter out other distractors (Alloway & Alloway, 2012). The difficulty to filter distractor stimuli aligns with findings of elevated levels of media multitasking (Cain & Mitroff, 2011; Ophir et al., 2009).

Preoccupation in smartphones was found to be a significant predictor of lower sustained attention accuracy as well as slower reaction times (Nason & Wilbiks, 2022). This is due to differences in cognitive load when individuals are more preoccupied with

their smartphones, leading to less working memory space and increased failures in attention (Ward et al., 2017).

Self-Perception of Attention

Although smartphones have been shown to hinder sustained attention performance, this effect is difficult to perceive by the individuals themselves. HMM's perceive themselves to report higher failures in attention (Parry & le Roux, 2019). Nason and Wilbiks (2022) also observed the absence of a relationship between those who perceive themselves to be higher in inattention and their sustained attention performance, indicating perception of attention is not linked to actual task performance. Awareness of smartphone usage also can be helpful in regulating attention: when individuals are aware of how much time they spend on their smartphone, time doing unrelated tasks is reduced (Whittaker et al., 2016). Users who have lower smartphone usage have the tendency to underestimate their use, while high users were more likely to overestimate their phone usage, leading to overall inconsistency in how mobile usage is reported (Goedhart et al., 2018).

Smartphone Addiction

Problematic smartphone use can sometimes be viewed as a behavioural addiction, similar to internet or gambling disorders whereby individuals participate in behaviours that provide short-term, immediate, reward, but also result in feelings of distress and often significant repercussions to their lives and wellbeing (James & Tunney, 2017). There is debate surrounding which behaviours might constitute a behavioural addiction, and how these behaviours should be measured to formally diagnose individuals. Although this debate is prevalent, and terminology has not been defined, many studies

aim to diagnose individuals with this disorder, and examine effects based on this diagnosis. The Diagnostic and Statistical Manual of Mental Disorders V (DSM-5; American Psychological Association, 2013) does not include smartphone addiction due to insufficient peer-reviewed evidence for the behavioural addictions, such as internet addiction or smartphone addiction. Because of this, research should be more careful in diagnosing individuals with a disorder such as smartphone addiction, specifically due to the inconsistency across studies when considering this diagnosis. The current study refers to smartphone addiction because the studies which are referenced refer to it as such, however it is acknowledged that there have never been formal criteria outlined for disordered usage or for addiction.

There is debate about what behaviours properly constitute a behavioural addiction, as there is a lack of formal evidence for the existence of these more specific behavioural addictions (Kardefelt-Winther et al., 2017). Gambling disorders are recognized by the DSM-5 with explicit criteria (American Psychological Association, 2013), however no other forms of behavioural disorders are formally recognized (Gutiérrez et al., 2016). Many have classified smartphone addiction as a form of technological addiction (i.e., a subset of behavioural addiction; Lin et al., 2014), with some similarities to internet addiction, although believed to be different classifications (Kwon et al., 2013). While behavioural addictions, such as internet gaming and smartphone usage, have gained increasing prevalence, many argue that we may be over pathologizing what may be due to evolving society. According to Billieux et al. (2015), "we cruelly lack a theoretically sound model that can specify the unique factors and processes involved" (p. 121) to classify an individual with a behavioural disorder such as

smartphone addiction. It is proposed by Billieux et al. (2015) that there may be several explanations for why these behavioural addictions are present, and that many are due to over pathologizing of individuals with normal tendencies.

With substance use disorders, there is a clear set of criteria that indicate when an individual has developed the disorder, and it is evident when it begins to affect daily functioning (Gutiérrez et al., 2016). Behavioural addictions have the tendency to focus on the presence or absence of symptoms, whereas substance use disorders also focus on the difference between symptoms present as well as distal antecedents (Kardefelt-Winther et al, 2017). Kardefelt-Winther et al., (2017) argue it is difficult to quantify symptoms such as tolerance and withdrawal in relation to behavioural addictions, whereas they are evident with substance use disorders, making them only useful to examine the latter.

However, some argue smartphone addiction is too severe to describe what may be simply an attachment to a mobile device (Konok et al., 2017). Because of the high rate of smartphone addiction (e.g., some studies report almost 50% of individuals as being addicted to smartphones by splitting addiction scores at the median and classifying each; Aljomaa et al., 2016), research may need to move beyond considering individuals addicted, and move towards an understanding that smartphones are an evolution of society. As Konok et al., (2017, p. 236) state:

"We are in the middle of a nascent digital culture, with children being born into the world of smart devices. There is a need for further research to investigate how these devices change our socioemotional life and cognitions, in order to overcome potential problems or challenges they might cause."

In addition to a lack of evidence for behavioural addictions, there are also significant differences between smartphone addiction and other behavioural addictions, such as internet addiction. Jin Jeong et al. (2020) compared users who were smartphone addicted with those with no addictions, internet addictions, and individuals with both smartphone and internet addiction in 11 factors. Those in the smartphone addiction group showed more similarities to having no addiction than those who were not addicted (Jin Jeong et al., 2020). Behaviours seen in both smartphone and internet addiction are limited to anxiety, and parent-child communication, while self-control and parent-child attachment were the only behaviours that differ between no addiction and smartphone addiction (Jin Jeong et al., 2020).

Emanuel et al. (2015) argue individuals are addicted to the behaviours from inside the phone, such as maintaining constant social contact. This, in combination with evidence from Konok et al., (2017) in which individuals are soothed by a phone that does not belong to them, indicates there is no attachment to the physical device itself, therefore addiction may not be the correct term for what is traditionally understood as smartphone addiction. Because of the inability to define proper language and a lack of understanding of the differences between addiction and the key features of smartphones (e.g., information being available at the touch of a screen, the screen is easily manipulated by the user), research should be focused on assessing effects of smartphones without using harmful language such as addiction (Panova & Carbonell, 2018). Due to this, the method of diagnosing young adults with an addiction to their smartphone may be harmful without more sufficient evidence for the legitimacy of the disorder (James & Tunney, 2017). Research may be better suited to ask why the individuals are using technology in

increasing amounts, and what behaviours are simply due to human desire for connection and belonging (James & Tunney, 2017; Konok et al., 2017).

Eye Tracking

Eye tracking is important in understanding overt attentional processes (Mele & Federici, 2012). Analysis of eye tracking in visual search tasks is critical in understanding how scenes are perceived in considering reaction times, accuracy, and eye-gaze parameters (Mele & Federici, 2012).

Eye tracking "measures where, how and in what order gaze is being directed during a specific task" (Carter & Luke, 2020, p. 50). Fixations and saccades are the most common eye tracking measurements in research (Carter & Luke, 2020). Saccades are defined as "rapid eye movements that are used to redirect the line of sight from one target of interest to another" (Thurtell et al., 2007, p. 407). Saccades are demonstrated in both endogenous, goal directed attention (i.e., opening an application to engage with a friend or family member), and exogenous, stimulus directed attention (i.e., receiving a notification). Because saccades are typically fast movement, lasting approximately 40-50 milliseconds (Carter & Luke, 2020), saccades impact visual memory, as visual information is not able to be processed due to speed (Rolfs, 2015). For information to be processed, fixations upon stimuli are necessary, and new information is processed through fixations (Rayner, 2009). Fixations are eye movements that stabilize on an object for a longer period (Duchowski, 2007). Research has traditionally used a range of between 150ms-600ms to define one fixation, and analyses are conducted by calculating proportion of time spent in regions of interest, which are defined in advance (Carter & Luke, 2020). In understanding where the participant was looking, researchers can

determine where the participant focuses while completing the experiment (Carter & Luke, 2020). Understanding regions of interest is helpful when measuring fixations, as fixations indicate areas the individual is processing, rather than mere saccades where perception may not be happening.

Cognitive load can also be measured using eye tracking data, specifically pupil size (Rahal & Fielder, 2019). Pupil size has been said to be an indicator of cognitive load as well as attentional allocation (Rahal & Fielder, 2019), and when more difficult tasks are performed, size of the pupil fluctuates more frequently (Demberg & Sayeed, 2016).

Participants dividing attention between multiple tasks reported higher saccades than those with focused tasks (Mutlu-Bayraktar et al., 2022). In addition, those focusing on one task had better retention following the learning task, compared to the group with more saccades (Mutlu-Bayraktar et al., 2022).

Task motivation can also be critical to eye movements. However, under cases of high perceptual load, participants can focus on the primary target for the same amount of time and are less likely to process other information, a case of inattentional blindness (Greene et al., 2017).

<div align="center">**The Current Study**</div>

Gaps in the Literature

Smartphones are important to individuals, especially younger generations. By believing it to be an extension of themselves (Harkin, 2003) and forming complex attachments (Konok et al., 2017; Zhang et al., 2022), it is clear that smartphones are a stable fixture in the lives of young people. Although phone use may be prevalent, researchers believe it expands levels of social connectedness (Alloway & Alloway,

2012). Because of this, understanding the effects of media multitasking and smartphone usage in high and low cognitive load conditions is important. Prevalence of completing a task while another task (e.g., music or a podcast; David et al., 2014) is running in the background is a common behaviour, and while it is perceived to be negative, it is important to distinguish between excessive usage and a healthy amount of usage (Przybylski & Weinstein, 2017). Two hours or less per day is recommended to achieve healthy screen time limits (Salmon et al., 2008). While excessive screen time has been demonstrated to be unhealthy (e.g., Haranto & Yang, 2016; Zhang et al., 2016), there is a lack of evidence for labelling individuals as addicted because of it (e.g., Jin Jeong et al., 2020; Kardefelt-Winther et al., 2017). Examining task performance in an objective way is critical in understanding the effects of smartphone usage, to eliminate issues where they may be present, while also understanding the positive aspects related to one's smartphone.

Research concerning smartphone usage has traditionally focused on clinical effects of smartphone usage, such as difficulty in academic contexts (Rosen et al., 2011), as well as memory (Junco & Cotton, 2011). In addition, smartphone research in cognitive contexts has focused on the influence of smartphones while they are being used (Stothart et al., 2015). Long term, or chronic effects of smartphone usage are unclear. Cognitive research frequently examines the influence of smartphones in current situations, however fewer studies have examined the long-term effects that may arise because of smartphone usage. The current study aims to help to address this gap, by comparing users based on a cognitive computer task, rather than a task where smartphones are being used.

In addition, extensive research has been conducted concerning addiction (e.g., Kwon et al., 2013), media multitasking (e.g., Elbe et al., 2019), or problematic smartphone usage (e.g., Bianchi & Phillips, 2005). However, there is conflicting evidence surrounding each of these. Therefore, the purpose of the current study is to focus on media multitasking and addiction, to focus on the effects of cognition that may be present because of these concepts. By focusing on these individuals, we will be able to form a better understanding of how mobile addiction may be defined in future research and for diagnostic purposes.

In addition, the current study is focused on observing the differences in eye movements, to examine differences between heavy and light media multitasking, to further understand differences in usage patterns.

Research Questions

The current study aimed to answer the following questions in order to gain a more comprehensive understanding of smartphone usage and behaviours, and the effects they may have on cognition.

1. First, do individuals with high media usage demonstrate differences in divided attention performance than users with low media usage? It is hypothesized that due to the broad attentional filters in HMM's, as well as the parallel streams of processing, users who reported higher smartphone usage will perform better in divided attention tasks. Due to evidence of expertise increasing accuracy on tasks of divided attention (Hirst et al., 1980; Schumacher et al., 2001), it is hypothesized (HI) that because media multitasking is so prevalent among young adults (David et al., 2014; Holz et

al., 2015), heavier multitaskers will perform better on these tasks when a video is present. This was tested by comparing task performance between heavy and light media multitaskers, as indicated using the MMI.

2. Will differences in performance be observed between high and low cognitive load conditions? It is hypothesized (HII) that individuals would perform better at tasks of low cognitive load (i.e., Experiment 1), due to load theory (Lavie et al., 2004). This is because individuals who are participating in tasks with higher cognitive load consider additional distractor stimuli, meaning they would spend more time watching the video than those focused on the task. In addition, this is hypothesized due to evidence suggesting individuals were less affected by a video while completing a task with low cognitive load, compared to high cognitive load (i.e., in Experiment 2; Ralph et al., 2020).

3. Will differences in task performance arise between those who demonstrate a traditional smartphone addiction diagnosis, and those who do not? It is hypothesized (HIII) there would be no differences between those who report social media disordered use and those who are not, due to the evidence that individuals who report being addicted are more similar to those with no addiction than those who are internet addicted (Jin Jeong et al., 2020). If there is a lack of difference observed, this will advance the literature concerning the lack of proper definitions for smartphone addiction.

4. Are there indicators in eye movements that distinguish those with higher media usage than those with lower media usage? Based on the lack of specific eye tracking evidence as per the current research base, this question is best

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suited for exploratory analysis, to examine the effects without any potential biases present. We will be looking to examine differences in pupil size between high cognitive load and low cognitive load conditions (Rahal & Fielder, 2019). In addition, we will be examining fixations, where it will be expected that those who are more frequent smartphone users would fixate more on the distractor task while completing the experimental task.

Method

Participants

Participants were recruited from the University of New Brunswick in Saint John, in exchange for one bonus point towards an eligible psychology course. Eligible participants had normal vision, or corrected to normal, in addition to being 18 years of age or older. No participants were excluded because of demographic characteristics. In addition, they consented to using the eye tracker prior to beginning the experiment. A target sample size was calculated using a medium effect size of $f = .25$. Power was calculated using G*Power version 3.1.9.4 (Faul et al., 2007). Using an α level of .05, to achieve a power level of .95 (1-β), a sample size of 84 participants was determined to be suitable.

Material

Sustained Attention to Response Task.

Participants in Experiment One completed the SART in the Fixed condition (Robertson et al., 1997). In this task, the numbers one to nine are presented sequentially on a computer screen. There was a total of 225 trials, with each number being presented 25 times. The participant pressed the middle button using the Cedrus RB-540 response

pad for each number, except for the number three. Stimuli were presented for 250ms, followed by a 900ms mask. This task measures sustained attention and was chosen for the low cognitive load condition because there is expectation present. As the number three follows the number two in every trial, participants will not be surprised by stimulus presentation, and therefore may not pay close attention to the task.

Letter-Number Classification Task.

Participants were presented with a stream of both letters and numbers, similar to the task in Experiment One by Alzhabi & Becker (2013). However, rather than classifying the stimuli as a letter or a number when it appears, the individual must only respond to the more precise specifications (i.e., odd versus even, and vowel versus non vowel). The numbers two to nine were presented. The number one was not included in order to reduce similarity with the letter I in the letter condition. There were also eight letters, consisting of four vowels and four consonants (i.e., A, E, I, U for vowels and C, G, K, T for consonants). The participant clicked one key if the letter was a vowel or an even number, and one key if the letter was a consonant or odd number. Keys were on a Cedrus RB-540 response pad, and were counterbalanced between participants. Each stimulus was presented for 16 trials, and the stimuli remained on the screen until the participant hit a key to sort it, or until 10 seconds have elapsed.

This task is a high cognitive load task because the participant must consider each individual stimulus, and distinguish both letter versus number and the specific characteristics of the letter or number (i.e., vowel versus consonant or odd number versus even number). Because there is the additional task of classifying letter or number mentally, this task was more difficult than the SART.

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Social Media Disorder (SMD) Scale

The SMD Scale (Short Version; van den Eijnden et al., 2016) is a nine-item scale assessing disordered social media use (see Appendix A). Subscales include *"preoccupation, tolerance, withdrawal, displacement, escape, problems, deception, displacement, and conflict" (*van den Eijnden et al., 2016, p. 479). These questions are answered as a dichotomous yes/no. To meet the threshold of having social media use disorder using this scale, an individual must answer yes to five of the nine questions. This scale was used in both conditions of the experiment, to examine differences in those who meet criteria for social media disordered use and those who do not, in order to test H3.

This scale reports acceptable reliability and validity, with α= .76–.82 across three samples (van den Eijnden et al., 2016), as well as adequate test-retest reliability.

Media Multitasking Index.

Media multitasking was measured using the MMI (Ophir et al., 2009), and was used to test H1. This scale assesses number of hours per week spent using the following 11 media sources: print media, television, computer-based video (e.g., YouTube or Netflix), music, non-music audio (e.g., podcasts), video or computer games, smartphone calls, instant messaging, email, web surfing, and other computer-based applications. In addition, participants completed a second portion comparing each of the eleven media sources directly to each of the other media sources, in addition to SMS (text messaging). Available responses were 'most of the time', 'some of the time', 'a little of the time', and 'never' based on how frequently the two sources are used together. These are each awarded a numerical value, with awarded values of 1, 0.67, 0.33, and 0, respectively.

Media Multitasking scores were calculated following the same procedure as outlined in Ophir et al. (2009); each multitasking score was first multiplied by the total number of hours spent using that medium. Next, each of the 11 sums from the first step were summed together, with this total being divided by the total number of hours spent using all media sources. For example, if a participant reported they spent three hours watching TV and three hours using their smartphone per week, but reported only using those devices together "never", both numbers would equal zero. If the participant reported using the devices together "always", both numbers would stay equal to three, as they would be multiplied by one. Each of these scores would then be summed together and divided by the total number of hours spent overall.

Video Condition

Participants were exposed to a video for the experimental trial. This was counterbalanced between being presented on the right half of the monitor and the left. The video was an episode from the TV show Friends (Crane & Kauffman, 1994–2004), and was presented throughout the experimental trial. Following the experimental condition, participants were asked how familiar they are with the show, as well as the specific episode. This is to compare those who are familiar with those who are not familiar.

Eye Tracking

A Tobii Pro Nano (http://www.tobiipro.com/) screen-based eye tracker was used to track eye movements of participants, to determine where individuals were focusing, and how much time they spend watching both the experimental task as well as the video, in the experimental condition. This eye tracker is monitor mounted, does not require a

chin rest, and measures gaze origin, gaze point, as well as pupil diameter, at a speed of

60Hz. For this experiment, data was analyzed using regions of interest. Three regions of

interest were defined (i.e., the area of the screen where the video will be presented, the

area of the screen where the task was presented, and the more precise location of the

stimulus) and eye movements were analyzed by determining number of fixations

throughout the task on both regions (i.e., what proportion is time is spent looking at the

video versus how much time is spent looking at the experimental task).

Procedure

The current study was reviewed by the Research Ethics Board at the University of

New Brunswick and is on file as UNB REB# 184-2022. Participants were recruited on

SONA and were granted one bonus point for completion of the study. Participants first

completed a consent form (see Appendix A), followed by a general demographics'

questionnaire, consisting of age, sex, and handedness (see Appendix B). Following this,

they completed the SMD Scale (see Appendix C), followed by the MMI (see Appendix

D). The eye tracker was then calibrated, to ensure participants' eyes were being recorded

throughout the trial. Participants then completed the SART, completing both the control

condition (i.e., the SART alone), followed by the experimental condition (i.e., the SART

while watching a video). They then completed the letter-number sorting task, for both the

control condition (i.e., the task alone), and the experimental condition (i.e., the task and

the video). Tasks were completed using PsychoPy software (Peirce, 2007), and task order

was counterbalanced across participants. Following the performance task, participants

were required to indicate how familiar they are with the video they watched, as well as

the specific episode (see Appendix E). Following this task, they were presented with a

debriefing form (see Appendix F). This study took, on average, 45 minutes to complete per person.

Data Analysis

Performance of the SART was assessed by calculating anticipatory responses as well as accuracy for each no-go trial (i.e., each time the number three is correctly not attended to; see Tables 2-3). A 2 (video condition versus no video condition; within subjects condition) x2 (individuals who meet addiction criteria versus those who do not; between subjects condition) x2 (heavy versus light media multitaskers; between subjects condition) ANOVA was conducted for each condition. Anticipatory responses were counted if the individual responded in the 100ms period before the stimuli is present, as well as 100ms after the stimuli is presented, due to inability to perceive visual stimuli within 100ms of change (Posner et al., 1980).

Performance in the high cognitive load condition was assessed using speed of responses in addition to accuracy of each letter-number classification (see Tables 4-5). Speed was estimated as average across trials. A 2 (switch trial versus non switch trial; within subjects condition) x2 (letter versus number trials; within subjects condition) x2 (video versus no video; within subjects condition) x2 (individuals who meet addiction criteria versus those who do not; between subjects condition) x2 (heavy versus light media multitaskers; between subjects condition) repeated measures ANOVA was calculated for each condition.

A paired sample t-test was used to compare average response time for low and high cognitive load conditions. Homogeneity of variance was established for reaction time, but not for accuracy, so Wilcoxon signed rank t-test was used for accuracy.

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Research question four was examined using a series of exploratory analyses. Total number of looks (i.e., anytime the participant's eyes passed by each of the target areas) were calculated by extracting eye tracking data and summing total number of looks at each area of interest. Number of looks at the control trial (i.e., number of looks at the one inch diameter surrounding the stimulus), number of looks at the focused stimulus (i.e., number of looks at the one inch region surrounding the stimulus), number of looks at the surrounding area (i.e., number of looks at the area surrounding the focused area, in the same size as the video), and number of looks at the video condition were each examined for both the letter number trials and the SART. Following the extraction of the number of looks, each onset and offset time were extrapolated, and the total number of milliseconds each look lasted was calculated. The number of fixations was calculated by summing the number of fixations greater than 250 milliseconds for each of the four areas. Average number of both looks and fixations are summarized in Table 1.

Two participants scored below 10 percent accuracy in the control condition for the control letter number task, but over 90 percent correct for the experimental trial. In these cases, it was evident the participants misread the instructions and used the opposite buttons as a result, only to correct themselves for the experimental trial. Incorrect responses were recoded to be correct, and correct responses were coded to be incorrect for the control trials for these two cases.

Results

Participants

Data were collected from 91 participants. Of these 91, one did not finish due to issues in technology, and one was eliminated due to interference from their own

smartphone. One participant responded only to the number three in the SART control condition (i.e., following the opposite of the instructions), so they were eliminated as they had zero percent accuracy, and one was removed for lack of experimental trial accuracy of the letter number task. Eighty-seven participants remained for final data analysis. Of these 87 participants, the average age was 21.00, in addition to sixty-eight participants identifying as female, three identifying as non-binary or gender fluid, and 14 identifying as male. Eleven participants were left-handed, while 77 were right-handed.

Scales

Fifteen participants answered yes to five or more questions on the SMD scale, classifying themselves as meeting criteria for disordered use. This proportion (i.e., 16.85%) is higher than the proportions found by van den Eijnden et al., (i.e., 7.30% to 11.60%). Participants meeting addiction criteria were coded as 2, while those who were not addicted were classified as a value of 1.

Mean scores for the MMI were equal to 3.34, while SD was equal to 1.87. This mean is comparable to the value identified by Ophir and colleagues in the original article. In total, 12 participants identified as HMMs, while 12 participants identified as LMMs. Light media multitasking was assigned a value of 0, while heavy media multitasking was assigned a value of 2, with other scores assigned a value of 1.

Research Question One: Media Multitasking

Hypothesis I states that HMMs would perform better on tasks of attention when a video condition was present compared to LMMs. For the low cognitive load condition, differences in anticipatory responses, $F(2, 83) = 0.15$, $p = .860$ and reaction time, $F(2, 83) = 2.49$, $p = .089$ were both not significant. For the high cognitive load condition,

differences in accuracy, $F(2, 81) = 1.80$, $p = .172$, and reaction time, $F(2, 81) = 0.002$, $p = .965$ were also not significant. The interaction of MMI score and video condition were also not significant for accuracy, $F(2, 81)$, 0.40, $p = .670$, or reaction time, $F(2, 81) = 1.10$, $p = .337$ in the high cognitive load condition or anticipatory responses, $F(2, 83) = 0.46$, $p = .631$, or no-go accuracy, $F(2, 83) = 0.85$, $p = .432$ for the low cognitive load condition. Media Multitasking scores did not have a significant effect on eye tracking data. Overall, this hypothesis was not supported.

Research Question Two: Cognitive Load

Hypothesis II stated that there would be improved accuracy, as well as faster reaction time for the lower cognitive load condition when compared with the high cognitive load condition. A paired sample t-test was used to compare average response time for low and high cognitive load conditions. Homogeneity of variance was established for reaction time, but not for accuracy, so Wilcoxon signed rank t-test was used for accuracy. Reaction time demonstrated the low cognitive load condition elicited faster response times when compared to the high cognitive load condition, $t(86) = -29.90$, $p < .001$, $d = -3.21$. Participants had a higher level of accuracy when completing the letter number sorting task compared to the SART, $W = 549.00$, $p < .001$, $d = 0.713$. Overall, hypothesis two received partial support, with the low cognitive load condition reporting faster response times, but poorer accuracy compared to the high cognitive load condition.

Research Question Three: Smartphone Addiction

Hypothesis III stated that the individuals who answered yes to five or more questions on the SMD Scale and would meet the criteria for disordered use would report no significant differences compared to those who did not. This hypothesis was supported,

as there were no significant effects observed among the four ANOVAs that were conducted across both conditions. The low cognitive load condition did not report any significant effects in either anticipatory responses, $F(1, 83) = 0.20$, $p = .657$, or reaction time, $F(1, 83) = 0.05$, $p = .825$. The high cognitive load condition also did not have any significant effects for reaction time, $F(1, 81) = 0.002$, $p = .965$, or accuracy, $F(1,81) = 0.002$, $p = .968$. There were also no significant differences in eye tracking data for the individuals that qualify for this disorder. Overall, the hypothesis was supported.

Research Question Four: Eye Movements

Total number of looks were calculated by summing each in both the experimental and control conditions for each participant. There were no significant correlations with any number of fixations and media multitasking scores. Reaction time for the letter number condition was significantly correlated with looks for the control trial, $r = .48$, $p < .001$, as well as the area surrounding the stimulus, $r = .36$, $p < .001$. A smaller, positive correlation was observed with number of looks at the video condition, $r = .25$, $p = .018$.

Paired sample t tests were conducted between each pair (i.e., for number of looks at the video, number of looks for the control task, number of looks at the focused stimulus, and the number of looks for the surrounding area). Shapiro-Wilk normality scores suggested a deviation from normality, therefore Wilcoxon signed rank t tests were used. A significant difference was observed between the letter number task and the SART, with the letter number task leading to fewer looks at the video than the SART, $W = 2852.00$, $p < .001$. Fewer looks were demonstrated among the SART for number of control trial looks, $W = 1269.50$, $p = .006$, as well as for focused stimulus looks, $W = 1285.00$, $p = .012$, and surrounding area looks, $W = 693.50$, $p < .001$. Independent sample

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t tests were conducted for each variable, with those who meet criteria for disordered use versus those who do not, and no results were significant.

Fixations

Paired sample t tests were used to compare number fixations across all conditions. Because Shapiro-Wilk scores suggested a deviation from normality, Wilcoxon signed rank t tests were used. A significant effect was observed for the video condition, $W =$ 2544.00, $p < .001$, for the focused stimulus, $W = 946.00$, $p < .001$, the surrounding area, $W = 497.00$, $p < .001$, as well as the control condition, $W = 659.50$, $p < .001$, meaning the SART reported fewer looks overall for the focused stimulus, the surrounding area, and the control trial, and more looks at the video condition. Independent sample t tests were used to compare those who meet criteria for a use disorder compared to those who don't, and no tests were significant, indicating no differences in number of fixations.

Pearson correlations were used to assess number of fixations with speed and accuracy. Significant correlations were observed between number of fixations in the region surrounding the stimulus, as well as reaction time for the control condition, $r =$ .37, $p < .001$ as well as reaction time for the experimental condition, $r = .32$, $p = .003$. Number of fixations on the video condition were also positively correlated with reaction time for the experimental trial, $r = .23$, $p = .036$, as well as reaction time for numbers, $r =$ .21, $p = .050$. Accuracy on switch trials was also negatively correlated with number of fixations on the stimulus, $r = -.25$, $p = .020$.

Media familiarity was analyzed using a series of correlations. Familiarity with the episode of Friends was positively correlated with fixations on the video, $r = .26$, $p = .018$,

and negatively correlated with fixations on the focused stimulus, $r = -.28$, $p = .009$. No other significant correlations were reported.

Discussion

The present study aimed to examine the influence of media multitasking as well as cognitive load and smartphone addiction on task switching, to observe effects that may arise when a video was presented next to a task. In the present study, Hypothesis I received no support, as media multitasking did not facilitate increased monitoring of the video condition, and it did not lead to faster reaction time or more accurate performance. This means that while media multitasking is something many individuals take part in, it is not necessarily contributing to performance improvements or decrements when these situations are present. The cognitive effects of media multitasking should continue to be monitored, as technology continues to improve and other mechanisms for such multitasking are introduced.

Hypothesis II received partial support, with performance deficits being observed in speed but not accuracy in the high cognitive load condition. This evidence is consistent with a speed accuracy tradeoff, in which participants favoured being faster, but not more accurate in the high cognitive load condition. In addition, higher number of overall video looks as well as fixations in the low cognitive load condition compared to the high cognitive load condition indicated the low cognitive load condition facilitated increased distractor processing, compared to when cognitive load was high. This eye tracking finding is in accordance with increased accuracy with the high cognitive load task, as the distractor was not processed as frequently. As well, the increased number of looks at the

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video with the low cognitive load task as well as faster reaction time indicates individuals were more likely to answer impulsively.

Hypothesis III was supported, as no effects were observed that were exclusive to the group of individuals meeting the criteria for smartphone use disorder in the four repeated measure ANOVAs or in eye tracking data. This means that in the present study, no observable differences are present for those who meet this diagnosis in either reaction time or overall accuracy, when compared to those who do not meet this diagnosis.

Research question IV utilized exploratory analysis to examine eye tracking patterns among participants. While the number of looks at the video was correlated with slower reaction time, a larger effect was observed with number of looks at the stimulus itself. To understand this finding, increased number of looks did increase reaction time, as while the participant was moving their eyes they were not responding to the number, compared to if an individual is fixated on the number from onset time until the response. A higher number of fixations were reported for time spent looking at the control condition, the focused stimulus, as well as the stimulus area in the letter number task. A smaller number of fixations were reported for the video condition in the letter number task, with a large effect size reported. This indicated participants spent more time engaging with the stimuli compared to the distractor task. Familiarity with the episode that was playing was also positively correlated with looks at the video and negatively correlated with looks at the stimulus, meaning the higher the familiarity, the more time spent watching the video, with less time being spent looking at the stimulus.

Average media multitasking scores were similar to those outlined by Ophir et al. in 2009, with mean scores of 4.38 in their study and 3.34 in the present study. This

evidence suggests media multitasking has not become more prevalent in the years since this study was conducted. In contrast, higher prevalence of individuals meeting criteria for disordered use is prevalent in this sample, with 16.85% meeting criteria for disordered use compared to the range of 7.30% to 11.60% observed in the study by van den Eijnden et al. in 2016. This rising prevalence may be of concern, as increasing numbers of individuals are meeting the criteria for this disorder.

Media Multitasking

No significant variations in performance were demonstrated between experimental and control conditions, indicating the video being played beside the task had no significant effects on reaction time or accuracy on participants. This may be due to the prevalence of media multitasking with a video that has been demonstrated in previous studies (i.e., Greer & Ferguson, 2015; Holz et al., 2015), with individuals frequently engaging in these situations, even when they may not be aware of the behaviour. To illustrate this point, while an individual may frequently be in spaces with the television running or with music playing in the background, they may underestimate the quantity of this multitasking if they are not actively manipulating the multitasking situations. This could indicate a difficulty, or an impossibility, to obtain an objective measure of media multitasking. While individuals may believe themselves to be low media multitaskers, they may be exposed to more instances than they realize. Developing techniques to objectively measure these behaviours may not be possible due to the frequency of situations in which this may occur.

A significant effect was demonstrated with number of fixations and familiarity with the episode that was being played, meaning individuals were more likely to look

more at the video and less at the stimulus while completing the experiment. Although this finding was significant, there were no significant performance differences with either reaction time or accuracy.

These findings do not align with those of Ralph et al. (2014), who demonstrated higher media multitasking scores led to more failures in attention. This discrepancy in findings could be due to subjective versus objective task performance, as Ralph and colleagues used a variety of self-report measures as opposed to measuring objective performance, as well as examining media multitasking on a scale rather than separating heavy and light media multitaskers. In this study, participants were to report the amount of time they felt distracted, and how frequently failures in attention were reported, in addition to measuring media multitasking and mind wandering. Self-report data in accordance with actual task performance is frequently not related, which may mean while individuals anticipated more failures in attention, their performance may not actually suffer to the degree that was expected. In the present study, while participants were asked to subjectively rate their media multitasking frequency, reaction time, accuracy, as well as eye movements can be used to obtain a more accurate picture of the behaviour of the participant. In addition, completing a task allowed for objective variation of task difficulty, to examine level of distractibility in both an easy and a more difficult task.

Results from the present study align with the findings of many studies demonstrating no switch costs among heavy and light media multitaskers (Alzahabi et al., 2017; Baumgartner et al., 2014; Cardoso-Leite et al., 2016; Minear et al., 2013). Although previous studies have found a positive effect on switch costs, and some studies have demonstrated negative effects, an increasing number of studies are finding no effect.

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As technology use continues to change, monitoring these effects may continue to provide no support for differences as multitasking opportunities continue to develop. While effects may have been more prominent in previous research (leading to more disruptive behaviour due to the novelty of the media that is present), as well as the amount of multitasking increasing as previously discussed, individuals may be more accustomed to this multitasking, and may be more effective at switching tasks without disruption. The results from the present study may therefore be due to expertise in navigating multiple forms of media, facilitating consistency in switch cost speed among young adults regardless of the amount of time they report spending time media multitasking. Continuing to monitor these switch costs and reaction times among young adults, as well as younger generations more innately accustomed to media multitasking is crucial to understand how exposure to media can evolve over time and with new generations.

Salience of the stimulus may also be considered when considering the level of distraction exerted by the video. Previous studies have demonstrated the effect notifications have on sustained attention performance and reaction time, when the individual was not aware their phone was going to ring (Stothart et al., 2015). Results from Nason and Wilbiks (2023) also suggest that visual pop-up notifications impact reaction time and accuracy of sustained attention performance, even when participants were aware of the objective of the study. As the video was consistently played next to the task, while it may have exogenously attracted the participants attention immediately on onset, following the novelty of the onset the video may be less impactful. This may be due to goal directed behaviour (i.e., endogenous attention), gaining control following stimulus onset.

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Smartphone Use Disorder

Based on the results of the present study, there is no evidence in support of any cognitive differences observed between those meeting the criteria for disordered use on the SMD scale, in reaction time or accuracy, as well as no observed differences in eye movements. This means that based on the results of the present study, future research should focus on furthering knowledge into behaviour patterns and effects to create a diagnosis that is more reflective of true disordered use. In developing a diagnosis for this disorder, or for any behavioural addiction, clear and measurable deficits should be observed, whether in performance of tasks, or in self-reported difficulty.

Kardefelt-Winther et al. (2017) propose four criteria for which a behaviour should not be considered a behavioural addiction. Each of these criteria are discussed below.

Smartphone checking could be due to an underlying disorder such anxiety or depression (Kardefelt-Winther et al., 2017). Problematic smartphone use may worsen symptoms of anxiety and depression according to a study by Augner et al. (2023). However, the authors conclude that directionality cannot be assumed, and it may be problematic smartphone use that increases these symptoms, or anxiety and depression may increase problematic smartphone use. Because it cannot be assumed that problematic smartphone use is increasing anxiety and depression, this principle is met.

In addition, there have been other diagnoses that have been associated with smartphone use that may be more appropriate in understanding the thoughts and feelings behind why individuals are using their devices. Fear of Missing Out (FoMO) is a concept associated both with media usage, and with smartphone use, and is characterized by individual worry they may be missing out on experiences that others are having

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(Przybylski et al., 2013). While this checking behaviour leads to additional looks at the smartphone and additional screen time, it can also be helpful in eliminating feelings of loneliness and isolation in an adolescent population (Kostić et al., 2022). While increased FoMO can lead to social media fatigue, it may depend on the application; individuals are more likely to experience more life satisfaction using Snapchat, compared to Instagram (Hattingh et al., 2022). Using an application with more passive usage used solely for sharing photographs, compared to using a direct messaging app where personal updates and stimulating conversation are more common may be the reason for these individuals feeling more contentment using a more active application. FoMO could be an underlying disorder influencing smartphone use. Both anxiety and depression, as well as FoMO could be an underlying influence on why individuals are frequently using their smartphones.

Self Determination Theory is a theory that posits humans strive for autonomy, competence, and relatedness (Deci & Ryan, 1985). With smartphones and social media, this theory has been linked to FoMO, and is an underlying mechanism that allows individuals to reach out to others to fulfill these innate needs (Hattingh et al., 2022). Although not through face-to-face contact as was required by this theory when it was proposed, individuals are having these needs met by engaging with their smartphones. Although in an unconventional manner, it is evident that individuals would want to engage with their smartphones when higher emotional fulfillment and stronger interpersonal connections can be developed even when isolated from others.

The second criteria outline that the behaviour is the consequence of a willful choice (Kardefelt-Winther et al., 2017). Many individuals choose to use their

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smartphones to escape from negative thoughts or ruminations, as demonstrated by a study by Wilson et al. (2014) in which 67% of males and 25% of females elected to give themselves an electric shock when instructed to sit in a room for 15 minutes and think, without any additional distractors. This finding supports the notion that individuals would rather have a negative experience than to sit with their own thoughts. This study also sent participants a link in another experiment, with the instruction to click the link provided and to think for 15 minutes. In the results of this experiment, 32% admitted to cheating by using their phone or playing music. These findings suggest using a smartphone is a choice to avoid negative intrusive thoughts or ruminations from their daily life. There is a lack of evidence for a relationship between objectively recorded smartphone use and anxiety, depression, or social isolation according to a recent study (Sewall et al., 2022). Based on the results of the present study, individuals can choose to ignore media if they are completing another task, indicating that the individual is free to choose what they pay attention to. This satisfies the second principle.

The third criteria suggests the behaviour may detract time and effort from other points in life but does not lead to distress for the individual (Kardefelt-Winther et al., 2017). While using a smartphone has been demonstrated to impact productivity (Duke & Montag, 2017), there is also evidence to support the notion that these individuals are not bothered by the effects that it may cause them. In addition, as previously mentioned, many individuals are not bothered by the relationship they have with their devices. It is harmful and stigmatizing to diagnose individuals with a behavioural disorder when there is no clear distress present in their lives, and they are not affected or negatively impacted by their device.

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In line with recommendations from Billieux et al. (2015), it is important to avoid diagnosing individuals with a disorder when there is no clear deficit associated with the disorder. However, according to previously discussed literature (e.g., Anderson & Jiang, 2018; Drouin et al., 2012) this is not the case, with many individuals not using their phones in a way that is disruptive to them. Based on this evidence, this principle is upheld, as there are no disruptions that are large enough for many individuals to care for change. Because the present study demonstrated no harmful effects, as well as many other studies that have found null results using this diagnosis should be avoided, to avoid the stigma that may be associated in suffering from a behavioural addiction.

Finally, the behaviour may be because of a coping strategy (Kardefelt-Winther et al., 2017). Evidence also suggests social media and smartphone use may be influential in making and maintaining relationships, to cope with loneliness. Results from Sherrell and Lambie (2018) demonstrated the more frequent social media practices are rather than number of friends or attachment style, the higher their self-reported relationship quality is. It is hypothesized by the authors that young individuals, specifically emerging adults, have created a culture on social media that older adults should be aware of.

Based on these four criteria, if a proposed disorder meets them further consideration should be given before concluding a behavioural addiction is present. The evidence supports the potential for alternative explanations that may underlie problematic behaviours, the behaviours in many cases are not harmful to the individual, and communicating on a smartphone is a mechanism to communicate with others, fulfilling a basic human need as well as supporting an individual when they may be distressed. As a

result of this, diagnosing individuals with this disorder should be cautioned against, in order to reduce stigma surrounding the individual.

An alternative explanation for addiction criteria is that the individual may have developed an attachment with their smartphone. Konok et al. (2017) have demonstrated proximity seeking and need for contact between individuals and their devices through experimental manipulation, even with an unfamiliar device. If individuals can attach to their devices or the information within, it may be helpful in explaining why some of these individuals met the criteria for this disorder. Creating and maintaining social connections is critical for individuals, especially in adolescence and young adulthood when their sense of identity is being developed, and social media and smartphones in general may be used as a tool for furthering connections among the young adults in this sample.

Task Motivation

In this experiment, participants were able to successfully ignore the background video that was presented in all experimental trials, with an average of 35 looks ($SD = 59$) for the low cognitive load condition and six for the high cognitive load condition looks ($SD = 10$) compared to an average of 277 looks ($SD = 186$) for the low cognitive load condition and 344 looks ($SD = 212$) for the high cognitive load condition for the focused stimulus. Number of video fixations were on average 22 for the low cognitive load condition ($SD = 41$), and 3 for the high cognitive load condition ($SD = 4$). In addition, experimental trials did not report slower reaction time or decreased accuracy due to more mistakes from watching the video. This evidence suggests participants were able to ignore the video to focus on completing the task. This was evident especially in the higher cognitive load condition when increased focus is required but was also consistent

despite changes in cognitive load. Even those who were addicted, or those who were HMMs did not look at the video while completing the task. This evidence suggests that individuals are in fact able to complete a task while a media distractor is present. These results suggest that despite varying levels of media multitasking and media usage in general, participants were all able to direct goal focused attention towards finishing the task. These eye tracking findings shed light on the ability for young adults to omit distractors if properly motivated, to complete the task. In addition to no differences in accuracy or reaction time in the control and experimental trial, eye tracking evidence provides objective measures, rather than a reliance on reaction time or accuracy. In addition, experimental trials did not report slower reaction time or decreased accuracy due to more mistakes from watching the video. This was evident especially in the higher cognitive load condition when increased focus is required but was also consistent despite changes in cognitive load.

These findings align with Kahneman's theory of attention and effort (1973). If an individual puts effort into completing the task, they are more likely to eliminate distractors, as demonstrated with eye tracking data as well as no changes in experimental and control conditions. In addition, hybrid theories of top down and bottom-up processing (i.e., Rogers & Monsell, 1995; Yantis, 2000) suggest participants likely devoted their attention to the cognitive task, facilitating distractor interference at a higher rate. The obtained results also align with this theory, as participants in the present study were also able to focus on the cognitive task. Although the video condition was present along with no instructions provided to focus on the task only, many participants did not choose to watch the video at all.

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Goal-directed behaviour should be further investigated to examine the change in performance of tasks for highly motivated and unmotivated conditions. Results of Ralph et al. (2021) demonstrated participants were more likely to omit a video playing if they were highly motivated to finish the task. This was also evident in the current study as participants could watch the video but frequently chose not to, as demonstrated by eye tracking data. In addition, participants were less likely to consider the video compared to the task that was easier to complete in the harder task. Although participants in the current study were not instructed to focus on the task over the video, fast responses may have been desirable to complete the task promptly. It has been proposed that HMMs are able to adopt a more exploratory nature and would be able to focus more on the video, however this was not supported by this study, as there were no differences in number of looks or number of fixations observed between HMMs and LMMs. While intrinsic load was manipulated by task difficulty, and extraneous load was manipulated by the presence or absence of the video condition, germane load (i.e., internal factors such as motivation) was not explored.

High motivation to finish the task could also be demonstrated in the speed accuracy trade-off that was demonstrated by hypothesis three; as in the high cognitive load condition participants were slower to respond, however less accurate (Schouten & Bekker, 1967). This difference in reaction time demonstrates the longer length of time to process the letter number task, as the participant had to first distinguish the stimulus as a letter or a number, and next classify whether the number was odd or even, and the letter a vowel or a consonant.

The low cognitive load condition also exhibited a lower amount of looks compared to the high cognitive load condition. This suggests that due to Load Theory, the combination of low cognitive load and low perceptual load led to participants considering the distractor video more than when they completed the high cognitive load condition. A paired sample t test revealed this difference to be statistically significant, $p < .001$, with a large effect size, $r = .76$. This means that because the individuals were aware of when the number three was to be presented, they were able to create awareness for when the number three was to be presented, to facilitate an easier glance at the video.

Divided Attention

Performance costs were demonstrated between switch trials and non-switch trials, with switch trials reporting less accuracy. However, these trials yielded faster reaction time compared to non-switch trials. Although both results were significant, effect size of accuracy was equal to a large effect size, while reaction time only demonstrated a small effect size (Cohen, 1992). This means the variation in speed was larger among reaction time, but that switch trials were decidedly more difficult for participants.

In addition, there were no significant differences between the letter distinguishing task and the number distinguishing task for either reaction time or accuracy. These findings align with those of Richter and Yeung (2012) who demonstrated that switching tasks reduces cognitive control, impairing memory ability. Participants make more mistakes when answering switch trials, demonstrating decreased working memory ability when the task has changed, reflecting the length of time it takes to change mindsets, and the processing time it takes to bring the new directions to working memory.

Limitations

The sample obtained for the present study was from a university consisting primarily of young adults, as well as a predominantly female sample. Future research may aim to replicate the study in older adults, to compare differences between older and younger adults, or to compare usage differences or habits among a more gender diverse sample to examine the way gender may influence these behaviours. Even though proportions of LMMs, HMMs, and individuals that were addicted were similar to previously obtained results, sample size may have limited the effects that were observed. Twelve individuals were HMMs and LMMs respectively, and 15 individuals met criteria for social media disordered use. Validating these effects or examining differences in a larger or more diverse sample may be beneficial to gain a better understanding of media multitasking and disordered use. Although sample size was sufficient to determine overall effects, a larger sample of participants meeting each criterion should be examined to validate these findings in a larger, more representative sample.

No subjective measures were included with performance to compare perceived ability to actual performance ability. Because discrepancies have been demonstrated in the past, examining perceived competence at media multitasking with actual media multitasking performance should be examined in the future. In this, researchers will be better able to understand the discrepancy between self-reported and actual media multitasking performance, if these discrepancies are present.

The video condition that was present for the experimental task used a video clip without audio, to isolate visual effects rather than the effects of visual and auditory

information. Future studies should aim to replicate these findings using a video with audio present, to examine the effects of auditory cues as well as the visual ones.

Implications and Future Directions

As the rise and prevalence of smartphones continues to develop, it is important to continue to monitor other developments, and the influence of other facilitating devices. For example, smartwatches may be of growing concern. Recent eye tracking data has suggested individuals are more distracted by smartwatches than smartphones while driving (Brodeur et al., 2021). In a study conducted by Brodeur and colleagues, eye tracking results suggest that participants receiving notifications on a smartwatch performed worse than when they received notifications to their phone. However, although smartwatches received more glances, this did not correlate with poorer driving performance: the results of the study suggested that responding to notifications on a smartphone itself was the sole condition that led to poorer performance, and this result was only seen for physically typing, not responding verbally to the messages they received.

Because the same television show was shown for both tasks, individuals may have been familiar with the show and did not feel the need to watch it while completing the task. Future studies may be interested in examining the effects of different shows on divided attention performance, to see if a novel show, or a show with more salient stimuli may divert attention from the task more frequently. Eye tracking data should continue to be collected for a variety of media multitasking constructs or situations where multitasking may be required. For example, examining eye tracking data on a cognitive task when notifications are being received may be beneficial.

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It is also important to continue to monitor the effects of screen time in a way that is not harmful to individuals. In a study by Psyzylbski and Weinstein (2017), moderate screen use is advantageous in a world where internet connection is commonplace, meaning that to reduce problematic effects, elimination may not be the best solution. Sherrell and Lambie (2018) recommend speaking to clients with a neutral tone when discussing device usage, to eliminate potential judgment from what may be considered excessive social media use. It is noted that social media has many positive associations, therefore speaking negatively may impart stigma upon the client, as well as emerging adults are "creating cybercultures that may be less understood by older counsellors" (Sherrell & Lambie, 2018, p. 313). Moving forward, understanding it may be more beneficial to focus on reducing harm rather than eliminating the usage completely. Understanding the influence of smartphones and having conversations surrounding usage and culture is encouraged in therapeutic practice in order to better understand the social media practices and behaviours of clients (Sherrell & Lambie, 2018).

Based on these findings, diagnosis and treatment approaches should focus on the individual rather than the usage behaviours itself. Rather than a "smartphone addiction" there may be other issues with the individual, such as anxiety depression, poor coping mechanisms, high levels of FoMO. The individual may report negative self-talk, or ruminations, and may use their phone to escape these thought patterns (e.g., Wilson et al., 2014). A myriad of explanations may be present before it is concluded the individual is suffering from an addiction, in which case the individual should be assessed based on the level of disruption to their own life, and guidance should be individualized in order to address the proper issues and to issue the most appropriate treatment. If the usage is less

disruptive to the individual and more disruptive to others, the reason for the perceived

misuse is that the individuals are using their phones in a way that is disruptive to others

rather than to themselves. Media etiquette is something that should be considered when

comparing the behaviours of young adults to adults or older populations; according to a

study by Kadylak and researchers (2018), older adults are more critical of younger adult

smartphone etiquette. Moving forward, considering usage by the individual by case may

be more effective than generating one diagnosis and applying it to a variety of individual

cases. Because of the differences in usage (e.g., passive versus active screen time, or time

spent cultivating existing relationships versus seeking out new connections) may all

influence whether an individual is effectively dependent on their smartphone, or if they

may just be using its advantages to benefit the individual.

Conclusions

The present study was conducted in order to understand the influence of task

difficulty, heavy and light media multitasking, and disordered smartphone use in a

cognitive task, while using eye tracking data to better understand patterns and

relationships in emerging adults. The present study did not find evidence for any

cognitive influences of media multitasking, or an effect of disordered social media use on

reaction time or accuracy. Eye tracking data suggests that individuals are able to

successfully ignore a distractor task in the form of a video. The implications of media

multitasking and smartphone addiction demonstrating non-significant effects across

groups is important in terms of understanding the impact of these concepts in a

population where it is becoming more prominent.

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Based on the results of the present study, there is no evidence to support differences in task performance of reaction time in a high or low cognitive load task. By including eye tracking data, the ability of young adults to focus on the task regardless of difficulty while omitting a distractor task is demonstrated objectively, rather than using a self-report measure or relying on accuracy and reaction time. While individuals are using their devices at higher levels, as well as multitasking more frequently, the present study was not able to support cognitive differences among individuals based on their usage.

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Appendix A- Consent Form

Influence of Media Multitasking, Cognitive Load and Smartphone Addiction on

Divided Attention Performance

Kathryn Nason, Graduate Student, Department of Psychology

Dr. Jonathan Wilbiks, Assistant Professor, Department of Psychology

University of New Brunswick – Saint John

I am a graduate student in the Department of Psychology conducting a research project about the effect of media use and divided attention ability. We would like to conduct an experiment on you to better understand the influence of notifications on your attention span. We are hoping to test 120 individuals in this study. All participants will be recruited through SONA.

You will complete a series of tasks to test your sustained attention span. You will also be asked to complete a letter-number sorting task. Each of these tasks will be explained to you before you complete them. You will be asked to complete four tasks altogether.

We do not anticipate any risks to you or others related to the experiment. The only potential risk of this study is mild fatigue, and you can take as many breaks as you would like between blocks.

We will be tracking your eye movements in this study using a screen-based eye tracker. There are no additional risks posed to you because of this.

You are under no obligation to participate, and you may discontinue the experiment at any time. If you choose to end the experiment early, you may wish to tell us that we cannot use the information you have provided. Also, if you change your mind at any time after the experiment is completed, you can also tell us that we cannot use the information you have provided.

We will be using the results to this research to publish in research journals. We also may present the findings at some research conferences. De-identified versions of the data will be posted to Open Science Framework. We will not be identifying any individual by person, title, or by any other identifying information.

We will be collecting basic demographic information (gender, age, handedness) in order to describe my sample, but we will not present the results in any way that might identify you personally. Only members of the research team will know who participated in the study, and have access to the data. All study materials will be kept on a password protected computer using the OneDrive server at UNB Saint John, and will be destroyed five years after study completion.

As a thank-you for your participation and as compensation for your time, you will receive one bonus mark in an undergraduate psychology course.

By signing this consent form, you are indicating that you fully understand the above information and agree to participate in this study.

Participant's signature:

_____

Date:

_____

Researcher's signature:

_____

Date:

_____

If you have any questions about this study, please contact us at jwilbiks@unb.ca or

Kathryn.nason@unb.ca. This research has been reviewed by the Research Ethics Board at UNB

and is on file as REB # 184-2022. For more information about the ethics review process, you can

contact the Chair of the Research Ethics Board by email (reb@unb.ca), or by phone

(506.648.5994).

Appendix B- Demographics

What is your age?

What is your gender?

What hand do you write with?

Appendix C- Media Multitasking Index

Part one: Participants will be presented with a text box, and will be prompted to type a number between one and 168.

How many hours per week do you use each of the following media sources?

Print media

Television

Computer-based video (e.g., YouTube or Netflix)

Music

Non-music audio (e.g., podcasts)

Video or computer games

Smartphone calls

Instant messaging

Email

Web surfing

Other computer-based applications

Part Two: Rated using "Most of the Time", "Some of the Time", "A little of the time", and "Never"

How often do you use print media at the same time as:

Television

Computer-based video (e.g., YouTube or Netflix)

Music

Non-music audio (e.g., podcasts)

Video or computer games

88

Smartphone calls

Instant messaging

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you use television at the same time as:

Computer-based video (e.g., YouTube or Netflix)

Music

Non-music audio (e.g., podcasts)

Video or computer games

Smartphone calls

Instant messaging

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you use Computer-based video at the same time as:

Music

Non-music audio (e.g., podcasts)

Video or computer games

Smartphone calls

Instant messaging

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you listen to music at the same time as:

Non-music audio (e.g., podcasts)

Video or computer games

Smartphone calls

Instant messaging

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you listen to non-music audio at the same time as:

Video or computer games

Smartphone calls

Instant messaging

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you use video or computer games at the same time as:

Smartphone calls

Instant messaging

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you make smartphone calls at the same time as:

Instant messaging

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you send instant messages at the same time as:

SMS (text messaging)

Email

Web surfing

Other computer-based applications

How often do you use SMS/text messaging at the same time as:

Email

Web surfing

Other computer-based applications

How often do you use email at the same time as:

Web surfing

Other computer-based applications

How often do you surf the web at the same time as:

Other computer-based applications

Appendix D- Social Media Disorder Scale

Each question is answered using a "Yes" or a "No".

Criterion	During the past year, have you …
Preoccupation	… regularly found that you can't think of anything else but the moment that you will be able to use social media again?
Tolerance	… regularly felt dissatisfied because you wanted to spend more time on social media?
Withdrawal	… often felt bad when you could not use social media?
Persistence	… tried to spend less time on social media, but failed?
Displacement	… regularly neglected other activities (e.g., hobbies, sport) because you wanted to use social media?
Problem	… regularly had arguments with others because of your social media use?
Deception	… regularly lied to your parents or friends about the amount of time you spend on social media?
Escape	… often used social media to escape from negative feelings?
Conflict	… had serious conflict with your parents, brother(s) or sister(s) because of your social media use?

Appendix E- Media Familiarity Measures

On a scale of 1- 10 with 10 being very familiar, how familiar were you with the television show in general?

- Answered on a scale of 1 to 10, with 10 being very familiar.

On a scale of 1- 10 with 10 being very familiar, how familiar were you with the episode?

- Answered on a scale of 1 to 10, with 10 being very familiar.

Appendix F- Debrief Form

Influence of Media Multitasking, Cognitive Load and Smartphone Addiction on

Divided Attention Performance

Kathryn Nason, Graduate Student, Department of Psychology

Dr. Jonathan Wilbiks, Assistant Professor, Department of Psychology

University of New Brunswick – Saint John

Thank you very much for your participation in our study. Your time and commitment to psychological research at the University of New Brunswick is very much appreciated.

The study you took part in will contribute to our understanding of how divided attention ability is influenced by elements such as media multitasking, cognitive load, and disordered social media use. We are interested in examining speed and accuracy of the tasks, both alone and together with the video, to examine differences in participant performance. We believe that understanding these effects is important in order to comprehend the effects of smartphone usage in society and on attention.

If you have any questions regarding your participation in this study, or would like to receive information about the results once they are available, feel free to contact Dr. Jonathan Wilbiks at jwilbiks@unb.ca or Kathryn Nason at knason5@unb.ca. We would be happy to provide you with the overall findings of our study at a later date.

This research has been reviewed by the Research Ethics Board at UNBSJ and is on file as REB# 184-2022. For more information about the ethics review process, you can contact the Chair of the Research Ethics Board by email (reb@unb.ca), or by phone (506.648.5994).

Table 1

Number of Looks and Fixations

	M	SD
Number of Fixations		
SART Control	203.91	69.32
SART Focused	86.79	84.74
SART Area	212.85	59.49
SART Video	22.21	41.11
Letter Number Control	232.10	82.52
Letter Number Focused	119.13	101.24
Letter Number Area	253.33	67.20
Letter Number Video	2.58	3.64
Number of Looks		
SART Control	401.98	231.76
SART Focused	276.68	185.99
SART Area	283.25	98.23
SART Video	34.72	59.80
Letter Number Control	441.81	235.46
Letter Number Focused	344.64	211.66
Letter Number Area	319.95	107.76
Letter Number Video	5.55	9.58

Note: N = 87

Table 2

SART Anticipatory Responses Repeated Measures ANOVA

Predictor	Sum of Squares	df	Mean Square	F	Partial η^2
Experiment	3.13	1	3.125	0.03	< 0.001
Experiment*SMD	134.52	1	134.52	1.31	0.02
Experiment*MMI	95.48	2	47.74	0.46	0.01
Error	8548.19	83	102.99		
SMD	91.43	1	91.431	0.20	0.002
MMI	138.68	2	69.34	0.15	0.004
Error	38159.76	83	459.76		

Note: N = 87

Table 3

SART No-Go Accuracy Repeated Measures ANOVA

Predictor	SS	df	Mean Square	F	Partial η^2
Experiment	0.19	1	0.19	0.04	< 0.001
Experiment*SMD	0.98	1	0.98	0.20	0.002
Experiment*MMI	8.163	2	4.08	0.85	0.02
Error	399.36	83	4.81		
SMD	0.40	1	0.40	0.05	< 0.001
MMI	40.82	2	20.41	2.49	0.06
Error	679.82	83	8.19		

Note: N = 87

Table 4

Repeated Measures ANOVA: Accuracy

Predictor	SS	df	MS	F	Partial η^2
Trial	.01	1	0.01	3.19	0.04
Trial*SMD	.001	1	0.001	0.46	0.01
Trial*MMI	.002	2	0.001	0.40	0.01
Trial*SMD*MMI	.01	2	0.01	1.79	0.04
Error	.21	81	0.003		
Stimulus	< 0.001	1	< 0.001	0.39	0.01
Stimulus*SMD	< 0.001	1	< 0.001	0.09	0.001
Stimulus*MMI	.001	2	< 0.001	0.61	0.01
Stimulus*SMD*MMI	< 0.001	2	< 0.001	0.84	0.004
Error	.09	81	.001		
Switch	.002	1	.002	2.02	0.02
Switch*SMD	< 0.001	1	< 0.001	0.28	0.003
Switch*MMI	< 0.001	2	< 0.001	0.03	< 0.001
Switch*SMD*MMI	< 0.001	2	< 0.001	0.05	0.001
Error	.10	81	0.001		
Trial*Stimulus	< 0.001	1	< 0.001	< 0.001	< 0.001
Trial*Stimulus*SMD	< 0.001	1	< 0.001	-0.04	< 0.001
Trial*Stimulus*MMI	< 0.001	2	< 0.001	< 0.001	< 0.001
Trial*Stimulus*SMD*MMI	< 0.001	2	< 0.001	-0.10	0.001
Error	< 0.001	81	< 0.001		
Trial*Switch	< 0.001	1	< 0.001	.001	< 0.001
Trial*Switch*SMD	< 0.001	1	< 0.001	.001	< 0.001
Trial*Switch*MMI	< 0.001	2	< 0.001	< 0.001	< 0.001
Trial*Switch*SMD*MMI	< 0.001	2	< 0.001	< 0.001	< 0.001
Error	< 0.001	81	< 0.001		
Stimulus*Switch	< 0.001	1	< 0.001	-0.002	< 0.001
Stimulus*Switch*SMD	< 0.001	1	< 0.001	-0.002	< 0.001
Stimulus*Switch*MMI	< 0.001	2	< 0.001	-0.001	< 0.001
Stimulus*Switch*SMD*MMI	< 0.001	2	< 0.001	-0.001	< 0.001
Error	< 0.001	81	< 0.001		
Trial*Stimulus*Switch	< 0.001	1	< 0.001	-0.004	< 0.001
Trial*Stimulus*Switch*SMD	< 0.001	1	< 0.001	-0.01	< 0.001
Trial*Stimulus*Switch*MMI	< 0.001	2	< 0.001	-0.01	< 0.001
Trial*Stimulus*Switch*SMD*MMI	< 0.001	2	< 0.001	-0.02	< 0.001
Error	< 0.001	81	< 0.001		
SMD	< 0.001	1	< 0.001	0.002	< 0.001
MMI	0.62	2	0.31	1.80	0.04
SMD*MMI	.53	2	0.27	1.54	0.04
Error	13.96	81	0.17		

Note: N = 87. *p > .05, **p > .01, ***p > .001

Table 5

Repeated Measures ANOVA: Reaction Time

Predictor	SS	df	MS	F	Pη²
Trial	9.30	1	9.30	0.10	0.001
Trial*SMD	2.81	1	2.81	0.03	< 0.001
Trial*MMI	199.48	2	99.74	1.10	0.03
Trial*SMD*MMI	168.76	2	84.32	0.93	0.02
Error	7325.73	81	90.44		
Stimulus	20.43	1	20.43	0.28	0.003
Stimulus*SMD	5.17	1	5.17	0.07	< 0.001
Stimulus*MMI	2.66	2	1.33	0.02	< 0.001
Stimulus*SMD*MMI	4.17	2	2.09	0.03	< 0.001
Error	5874.33	81	72.52		
Switch	3799.00	1	3799.00	37.79***	0.32
Switch*SMD	0.83	1	0.83	0.01	< 0.001
Switch*MMI	181.178	2	90.59	0.90	0.02
Switch*SMD*MMI	621.04	2	310.52	3.09	0.07
Error	8142.74	81	100.53		
Trial*Stimulus	< 0.001	1	< 0.001	< 0.001	< 0.001
Trial*Stimulus*SMD	< 0.001	1	< 0.001	< 0.001	< -0.001
Trial*Stimulus*MMI	< 0.001	2	< 0.001	< 0.001	< -0.001
Trial*Stimulus*SMD*MMI	< 0.001	2	< 0.001	< 0.001	< -0.001
Error	< -0.001	81	< 0.001		
Trial*Switch	< 0.001	1	< 0.001	< 0.001	< -0.001
Trial*Switch*SMD	< 0.001	1	< 0.001	< 0.001	< -0.001
Trial*Switch*MMI	< 0.001	2	< 0.001	< 0.001	< -0.001
Trial*Switch*SMD*MMI	< 0.001	2	< 0.001	< 0.001	< -0.001
Error	< -0.001	81	< 0.001		
Stimulus*Switch	< 0.001	1	< 0.001	< 0.001	< -0.001
Stimulus*Switch*SMD	< 0.001	1	< 0.001	< 0.001	< -0.001
Stimulus*Switch*MMI	< 0.001	2	< 0.001	< 0.001	< -0.001
Stimulus*Switch*SMD*MMI	< 0.001	2	< 0.001	< 0.001	< -0.001
Error	< 0.001	81	< 0.001		
Trial*Stimulus*Switch	< 0.001	1	< 0.001	< 0.001	< 0.001
Trial*Stimulus*Switch*SMD	< 0.001	1	< 0.001	< 0.001	< 0.001
Trial*Stimulus*Switch*MMI	< 0.001	2	< 0.001	< 0.001	< 0.001
Trial*Stimulus*Switch*SMD*MMI	< 0.001	2	< 0.001	< 0.001	< 0.001
Error	< 0.001	81	< 0.001		
SMD	< 0.001	1	< 0.001	- 0.11	-0.001
MMI	< 0.001	2	< 0.001	- 0.05	< -0.001
SMD*MMI	< 0.001	2	< 0.001	- 0.03	< -0.001
Error	< -0.001	81	< 0.001	- 0.02	< -0.001

Note: N = 87. *p > .05, **p > .01, ***p > .001

Curriculum Vitae

Candidate's full name: Kathryn Victoria Nason

Universities attended (with dates and degrees obtained):

University of New Brunswick Saint John

- Bachelor of Arts (2018-2022)

- First Class Honours in Psychology, Minor in Criminal Justice Studies

Conference Presentations:

The Relationship between Sustained Attention and Mobile Phone Screen Time

- Canadian Society for Brain and Behavioural Sciences (Presentation)

  - July 2022

- Object Perception, Attention, and Memory 2022 Conference (Poster Presentation)

  - November 2022

Effect of Notification Type on Sustained Attention Performance

- Student Psychology Studies Symposium

  - April 2023