INDIVIDUAL DIFFERENCE AND TASK FACTORS RELATED TO MULTITASKING SUCCESS

by

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ABSTRACT

Many aspects of one's daily life require multitasking in order to accomplish tasks. This study investigated individuals' multitasking success on two different types of task and the relationship between task performance and specified individual difference factors. The tasks were a study and recall of text task and a simulated making breakfast task. Three questions were addressed: (1) how well do students recall text material studied under different levels of distraction from a competing video; (2) how do individual differences in working memory, GPA, polychronicity, and perceived multitasking ability relate to performance on the study task and the simulated making breakfast task; (3) is there a relation between effective multitasking on the two tasks, and do successful multitaskers on each task share any individual difference characteristics? Results indicated that multitasking leads to performance decrements in the retention and recall of material. Examination of the individual difference factors revealed that working memory, specifically having a higher working memory capacity, was a key factor in successful performance during both experimental tasks.

Keywords: *multitasking, individual differences, polychronicity, working memory, perceived ability*

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

AVGPs	Action Video Game Players
BTAE	Better Than Average Effect
BTV	Background TV
GPA	Grade Point Average
MATB	Multitasking Attribute Task Battery
MPI	Multitasking Preference Inventory
MT	Multitasking
OSPAN	Operation Span
PMA	Perceived Multitasking Ability
PREP	Psychology Research Experience Pool
PRP	Psychological Refractory Period
RT	Reaction Time
S-R	Stimulus-response
TSR	Task Set Reconfiguration
SOA	Stimulus Onset Asynchrony
WM	Working Memory
WMC	Working Memory Capacity

List of Appendices

Chapter 1: Introduction

Individual Difference and Task Factors Related to Multitasking Success

In today's fast-paced society, multitasking has become a way of life. Everywhere you look there are individuals trying to juggle several activities at once. Whether it is students texting while listening to a lecture, couples on their phones while out to dinner, or adults relaxing and watching television with their laptops open, multitasking is evident in many aspects of our daily lives. Even infants, toddlers and young children multitask as they switch their attention between toys and television during play or use e-books with interactive features to follow a story (Smeets & Bus, 2012). Among older children, a report from the Kaiser Family Foundation (Rideout, Foehr, & Roberts, 2010) indicated that children and youth between 8 and 18 years of age spend about 8.5 hours per day using entertainment media and nearly two-thirds of that time is spent doing something else such as eating, doing chores, talking on the phone, completing homework, or using additional media.

Multitasking is not limited to leisure activities. With the availability of new technologies that allow people to work on several activities concurrently from a single location, multitasking has gradually become a requirement in many academic, professional, and business environments (Adler & Benbunan-Fich, 2012; Foehr, 2006). Consistent with this, there is also a widespread belief that multitasking allows individuals to be more productive, to achieve more goals and to do so more quickly than does single tasking, although this is still a matter of active debate (Sanbonmatsu, Strayer, Medeiros-Ward & Watson, 2013). In any event, managers in the business world often seek out employees for senior and entry level jobs who are able to handle a number of different tasks simultaneously (Marks & Gonzalez, 2005). Students face similar pressures as their heavy workloads force them to take on several projects at once to meet deadlines (Rosen, 2010). Medical professionals find themselves dealing with several patients at a time as they use on-line resources to read reports and update records (Weksler & Weksler, 2012). These are just a few examples of the impact of multitasking in the everyday world.

The widespread adoption of multitasking strategies in learning, work, and play contexts has motivated researchers to examine the consequences and effectiveness of multitasking compared to single tasking. The results from many studies in which diverse situations and tasks have been examined have generated a growing debate. On one hand, some have argued that for many tasks, performance degrades when attention is divided and switched amongst a number of different tasks compared to doing them one at a time (Junco, 2012; Weaver & Arrington, 2013). This is consistent with decades of experimental research indicating that when individuals perform two tasks concurrently or successively interference occurs that results in slower response times, more errors, or prolonged completion times. On the other hand, some contend that multitasking can actually improve certain aspects of cognitive functioning through practice that changes the way users attend to and process task-relevant information (Lui & Wong, 2012; Maclin *et al.* 2011). As evidence, they point to a small portion (about 2.5%) of the population who are able to multitask effectively without incurring any costs to performance (Watson & Strayer, 2010). Given that these two perspectives are inconsistent, it is important to consider the frameworks and theory behind both sides of the debate in order to understand the conditions under which multitasking can be beneficial or detrimental. The following research will examine a number of individual difference (polychronicity, working memory capacity and perceived multitasking ability) and task (study and recall of text, making breakfast) factors in order to determine how they affect individuals' ability to multitask and to provide further evidence to the debate surrounding multitasking.

Chapter 2: Review of the Literature

2.1 Some Historical Background to the Multitasking Debate

Successful multitasking requires that individuals divide and direct their limited attention resources effectively; that they flexibly select, focus and switch attention to the features of the environment that are currently most important while resisting distraction from those that are less so (Posner & Peterson, 1990; Posner & Rothbart, 2007; Ruff & Rothbart, 2001). A key question is whether (or under what conditions) two or more tasks that might share common perceptual, motor and cognitive resources can be performed either concurrently or in rapid succession. As William James (1890) noted in the *Principles of Psychology*, this will be very difficult unless the tasks are habitual. In that view, which has been shared by others (e.g., Kahneman, 1973; Navon & Gopher, 1979; Pashler, 1994), attention is a finite mental resource that underlies all cognitive activity. Depending on the activity, the resource can be focused on a single task or shared more widely across several tasks. The results of many experimental studies, some of which go back to the 1920s (e.g., Jersild, 1927), indicate that when attention is divided, some degree of dual-task interference or task switch cost is seen in slower reaction time, increased error, and longer completion times (see Monsell, 2003; Pashler, 2000; Pashler & Johnson, 1989). These findings are true for non-automatic tasks but may not true for fully automatic processes. Schneider and Shiffrin's (1977) two-process theory proposes that when a task becomes automatic (i.e. after extended practice) it can be performed simultaneously with no costs to performance. The findings from these experimental literatures are relevant to questions about the nature and effectiveness of multitasking in the everyday world.

2.1.1 Dual-task interference research. In the basic dual-task experiment, two simple, speeded tasks are presented concurrently or with a very short delay (*i.e.* stimulus onset asynchrony, or SOA) between them and the individual responds to them simultaneously. For example, a participant must say aloud whether a tone is high or low in pitch (auditory-vocal task) and press a button to indicate whether a number shown on a screen is greater or less than ten (visual-manual task). To assess interference, performance on each task done singly is compared to performance in the dual-task condition. When the tasks are performed in the presented order, the basic finding is that as SOA decreases, the reaction time (RT) to the second task increases, a delay termed the psychological refractory period (PRP) (Welford, 1952). This PRP effect was observed in many task pairs, and was neither eliminated nor reduced by practice (Levy & Pashler, 2001; Meyer & Kieras, 1997; Ruthruff, Johnson, Van Selst, Whitsell, & Remington, 2003). The favored explanation for dual-task interference was that there was an all-or-none central processing bottleneck in the brain (Pashler, 1994; Pashler & Johnston, 1989; Welford, 1952). In that view, the central processing (e.g., response selection; memory retrieval; decision making) that followed stimulus onset and preceded response production, could take place for only one task at a time, so performance on a secondary task was delayed. Consistent with this, Dux, Ivanoff, Asplund, and Marois (2006) used time-resolved fMRI to identify a likely neural basis for such dual-task limitations: the inability of the posterior lateral prefrontal cortex, and the superior medial frontal cortex, to process two decision-making operations at once. They suggested that this network of frontal lobe areas acts as a central bottleneck of information processing that severely limits our ability to multitask.

Although the evidence from the PRP paradigm was strong, the idea of a single channel, central, response selection bottleneck was challenged. Others suggested that in more flexible task conditions, individuals have more control over the course of secondary-task processing (Anderson, 1982; Meyer & Kieras, 1999). Secondary task slowing at short SOAs was seen as a strategic rather than a structural property of the cognitive system. This implied that the bottleneck was not fixed and that perfect time-sharing (*i.e.* multitasking) might be possible under certain conditions. Many researchers conducted studies in which they tried to find tasks or special conditions that could bypass the bottleneck (e.g., Logan & Gordon, 2001; Meyer & Kieras, 1997; Schumacher *et al.*, 2001; Tombu & Jolicoeur, 2004). Although some appeared to do so, methodological confounds made it unclear whether the bottleneck was actually bypassed or simply latent (Lien, Ruthruff, & Johnston, 2006; Pashler *et al.*, 2001; Tombu & Jolicoeur, 2004).

An alternative to bottleneck models were central capacity-sharing models in which performance of several tasks can occur in parallel by distributing limited mental resources differentially among them (e.g., Kahneman, 1973; Navon & Miller, 2002; Tombu & Jolicoeur, 2004). In that case, less capacity is available for any individual task and performance may be diminished on any one of them. This is consistent with everyday experience in which one carries out several tasks simultaneously (e.g., conversing while driving and attending to the GPS) without a problem until one task becomes effortful. At that point the resource has to be redistributed (e.g., less effort spent on conversing as traffic becomes heavy) to avoid error. An issue in capacity-sharing models concerns the nature of the resource itself and how such a resource (or resources) is distributed (Broadbent, 1958; Just & Carpenter, 1992; Kahneman, 1973; Logan, 1979; Meyer & Kieras, 1999; Salvucci

& Taatgen, 2008; Wickens, 1984).

2.1.2 Task-switching research. Task switching occurs commonly in many real world work and learning situations where multitasking is required. In the basic experimental task-switching procedure, participants try to complete two or more tasks by alternating between them rather than by doing them concurrently. Participants are trained to respond (usually with a manual or verbal choice) on two simple tasks (e.g., word reading; color and object naming; categorizing digits, letters, or words; responding to stimulus location) and then to perform each of them on separate trials. On some trials the task changes (switch trials; AABB; AABB) and on others it does not (repeat trials; AAAA; BBBB). When performance on the two trial types is compared across blocks, the usual result is a large "switch cost" seen in longer reaction times and increased error rates on the switch trials and on the blocks where a switch occurs. This phenomenon has been seen in a range of tasks and is affected by a number of procedural and cognitive variables (see Kiesel *et al.*, 2010; Monsell, 2003; Vandierendonck, Liefooghe, & Verbruggen, 2010).

There have been two types of explanations for the performance decrement on switch trials. In one, the switch cost is said to reflect the preparation time needed for a task-set reconfiguration (TSR) to occur. The idea is that as a person prepares to do any task a corresponding mental task set is adopted. This means that a schema for "what has to be done to complete this task" is generated. This schema can be quite complex and includes the organization of cognitive processes and mental representations of task-relevant stimuli, responses, and their corresponding stimulus-response (S-R) mappings (Jersild, 1927; Rogers & Monsell, 1995). In order to switch tasks, a new task set must be configured that is appropriate to the new task. This TSR can involve shifting attention between stimulus attributes or elements, or between conceptual criteria, retrieving goal states (what to do) and condition-action rules (how to do it) into working memory, or deleting them to enable a completely different task set. In contrast, on repeat trials TSR is not necessary and these processes are not invoked.

In the second class of explanations, the switch cost is said to occur because of proactive interference from the previously performed task. Allport, Styles and Hsieh (1994) described task-set inertia as the persisting activation of previously used task-set features that interfere with responding to a stimulus that has been processed in the context of another task. Others have suggested that interference can disrupt performance when the stimulus-task associations that were acquired during a previous task become irrelevant and must be suppressed once the task changes. In any case, the switch cost reflects the time needed to overcome this interference (e.g., through trace decay; response inhibition). There is evidence that both sets of factors are involved in switch-cost effects, though the conditions that favour one or the other in any particular tasks have not been clarified (Kiesel *et al.,* 2010; Koch, Gade, *et al.,* 2010; Vandierendonck *et al.,* 2010).

Although the experimental literatures of dual task interference and task switching have been carried out as independent lines of research, it has been suggested that they actually lie on a continuum defined by the time that elapses between the two task onsets; milliseconds for dual task or concurrent performance; minutes or hours for sequential task switching (Salvucci & Taatgen, 2010). Indeed, Lien, Schweickert, and Proctor (2003) showed in a series of experiments that dual task interference and task switch costs may have processes in common such as a difficulty in reconfiguring task sets (see Pashler, 2000). However, there is still not a consensus on the nature or extent of the limitations to human information processing that these multitasking strategies incur. What is clear is that when individuals must divide their attention to perform two tasks either sequentially or concurrently, there is almost always a cost to be paid in terms of increased response times and more frequent errors, unless one task has undergone significant practice and can be completed without conscious thought (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). These data imply that multitasking in parallel contexts in the real world will also show such response costs. However, critics have argued that the tasks used in these experimental paradigms are artificial and constrained and do not necessarily reflect multitasking in the real world. Some of these everyday examples will be examined next.

2.2 Multitasking: Positive Outcomes

A number of researchers have found that multitasking can have beneficial effects on performance. The idea is that multitasking can change the way the brain processes information, particularly in terms of enabling more effective distribution of attention resources and decreasing reaction times (e.g., Dye, Green, & Bavelier, 2009; Maclin *et al.*, 2011). In these situations, flexible training regimens that involve constantly changing the information being processed and adjusting to new task demands, allow one to focus attention across a greater number of tasks or task components (Bherer *et al.*, 2005).

Perhaps one of the strongest examples is found in literature on the effects of playing action video games (Dye, Green & Bavelier, 2009). When playing action video games, specifically first person shooter games, players constantly face distraction from unexpected objects or characters that draw their attention from the main goal. Players must be quick to identify these objects/characters, decide which are relevant and determine how to deal with them, while ignoring irrelevant distractors (Chiappe *et al.*, 2013). Thus, action video games are a good example of everyday multitasking as they provide information from multiple input sources, involve complex visual scenes with several goals at different time scales, and require the coordination of memory tasks, executive function tasks, visual attention, and visuomotor skills. Bavelier and collaborators (Bavelier, Green, & Pouget & Schrater,2 2012; Bavelier *et al.*, 2010; Dye *et al.*, 2009; Green & Bavelier, 2008; Green, Sugarman, Medford, Klobusicky, & Bavelier, 2012) conducted a series of experiments that showed a number of positive effects on aspects of vision, attention, cognition and motor control from their use.

It has been demonstrated that action videogame players (AVGPs) exhibit distinct visual enhancements compared to non-gamers. For example, AVGPs are able to respond faster than, and as accurately as non-gamers (Dye, Green & Bavelier 2009) when completing visual tasks, such as visual search and stimulus detection tasks (Castel, Pratt & Drummond, 2005). AVGPs also develop enhanced spatial and temporal resolution of vision as well as contrast sensitivity (Green *et al.,* 2010) and AVGPs are better able to resolve small details (e.g., the orientation of the letter T) in the context of clutter (e.g., distractor letters) (Bavelier, Green, Pouget & Scharater, 2012).

Benefits from action videogame playing also extend to visuocognitive tasks, decision-making (Bavelier, Green, Pouget & Schrater, 2012) and even aspects of executive function and multitasking (Chiappe *et al.,* 2013; Anderson & Bavelier, 2011; Andrews & Murphy, 2006; Green & Bavelier, 2006; Green *et al.,* 2012). It has been proposed that action videogame play retrains cortical networks such that each layer of the processing hierarchy makes better use of information from earlier layers (Bavelier, Green, Pouget & Scharater, 2012). The documented benefits can occur in non-gamers who have undergone as little as six hours per week of training on the games over four weeks. For example, Maclin *et al.* (2011) trained people on the video game Space Fortress. Their training resulted in improved performance on both the videogame and a secondary auditory task. Using an EEG the researchers found that as participants' skill improved on Space Fortress so did their ability to respond accurately and efficiently to the auditory task. Chiappe *et al.* (2013) found similar results. After "prescribed" videogame training on a first person shooter game, players' performance significantly improved on aspects of the Multitasking Attribute Task Battery (MATB) including communication and system monitoring, faster and more consistent responses to communication requests and faster reactions to lights and dials (like those on a plane dashboard).

Multitasking can also benefit performance in situations where an individual chooses to switch among tasks. Such self-interruptions, or internal decisions to stop an on-going task to attend to another, can help increase motivation and improve task outcomes (Adler & Benbunan-Fich, 2013). External or internal/self-interruptions suspend one's current goal(s) in pursuit of a new goal (Mark, Gonzalez, & Harris 2005). External interruptions are caused by alerts, notifications or environmental distractions, while internal interruptions are personal decisions to stop a task and undertake another activity. Using six different problem-solving tasks, combined in a custom computer program, Adler and Benbunan-Fich (2013) measured participants' multitasking behavior and assessed their explanations for choosing to switch among tasks. Participants worked to solve a main task (a Sudoku puzzle) and five peripheral tasks (a word de-scramble, two visual identification tasks, and two numeric tasks) in any order, within a limited time frame. They were able to switch between tasks as needed and the program recorded performance and switch behavior for each user. Finally, participants completed a questionnaire assessing their reasons for task switching. The analysis revealed that participants who chose to switch between tasks did so for both positive reasons (e.g., to reorganize thoughts, re-stimulate interest) and negative reasons (e.g., frustration, exhaustion, obstruction). Self-interruptions due to positive triggers occurred least frequently but enabled participants to stay motivated and be productive, resulting in the best overall task performance compared to those who self-interrupted for negative reasons and non-multitaskers. Consequently, actively choosing to multitask can have benefits for task performance compared to single tasking, when the reasons for multitasking are positive.

A final benefit of multitasking behavior is the development of a "breadth-biased style" of cognitive control (Lui & Wong, 2010). Previous research had shown that students who were high media multitaskers showed poorer performance on tasks requiring focused attention, resistance to distraction, and task switching compared to those who were low media multitaskers (Ophir, Nass & Wagner, 2009). This may be attributable to high media multitaskers having a "breadth-biased style" of cognitive control, whereby they pay attention to large amounts of information from the environment, rather than focusing solely on information relevant to the current task (Lui & Wong, 2012). While this style of processing may sound disadvantageous, scenarios often arise where attending to all the available information provides an advantage. For example, Lui and Wong (2010) asked participants to locate a specific line segment, and indicate its orientation, as it changed color on a computer screen amongst a number of distractors. In some cases, the color change was accompanied by a short auditory pip. Heavy media multitaskers located the target line segment more rapidly than light multitaskers when it coincided with the auditory pip.

Development of “breadth-biased” cognitive control allowed heavy multitaskers to utilize the unexpected auditory tone as a cue, whereas light multitaskers were less able to synthesize the two sources. As many unexpected environmental stimuli may carry important information, heavy media multitaskers may be at an advantage, as they are able to receive information from a number of channels. However, whether this outweighs the difficulty that high media multitaskers have in focusing their attention and resisting distraction remains to be seen.

2.3 Multitasking: Negative Outcomes

There is evidence that distractions (or secondary tasks) can be detrimental to performance on a primary task as they increase cognitive load and reduce working memory capacity available for the focal task (Baddeley & Hitch, 1974; Baddeley, 1992). Baddeley’s (1992) model of working memory (WM) proposed that the main component of the system, the central executive, coordinates information from two “slave” systems involved with working memory (the phonological loop and visuospatial sketchpad). He suggested that “the coordination of resources is the prime function of working memory, with memory storage being one of many potential demands” (*p.* 557). Baddeley (1992) argued that as WM has a limited capacity, its operation can be impaired when people are required to complete a number of different tasks requiring that resource. Similarly, Engle (2002) found that individuals differ in their ability to “maintain and inhibit information [in working memory], particularly in the face of distraction and interference” (*p.* 21). This further implies that working memory plays a significant role in multitasking ability.

A number of researchers have found support for the idea that multitasking can increase the cognitive load placed on WM and other executive functions. As noted above, Ophir, *et al.* (2009) examined whether self-declared, high media multitaskers would perform better on tests of cognitive control (or executive functioning) than would low media-multitaskers. Participants were given a series of cognitive control tasks, including filtering tasks (e.g., determining whether the orientation of a rectangle changed from one presentation to the next while ignoring the distractor triangles) and task-switching tasks (e.g., classifying a letter and number as either odd or even, or as a vowel or consonant, respectively). Their results showed that heavy media multitaskers performed more poorly on all of the tasks; they were more easily distracted by the number of media streams they consumed and had more trouble focusing their attention on central information. Those who rarely multitasked were better at maintaining focus in the face of distraction and performed better on tests of executive function.

Further examples of the negative effects of multitasking come from studies in which university students study and learn material while attending to other media (e.g., Internet, social media, music). Recent trends suggest that multitasking is increasing in the millennial generation (Carrier, Cheever, Rosen, Benitez & Chang, 2009; Junco & Cotton, 2012; Lee, Lin & Robertson, 2010) who are rapidly adopting new technologies and using them at high rates. For example, Junco and Cotton (2012) reported that 96% of college students owned cellphones and 71 out of an average of 97 text messages per day were sent during class time. Furthermore, Smith and Caruso (2010) found that 84% of student's own laptops and 90% use social networking sites.

The results of many studies (surveys, observations, experiments) indicate that multitasking impairs learning and can negatively affect academic performance overall (e.g., Kraushaar & Novak, 2010; Lee, Lin & Robertson, 2010; Sana, Weston & Cepeda, 2013).

Junco (2012) found that using technology at a high frequency during class time (*i.e.* texting and Facebook) was negatively predictive of overall semester GPA. Similarly, Wood *et al.* (2012) found that students who got off task and used Facebook and MSN messaging during class performed more poorly on lecture-based quizzes compared to students who took notes using paper and a pencil. Sana, Weston and Cepeda (2013) not only replicated this finding but found that comprehension was also impaired for peers in the vicinity of the multitasking student. Students who were close enough to view the multitasking student's computer also showed deficits in learning without actively multitasking themselves. These findings are particularly worrisome given the high number of students who engage with various media during study and lecture periods. However, Bowman, Levine, Waite, and Gendron (2010) showed that students who studied a passage of text while attending to incoming e-mails took longer to study the passage but showed equally good comprehension of the material as did students who did not check e-mails during study. What this means is that when time is not important, some students may be able to switch between tasks without a detriment to performance.

Finally, a clear example of a negative impact of multitasking on one's daily life is the use of cellphones while driving. Glassbrenner (2005) estimated that during any daylight hour over 10% of drivers in the US are talking on their cellphones. This is important as research has consistently demonstrated that when drivers talk on their phones (either handheld or hands-free) their brake reaction times are delayed, object detection is impaired, traffic related brain potentials are suppressed and accident rates increase (Stayer, Drews & Johnston, 2003; Strayer & Johnston, 2001). Furthermore, 14.8% of all drivers, and a startling 48.5% of those aged 18 – 24, admit to texting while driving (American Automobile

Association, 2008). This leads to more distracted driving and increases the likelihood of crashing by 2.8 – 5.0 times that of normal driving rates. Consequently, the percentage of distraction-related accidents has increased by over 5% over the last 15 years, with the increase in texting considered a significant contributing factor (Wilson & Stimpson, 2010). Such statistics concisely demonstrate how multitasking can have a negative effect on routine tasks; as people become accustomed to multitasking they may become less aware of its potential consequences.

2.4 Individual Difference Factors that Affect Multitasking

The wide variety of everyday multitasking situations and the complexity of the interactions among the individual, task, and situational factors that can affect performance make it difficult to predict multitasking outcomes in general. To address this, researchers have tried to move beyond assessing particular occupations or work settings to looking for individual differences that might characterize successful or unsuccessful multitaskers. Such a general multitasking ability or talent would enable researchers, educators, and employers to identify those who would likely be successful across a variety of work settings in which dual task or task switching performance is required. This approach should also help to explain the mixed results that have been found in multitasking effectiveness across situations thus far.

Watson and Strayer (2010) investigated individuals' ability to complete two demanding tasks without incurring deficits, specifically, drivers' claims that talking on their cellphone does not interfere with their driving ability. To do so, they had participants perform a simulated driving task along with an auditory version of the OSPAN test of working memory (Engle, 2002) simultaneously. The overall results from this experiment showed the typical pattern; dual task performance was inferior to single task performance (control condition) on measures of brake reaction time, following distance and OSPAN performance. However, detailed analysis showed that a small subset of their sample (2.5%) showed no performance decline from the single to dual task conditions across all dependent measures. They called these participants "supertaskers" as they appear to have the ability to successfully perform two attention-demanding tasks without performance deficits, which the vast majority of the population cannot do without suffering serious costs. This finding has important implications for multitasking ability and demonstrates the need to analyze the relationship between multitasking and individual difference factors — combinations of various traits may account for the "supertaskers'" rare ability.

2.4.1 Personality Traits. To date, researchers have found relationships between multitasking behavior and a number of different personality traits. For example, well-documented relationships have been found with sensation seeking, impulsivity and self-control. Sensation seeking correlates with multitasking behavior such that those who score high on sensation seeking scales (e.g., The Brief Sensation Seeking Scale) are more likely to multitask task than those who are low on sensation seeking (Yang & Zhu, 2015). In general, undertaking multiple tasks provides higher levels of stimulation along with more potential rewards and challenges than does single tasking, partially explaining the desire of high sensation seekers to multitask (Jeong & Fishbein, 2007). Impulsivity has similarly been associated with multitasking behavior. Individuals may multitask because of an inability to tune out distractions and focus on a single task; as a result, those who are highly impulsive are more likely to act without forethought and to engage in distracting tasks, regardless of performance costs (Yang & Zhu, 2015). Trait self-control is an individual difference factor that has a complex relationship with multitasking behavior. Trait self-control refers to one's ability to exercise self-discipline, to avoid impulsive behaviors, and to effectively regulate cognitive resources in order to meet situational demands (Grawitch & Barber, 2013). In multitasking situations, those with high self-control are better able to self-regulate task demands and ensure that they are completed efficiently and appropriately, especially when resources are becoming depleted. Trait self-control mediates the effects of other characteristics on multitasking success (Grawitch & Barber, 2013).

In summary, individual difference factors play an important role in determining the choice, frequency, and success of multitasking. Further investigation of other traits and characteristics may enable researchers to predict individuals' success in various multitasking situations in work, school and everyday life. For example, researchers have found that working memory, polychronicity and perceived multitasking ability are individually related to multitasking performance but have never been simultaneously compared to determine if, and how, they interact to influence multitasking behavior. Such analysis could reveal unique factor combinations that lead to superior or inferior, multitasking performance. Background research and the significance of these variables is discussed next.

2.4.2 Working Memory. Working memory (WM) is "the cognitive system in which memory and attention interact to produce complex cognition" (Shipstead, Harrison & Engle, 2015, p. 1863), especially under states of distraction and interference (Harrison *et al.*, 2013). Working memory capacity (WMC) is related to a wide variety of important characteristics. For example, individuals with higher WMC can better understand complex language, can better follow directions (Foster *et al.*, 2015) and are better able to block out distractions and keep focal tasks active in their mind. Furthermore, there is evidence that measures of WMC are related to greater ability to multitask and less frequent multitasking behavior (Sanbonmatsu *et al.*, 2013). Working memory allows people to keep long-term goals active in mind and to monitor/control their actions in order to meet these goals. It also enables intentional and effortful processing of information – rather than automatic or unintentional processing — allowing people to make purposeful behavioral decisions (Hofman *et al.*, 2008). When working memory is taxed, as is the case in many multitasking scenarios, goals are harder to keep active and automatic processing dominates making it more difficult to maintain self-control (Hofmann *et al.*, 2012).

Multitasking can be difficult, as many tasks lead to competition between the cognitive, perceptual or motor resources that the tasks require. Tasks that do not cause resource competition may be performed together easily, such as walking and talking. However, the more competition, the greater the interference between the tasks. For example, typing a project while talking to a friend is laborious as both tasks require language faculties, resulting in major interference between the tasks (Borst, Taatgen & van Rijn, 2010). If a particular mental resource can only be used by one task at a time, secondary tasks are put on hold leading to a similar cognitive bottleneck to that found in the dual-tasking literature. For example, the "problem state" is a cognitive resource that keeps track of task-related information in WM during multitasking but only holds the most recent representation of a task or problem (Anderson 2005; Borst, Taatgen & van Rijn, 2010). As it takes time to store and retrieve competing task information, the problem state can be a source of interference when two or more tasks require the use of this resource (Borst, Buwalda, van Rijn & Taatgen, 2013). Individuals with larger WMC may have the capability to hold more resources active at one time and may be more effective multitaskers than those with lower WMC.

Using a “synthetic work” task, Hambrick, Oswald, Darowski, Rench, and Brou (2010) investigated WMC as a predictor of multitasking ability. WMC was measured using operation span and symmetry span tasks. The “synthetic work” task consisted of a number of component tasks designed to mimic the requirement for multitasking that is present in most jobs. The components were not specific to any job in particular but were basic tasks including arithmetic, memory search, auditory and visual monitoring common to many different work environments. The results of this study suggested that working memory is an important factor underlying the ability to multitask. Furthermore, working memory capacity predicted the use of an effective strategy, which also contributed substantially to multitasking ability.

Similarly, Morgan *et al.* (2013) examined the relationship between a number of cognitive factors, including working memory, scholastic aptitude, spatial manipulation, creativity, and performance on the Multitasking Attribute Task Battery (MATB). The MATB mimics a plane dashboard and requires monitoring and attending to a number of controls simultaneously. They found that working memory, along with scholastic aptitude, predicted multitasking ability and performance on the task at baseline difficulty. Working memory, combined with spatial manipulation, was also the strongest predictor of adaptability to changing difficulty during the task. These results further demonstrate the relationship between working memory and multitasking ability.

2.4.3 Polychronicity. Polychronicity, or one's preference for multitasking over single-tasking (Konig & Waller, 2010), is a distinct personality and dispositional trait. Polychronicity is related to a number of personality dimensions and work related outcomes, including significant relationships (positive and negative) with a number of the Big Five personality dimensions, including conscientiousness (negative) and extraversion (positive) (Conte & Gintoft, 2005; Conte & Jacobs, 2003). People who are high in polychronicity tend to be relationship-oriented (focused on the well-being of those completing a task) compared to those high in monochronicity, who are more task-oriented (focused solely on the tasks needed to reach a goal) (Hall, 1983). Polychronic individuals are usually less organized and less reliable in terms of sticking to deadlines and schedules than are monochronics (Hall, 1983) and are less likely to show conscientiousness (Conte & Jacobs, 2003). A high level of polychronicity is also associated with more frequent lateness and absences from work (Conte & Jacobs, 2003).

Recent research on polychronicity has focused more directly on its relationship with job performance. The results of these studies have been inconclusive as some have found a positive relationship between polychronicity and work performance (Conte & Gintoft, 2005) while others have found a negative or no relationship (Conte & Jacobs, 2003). Konig and Waller (2010) offered an explanation for the inconsistent findings: neither polychronicity nor monochronicity is better for performance, it depends on the situation. Polychronicity is only better in situations where the job demands multitasking.

Sanderson, Bruk-Lee, Viswesvaran, Gutierrez and Kantrowitz (2013) examined the moderating role of polychronicity between multitasking ability and job performance in a variety of professional occupations (e.g., finance, human resources, *etc*.). They found that polychronicity played an important role in performance when multitasking was rated as necessary (by a panel of subject-matter experts) to complete the job. Participants who preferred to multitask outperformed those who did not in jobs involving high levels of multitasking. Kantrowitz, Grelle, Beaty and Wolf (2012) also adopted the person-situation approach to studying polychronicity and found that polychronicity was significantly related to job performance ratings in a managerial (*i.e.* high multitasking) job. To the extent that multitasking was critical to the job, their results showed that individuals who preferred to multitask performed better overall. They also found that polychronicity was positively related to ratings of time and task management ability in a sample of call center employees. The results of these studies and a number of others (e.g., Conte, 2005; Konig, Oberacher & Kleinmann, 2010) illustrate the importance of polychronicity as a predictor of multitasking behavior and its relationship to performance. To date, most of the research on the relationship between polychronicity and performance has involved business (managerial, clerical) contexts. The relationship has not been studied with regard to students and their academic task performance, although busy time schedules often require them to multitask (Chang, 2013). Polychronicity may be an important factor that affects students' academic performance as well.

2.4.4 Perceived Multitasking Ability. Another understudied factor related to multitasking is the individuals' perception of their multitasking ability. The goals people pursue and activities they choose to undertake strongly depend on perceptions of their own abilities relevant to those tasks (Sanbonmatsu *et al.*, 2013). Therefore, if people feel they are efficient and effective at multitasking they will be more likely to engage in this behavior. The important question stemming from this finding is whether individuals' perceived abilities map onto their actual ability to multitask.

Literature on this topic from other areas of research suggests that people generally tend to overestimate their abilities in comparison to their peers; this has been termed the "better than average effect (BTAE)" (e.g., Brown, 2012; Kruger, 1999; Zell & Alicke, 2011). Zell and Alicke (2011) showed that the BTAE is evident in a number of different characteristics ranging from emotional stability to intelligence to being tech-savvy. Horswill, Waylan and Tofield (2004) found that this effect can even be seen in people's ratings of their driving ability. This research demonstrates the pervasiveness of the BTAE, and so the question remains whether the BTAE will extend to one's perception of their multitasking ability. Although the literature is sparse, there is evidence that individuals' ratings of their multitasking ability also exhibited the BTAE. Sanbonmatsu *et al.* (2013) demonstrated that individuals' perceptions of their multitasking ability can be badly inflated, with the majority of participants rating themselves above average, which is not consistent with how they performed in an actual multitasking situation. Uncovering a relationship between individuals' perceived abilities and their actual performance would enable accurate inferences about one's performance in various multitasking scenarios and enable important decision-making based upon this relationship.

Chapter 3: The Current Experiment

Dual task interference and task switching literatures, as well as more recent studies of students who use multiple media in learning situations, typically have indicated a response cost to performance during such multitasking (Rosen, 2010). However, others contend that millennials who have grown up with access to a variety of technologies are more practiced in using these media and may process information from multiple sources more efficiently than previous cohorts of students who were less practiced (Schneider & Shiffrin 1977; Shiffrin & Schneider, 1977; but see Ophir *et al.*, 2009). Moreover, there is evidence that a number of task and individual difference factors can interact with multitasking skill to affect performance outcomes, although most of the evidence is based on individuals working in business contexts. Given the prevalence of multitasking in today's society and the increased pressure to multitask, it is important to ask the question of what predicts multitasking ability. In response to this question and to the mixed evidence surrounding multitasking, three research questions were addressed in the current study. First, how well do students recall text material that they studied under different levels of distraction from a competing video segment? Second, how do individual differences in working memory, GPA, polychronicity, and perception of multitasking effectiveness relate to performance on two tasks with different multitasking requirements: (a) the study and recall of text material, and (b) a simulated breakfast task? Third, (a) is there a relation between effective multitasking on the two tasks, and (b) do successful multitaskers on each task share any of the individual difference characteristics? These individual difference factors were chosen as researchers have examined them in past multitasking literature (see above) but have produced mixed evidence regarding how they affect multitasking ability and performance. Each factor has been found to relate to multitasking ability in certain scenarios and the study aimed to understand the nature of this relation, to determine how they affect performance in different contexts and whether or not a combination of these factors accounts for more variance in multitasking ability than either factor individually.

Our research questions were addressed in a study in which students performed two different activities (Study Task, Breakfast Task) that required multitasking. They were (1) asked to learn and recall information from an article that contained text material while a televised episode of the *CBS* program *60 Minutes* played in the background (Study Task). Students in a multitasking condition (MT) were instructed to attend to both the article and the video for later testing whereas those in a background TV condition (BTV) were instructed to ignore the video. Either before or after the Study Task, students were then asked (2) to monitor the "cooking" times of several different foods during a computerized simulated making breakfast task (Breakfast Task). Performance on the two multitasking experiences was also examined in relation to the measures of individual difference. Finally, participants' multitasking performance on the Study Task was then compared to their performance during the Breakfast Task.

Chapter 4: Methods

4.1 Participants

One hundred and five female and 20 male university students, aged 19 to 30 years (M = 21.10, SD = 2.24) participated in this study. Data from five females and one male had to be excluded due to being distracted during the Breakfast Task (n = 4), software malfunctions (n = 1) or having completed a separate study that used the same reading material as the current experiment (n = 1). Therefore, complete data were available for 120 participants (N = 120). Participants were recruited from Memorial University of Newfoundland using the Psychology Department's Participant Research Experience Pool (PREP) and also through poster advertising on campus, word-of-mouth, and social media (Facebook). Participants from PREP were enrolled in second year psychology courses and received 1% course credit for taking part in the study. Those recruited through other means received monetary compensation of $10.50 per hour for their time. Students from a wide variety of disciplines participated in this study, however the most common major was Psychology (n = 39). Students were not eligible for both course credit and remuneration. There were no exclusionary criteria other than age and the restriction that they had not participated in another study using the same reading material.

4.2 Materials and Measures: Multitasking

4.2.1 Recall of Study Material (Study Task). To simulate the multimedia conditions under which many students report that they study course material and complete assignments (e.g., computer use, music, monitor social media, read and reply to text messages), we assessed participants' ability to remember educational text material learned under various conditions of distraction from an episode of the *CBS* television program *60 Minutes* that played concurrently. The text passage was a general knowledge article about *Toucans* created by Chan, McDermott and Roediger (2006). A number of fill-in-the-blank questions accompanied the article. From these, 12 were chosen to use as questions for the current experiment, six of which were kept in their original format while the other six were reworded and turned into multiple choice questions. The same number and type of questions were created on information from the *60 Minutes* segment. The video and text material were selected as they contained similar content; both sources describe behavioral habits of animals.

For the Study Task there were two dependent measures. The first was the mean number of comprehension questions that the participants answered correctly from the information in the article and from the video. The performance of the two experimental groups (MT, BTV) was compared to a control group in which participants either read the article or viewed the video in a single-task condition. This measure provided an evaluation of how multitasking affected participants' comprehension of the information from each source. The second measure of interest was how participants divided their visual attention during the Study Task. As the Study Task was video recorded, the footage was used to determine how often and for how long each participant spent looking at the text, at the video or somewhere else during the task. This provided a measure of how the distribution of their visual attention was related to their recall performance.

4.2.2 The Breakfast Task. As a measure of everyday multitasking on a familiar routine task, we asked participants to prepare a virtual breakfast meal. Craik and Bialystok (2006) devised a computer simulation of cooking breakfast — a task in which various foods must be started at different times and monitored while cooking in order for all the food to be ready at the same time. The task involved starting, monitoring and stopping the cooking of five foods (eggs, sausage, toast, coffee and pancakes) while also setting a virtual table in between these operations. The table setting was a distractor task and involved participants placing plates, forks, knives and spoons in their correct places on the onscreen table for up to four table settings; when four settings were completed all the utensils returned and participants were asked to complete the task again (for as many times as they could before the food was done). However, participants were made aware that the main focus of the task was having all the food cooked properly and finished at the same time. We used the most complex version of the task (involving six screens), in which the participants were required to click on a food icon on the home screen in order to bring up the screen for that food, for example, the eggs. The eggs are started and then the participant returns to the home screen to carry out the table setting as a distractor task. Participants were able to check the progress of each food by revisiting the screen for that food and eventually stopping its cooking. Efficient performance involves working memory, task switching, planning, monitoring and execution — all abilities that underlie multitasking. The software and instructions for the Breakfast Task were purchased from the developer of the task.

For the Breakfast Task, there were five measures of interest that were calculated from the key presses recorded by the Breakfast Task program; *discrepancy, range, average deviation of start times, number of clicks* and *table setting* data. *Discrepancy* is a measure of the disparity between the actual cooking time of the food and the time required to cook the food (actual time — ideal time). This measure represents the ability to attend to the various foods being cooked and to remember to stop them at the correct time, thus it serves as a measure of prospective memory. The second measure is *range of stop times*, which is the difference (in seconds) between stopping the first and last foods. This number should be close to zero because participants are told that the main goal of this task is to have all the food ready at the same time. This measure reflects planning ability and working memory. The third measure is the *average deviation of start times*. For participants to have a low range of stop times they had to be able to calculate the ideal start times for each food so that all the foods would be done at the same time. These ideal times changed for each food. For example, in order for a food that takes 2 minutes to cook to be done at the same time as a food that takes 4 minutes, the two-minute food must be started 2 minutes after the 4-minute food. This becomes difficult when 5 foods are being cooked at the same time (as in the Breakfast Task). As a result, the incorrect start time of one food affects the ideal start time of foods that were to be started after it. Therefore, the deviation of start times measure is calculated as the average deviation between ideal and actual start times for foods 2 to 5. This measure further reflects planning ability. The next measure is *number of clicks* data which is a measure of how many times each participant clicked on each food to monitor its cooking time. Participants had to switch back and forth between various screens in order to see how much time was left for each food, thus having a large *number of clicks* indicates that the person had to check the cooking times frequently, demonstrating poorer ability to keep the cooking times active in their mind. *Number of clicks* represents prospective memory and participants' planning ability. Finally, the last measure was the *table setting* data. This was a measure of how many times each participant set the table while monitoring the cooking times of their foods. It serves as a measure of distraction during multitasking with more place settings indicating a failure to recognize that the cooking was the main task. High levels of table setting therefore indicates inefficient performance.

4.3 Materials and Measures: Individual Differences

4.3.1 Polychronicity. Polychronicity refers to the extent to which individuals prefer to be engaged in two or more tasks at a time rather than performing tasks one at a time. To measure polychronicity we used the Multitasking Preference Inventory (MPI) developed by Poposki and Oswald (2010). This inventory consists of 14 questions designed to measure individual differences in multitasking preference. The statements are rated on 5-point Likert-type scales ranging from 1 - strongly disagree to 5 - strongly agree, with 3 being neutral and representing no preference. A sample statement from the questionnaire is "I prefer to work on several projects in a day, rather than completing one project then switching to another”. The maximum score was 70. The questionnaire took about 5 minutes to complete.

4.3.2 Perceived Multitasking Ability. To measure individuals’ perceived multitasking ability, we followed the method of Sanbonmatsu *et al.* (2013) and simply asked participants to rate their ability in comparison to that of their peers, using a 5-point Likert scale. The scale ranged from 1, which indicates, “far below average” compared to my peers to 5, which indicates, “far better than average”. This took about 1 minute to complete.

4.3.3 Working Memory Capacity. Performance on measures of working memory (WM) predicts performance on a variety of real-world cognitive tasks including multitasking ability. To measure WMC we used a computerized version of the Operation Span (OSPAN) task that was adapted from Turner and Engle (1989) by Dr. Ian Neath at Memorial University. This measure required participants to read aloud a series of operation-word strings such as “Is 4/4 + 3 = 6? DOG”. Participants first read aloud the equation and responded as to whether or not it was correct by clicking “yes” or “no” on the computer screen. After each response a word appeared on the screen, which they also had to read aloud. These operation-word pairs were displayed in sets of 2 to 6 and once the set was finished all the words the participants read popped up along the bottom of the screen. Participants were then asked to recall the words in the correct serial order by clicking on the words in the order they had been shown during the trial. After a brief practice participants completed 16 test trials. The measure of WM capacity is the number of words recalled correctly. Math accuracy is also recorded separately and results were available at the end of the task. This version of the OSPAN task takes about 10–15 minutes to complete.

4.3.4 Academic Performance. Participants were asked to report their cumulative academic average on a General Information form, along with their age, gender, major and minor subject areas, and years of post-secondary education.

4.4 Procedure

Participants were tested individually in a room in the psychology department lab space. Upon entering the room participants were greeted and given a brief description of the tasks and procedure and were then asked to read and sign a consent form. There were two versions of the consent form — one for the students who received remuneration for participation and one for participants from PREP who received course credit for (see Appendix A). The consent forms included information about the study, participant anonymity and confidentiality, data security, and assurance that they could discontinue participation at any time without prejudice. Any questions the participants had were answered at this time. The order of tests and assessments was randomized across participants with the constraint that the Study Task and Breakfast Task were completed before the individual differences measures. The protocol for the study was approved by the Interdisciplinary Committee on Ethics in Human Research (ICEHR # 20141110-SC).

For the Study Task, participants were randomly assigned to one of three conditions (n = 40) using a random number table. Following the groups of Lin, Lin and Robertson (2010), participants read (and were tested on) text material in one of three conditions; (a) with background TV that they were told to also attend to or (b) with background TV playing that they were told should be ignored, or (c) one of the two control conditions in which they experienced either the text article or the video condition in a single-task condition. Participants in the experimental group (conditions a and b) were given questions on material from both the article and TV segment and had a maximum of ten minutes to answer the questions. The experimental sessions were also video-recorded (if consent was given) in order to measure how long each person spent attending to each medium. Participants in the control group (condition c) were only asked to attend to one of the media; half read the article without the presence of background TV and the other half watched the video without having to read the article. They were then given the 12 questions that corresponded with the type of medium they used and had the same amount of time to read or watch the video and complete the questions as in the other two conditions.

For the Study Task, participants were seated at table facing the wall with a separate table to their right on which a Toshiba computer with a 21-inch monitor was placed. The computer monitor served as the TV and was used to play the segment from *60 Minutes*. Participants were given a paper copy of the Toucan article and asked to sit forward while reading in order to clearly determine when they turned their head to watch the TV segment. A Panasonic VW-ACK-180 video camera was used to record this portion of the experiment.

The Breakfast Task was completed on the same computer as the Study Task and participants were simply asked switch tables to complete it. Prior to beginning the Breakfast Task participants were given a description of the task, instructions and a demonstration on how to start/stop “cooking” the food and on how to set the table, *etc.* The main objectives (having all the food ready at the same time and setting the table as much as possible) of the Breakfast Task were also explicitly stated. Following the instructions, participants were given the chance to complete a shortened practice version of the task, during which they could ask questions and seek further help if necessary. Once the practice trial was finished the experimenter started the test version and participants were asked to complete the task as best they could. No further direction was provided during the test trial.

The order of the presentation of the Study Task and the Breakfast Task was alternated across participants. Following completion of the Study Task and Breakfast Task, participants completed the OSPAN task and filled out the MPI, the measure of perceived multitasking ability and the General Information form. Before completing the OSPAN task they received a brief demonstration of how the task worked and then completed two practice trials before the task started to record performance. When filling out the MPI and General Information form participants were simply asked to answer the questions as they related to themselves and to provide whatever information they were able (and that was asked of them).

4.5 Video Data Coding and Reliability

To analyze the attention data from the Study Task each video had to be coded to determine where, and for how long, each participant looked while completing the Study Task. To do this the videos were played with in-house custom software (Earle, 2012). The program allowed the primary investigator to watch each video in real time and record where participants were looking by pressing certain designated keys on the computer. Once each video was coded, a text file was produced from the key-stroke data that showed how many times participants looked to each place and for how long. To use this information all the looking times and frequencies were summed with another piece of in-house custom software (Earle, 2010). To check for reliability, a second observer who was naïve to the purpose of the study viewed and coded 20% of the visual attention data. Overall, the inter-rater reliability was high: Cohen's kappa = .91.

Chapter 5: Results

5.1 Overview of the Analyses

Three questions were addressed in the research: First, how well do students recall text material that they studied under different levels of distraction from a competing video segment? This question was addressed in the Study Task in which students learned text material under different levels of distraction, *i.e.* to attend to the background video or to ignore it. Second, how do individual differences in working memory, GPA, polychronicity, and perception of multitasking effectiveness relate to performance on two tasks with different multitasking requirements: (a) the study and recall of text material, and (b) a simulated making breakfast task? To address this question, the individual difference measures were examined in relation to the Study Task and to the Breakfast Task. These factors were chosen as there is mixed evidence regarding their effect on multitasking ability and performance and we were interested in determining the nature of this relation and whether a combination of these factors might account for more variance in multitasking ability than each factor individually. Third, (a) is there a relation between effective multitasking on the two tasks, and (b) do successful multitaskers on each task share any of the individual difference characteristics? To address this question, students' performance on the two tasks was compared with each other and also with the individual difference measures. Data on these questions were analyzed using analyses of variance, t-tests, multiple regressions, and bivariate correlations as described below.

5.2 Study Task

The first research question addressed how well students were able to recall text material studied under different levels of video distraction. This was examined with two one-way ANOVAs with condition (multitasking, background TV or control group) as the independent variable and the number of correct answers from the article material or video material as the dependent variables. LSD post-hoc tests were run to examine main effects and interactions. Paired samples t-tests were also conducted to compare the number of correct answers from each medium for those in the multitasking and background TV groups. The same comparison was made for the control group with an independent sample t-test.

To determine how well participants performed on the Study Task, the number of correct answers from both the article (maximum = 12) and the video (maximum = 12) were tallied and compared among experimental conditions. The means and standard deviations are shown in Table 5.1.

Table 5.1
Mean Number of Questions Correct as a Function of Condition from the Study Task

	Multitasking	Background TV	Control
Article	6.90 (1.85)	7.65 (1.94)	8.04 (1.89)
Video	5.38 (1.58)	3.10 (1.45)	8.94 (2.08)

Note: Standard deviations are in parentheses

To examine the difference in performance between participants within each condition, two one-way ANOVAs were conducted. For the first analysis, condition was the independent variable and number of correct answers from the article was the dependent variable. The ANOVA indicated that the main effect of condition approached significance: $F(2, 102) = 3.03$, $p = .053$, $\eta_p{}^2 = .06$. Post-hoc comparisons between the means showed that the number of questions answered correctly from the article by those in the multitasking group was significantly fewer than those answered correctly by the control group (p = .023). Those in the background TV condition did not differ significantly from either the multitasking group (p = .080), or the control group (p = .430), in terms of the number of questions answered correctly from the article.

A second ANOVA was conducted with condition once again as the independent variable and number of correct answers from the video as the dependent variable. This analysis revealed a significant main effect of condition, $F(2, 96) = 78.43$, $p < .001$. Post-hoc tests between the means indicated that all three conditions differed significantly from one another ($p < .001$ for all comparisons). Those in the control group performed better than both the multitasking and the background TV groups, while the multitaskers also performed better than participants in the background TV condition.

In order to compare the correct article and video questions within each group directly, paired-sample t-tests were conducted for the multitasking and background TV conditions. These analyses indicated that participants in the multitasking condition had significantly fewer video questions correct compared to the article questions $t(39) = 4.393$, $p < .001$. This pattern was also found for those in the background TV condition $t(39) = 12.71$, $p < .001$. Finally, an independent samples t-test revealed that participants in the control group did not differ in terms of the number of questions they answered correctly from either medium: $t(38) = -1.42$, $p = .163$. This is important because it indicates that the questions from each source were equally difficult. These results are shown in Figure 5.1.

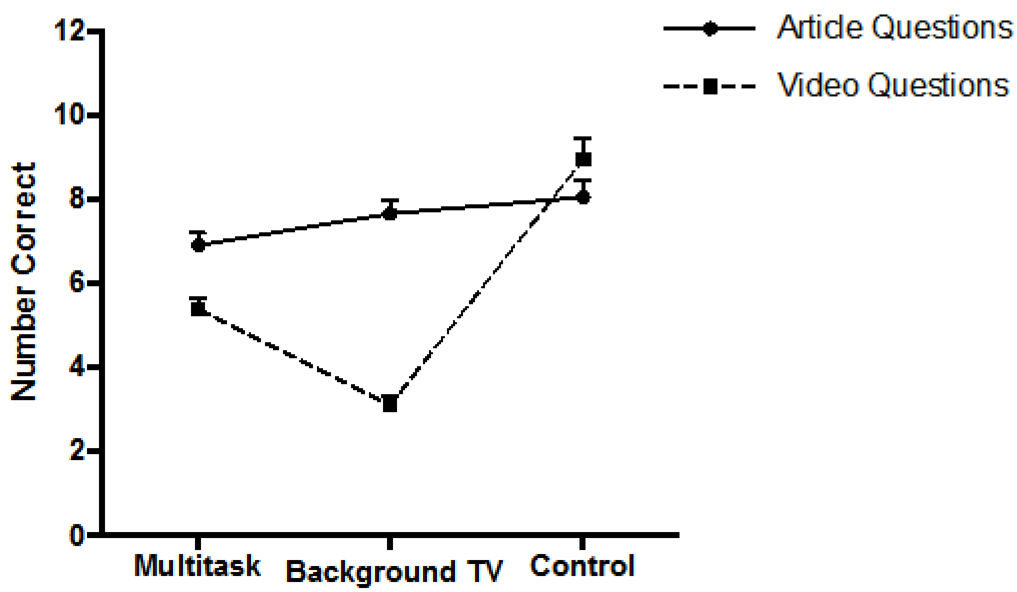

Figure 5.1. The number of questions correct and standard error from each medium by condition.

5.3 Deployment of attention during the study task.

Participants' correct recall measures were supplemented with a measure of how they deployed their visual attention during the study period: to the text material, to the video, or off task.

5.3.1 Video analysis. To analyze the videos each one was coded to determine where the participants were looking (duration and frequency) while completing the study task. To do this the videos were run through a program created by Mr. Avery Earle at Memorial University. The program allowed the primary investigator to watch each video and record where participants were looking by pressing certain keys on the computer. For our purposes the codes were as follows; 1 meant that participants were looking at the article, 2 meant they were looking at the video on the computer screen, and 3 meant they were looking elsewhere. Once each video was coded, a text file was produced that showed how many times participants looked to each place and for how long. To use this information all the looking times and frequencies had to be summed which was done using an add-up program that was also created by Mr. Earle. When the looking times and frequencies were finally compiled, the data were analyzed within and between conditions to determine and compare where participants focused most of their attention. Descriptive statistics for the duration and frequency of looking are shown in Table 5.2.

Table 5.2

Mean Looking Time (in seconds) and Frequency of Looks to Each Source, By Condition, During the Study Task

	Multitasking		Background TV	
	Looking Time	Frequency	Looking Time	Frequency
Article	639.0 (109.50)	15.92 (13.05)	767.20 (16.94)	3.64 (3.41)
Video	137.40 (109.60)	15.61 (13.22)	4.51 (8.52)	1.97 (3.15)
Elsewhere	1.87 (4.31)	.67 (1.15)	3.56 (7.46)	.72 (1.30)

Note. Standard deviations are in parentheses.

A set of two 2 (location: article, video) × 2 (condition: MT, BTV) repeated measures ANOVAs were conducted to examine look duration and look frequency. Where the participant looked was within subjects and condition was between subjects. As 61.45% of participants did not look off task at all during the study (*i.e.* somewhere other than the article or video), those data were not included in the analysis.

The first analysis revealed a significant main effect of location on look duration, $F(1, 67) = 1089.91$, $p < .001$, $n^2 = .94$; participants spent significantly more time looking at the article than they did looking at the video material, regardless of condition (see Table

5.2). There was no effect of condition, $F(1, 67) = 2.58$, $p = .113$, $n^2 = .04$. However, the interaction between where the participant looked and condition was also significant, $F(1, 67) = 46.48$, $p < .001$, $n^2 = .41$. Follow up paired samples t-tests on the two treatment groups revealed that participants in the multitasking group spent significantly more time looking at the article compared to the video, $t(35) = 13.75$, $p < .001$. The same was true for those in the background TV group, $t(32) = 201.40$, $p < .001$ but the effect was much more pronounced as they spent very little time looking at the video at all. This interaction is shown in Figure 5.2.

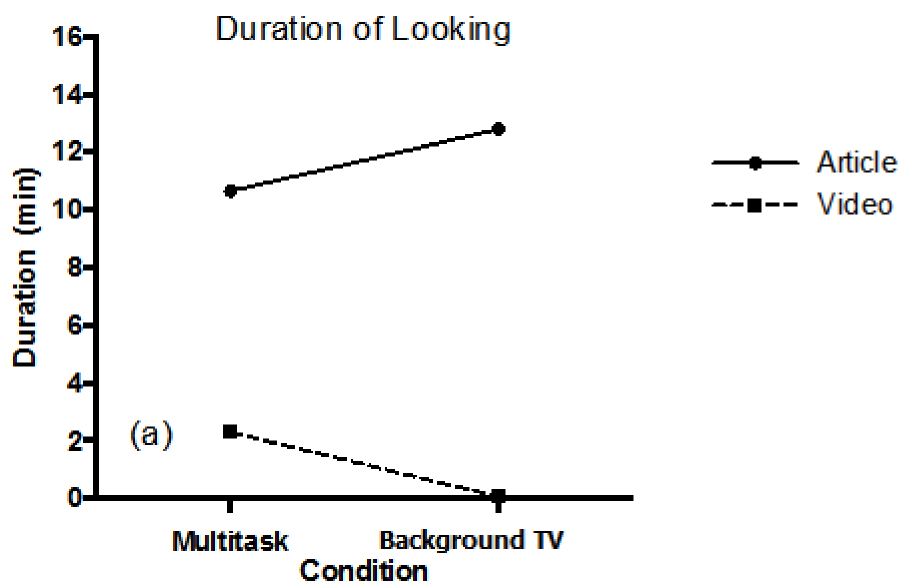

Figure 5.2. Duration looking time at the article and video material by participants in the multitasking and background TV groups.

A second repeated measures ANOVA was conducted to examine how frequently participants in each condition looked at the article or video. The analysis revealed a significant main effect of where the participants looked: $F(1, 67) = 30.46$, $p < .001$, $n^2 = .31$ and of condition: $F(1, 67) = 21.17$, $p < .001$, $n^2 = .24$. Overall, participants directed more looks at the article than at the video and those in the multitasking group more frequently switched looks between the media than participants in the background TV group. These main effects were qualified by a significant Location × Condition interaction: $F(1, 67) = 44.44$, $p < .001$, $n^2 = .40$. Follow up analysis of the interaction revealed that participants in the multitasking group looked between the article and the video equally often, $t(35) = 1.51$, $p = .140$, while those in the background TV group more frequently looked at the article, $t(32) = 7.71$, $p < .001$, but made far fewer looks relative to the multitasking group. This interaction is shown in Figure 5.3.

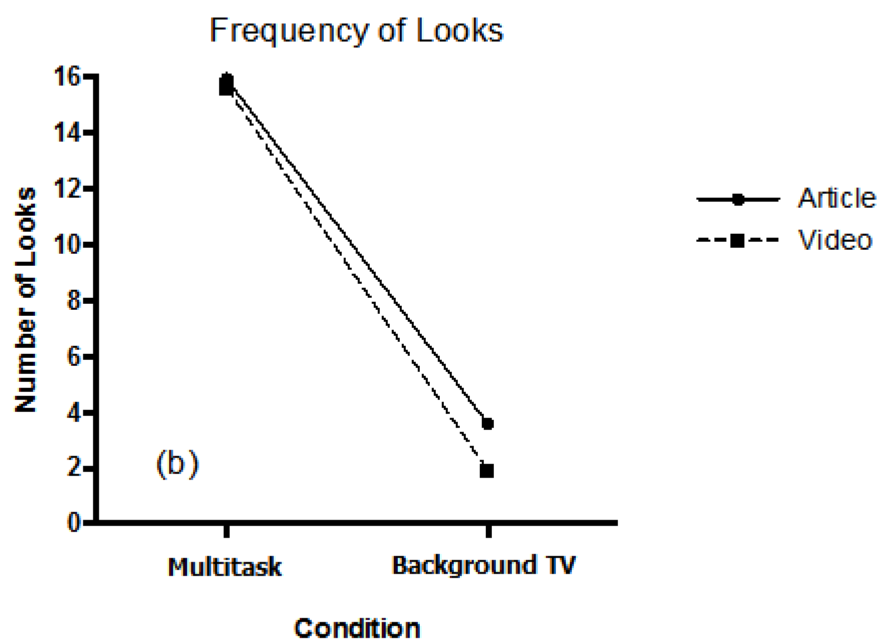

Figure 5.3. Frequency of looks to the article and video material by participants in the multitasking and background TV conditions.

In summary, the analyses of the Study Task data indicated that students in the multitasking condition answered fewer questions correctly from both sources than those in the control group. However, students in the background TV condition answered fewer questions correctly from the video than multitasking or control groups overall. Within groups comparisons indicated that both treatment groups answered significantly more questions correctly from the article than from the video. This finding was consistent with the fact that participants in both treatment groups spent more time looking at the information in the article than to the video. Finally, those who multitasked looked between both media equally often while those in the background TV group looked significantly more frequently at the article.

5.4 Individual Differences and the Study Task

The second research question (2a) addressed the relationship between specified individual difference factors (working memory, GPA, polychronicity, and perception of multitasking effectiveness) and the participants' ability to study and recall text material. To answer this question four multiple regressions were conducted to investigate whether each of the individual difference factors jointly predicted the number of article and video questions answered correctly by students in the multitasking and background TV groups.

Descriptive statistics for the individual difference factors are shown in Table 5.3. The first individual difference factor examined was perceived multitasking ability. To measure this variable, participants rated themselves on a scale of one (lowest) to five (highest) based on how well they thought they were able to multitask. As Table 5.3 shows, participants rated themselves to be almost exactly in the middle of the scale, indicating that the majority of participants considered themselves to be on par with their peers in terms of multitasking ability. The second individual difference factor measured was multitasking preference. This was measured using a standardized scale in which the highest a person could score was 70, indicating they always preferred to multitask rather than completing tasks in sequence. As shown in Table 5.3, participants from the current sample scored just above the midpoint of this scale (35) indicating a balance between preferring to multitask and single task. Finally, the operation span task (OSPAN) was used as a measure of participants' working memory. In this version of the task the highest participants could score was 60, indicating that they remembered the words from every trial in the correct serial order. College student norms for the OSPAN task indicate the mean score to be approximately 42.04 (Redick *et al.* 2012), slightly higher performance than demonstrated by students in the current sample that was 34.98 overall (see Table 5.3).

GPA was also measured. Participants were asked to self-report their most recent GPA when they completed the General Information Questionnaire. This was included to see whether students who performed well on the multitasking activities were those with the highest academic performance. Descriptive statistics for all measures are shown in Table 5.3.

Table 5.3

Means and Standard Deviations for the Individual Difference Measures for Participants in the Multitasking, Background TV, and Control Conditions (*n* = 40)

	Operation Span	Grade Point Average	Multitasking Preference Inventory	Perceived Multitasking Ability
Multitasking	35.45(11.44)	3.21(.47)	37.40(9.53)	2.83(.71)
Background	33.75(10.33)	3.29(.47)	37.95(9.94)	2.88(.91)
Control	35.75(9.66)	3.31(.58)	39.75(9.88)	3.08(.73)

Note: The range of scores for the Operation Span measure is 0-60; for the Multitasking Preference Inventory is 14-70; for Perceived Multitasking Ability is 1-5.

Four standard multiple regressions were conducted to assess the contribution of working memory (OSPAN), grade point average (GPA), polychronicity (MPI), and perceived multitasking ability (PMA) in predicting the number of correct article and video questions by students in the multitasking and background TV treatment groups. The assumptions of multiple regression including linearity, normality and multicollinearity were checked and found to be acceptable. No outliers were identified. Table 5.4 shows the results of these four regression analyses. However, the predictor variables only had a significant effect on the number of correct video questions answered by those in the multitasking group: $F(4, 39) = 4.12$, $p = .004$. Together, the individual difference measures accounted for 24% of the variability in correct answers to video questions by the Multitasking group (adjusted $R^2 = .240$). Of those predictors, only OSPAN made a significant contribution to the model. Students with higher OSPAN scores (*i.e.* better working memory) answered more questions correctly from the video.

Although the remaining predictors (GPA, MPI, PMA) did not contribute to the model, an examination of the bivariate correlations among them indicated that the number of questions correct from the video significantly correlated with polychronicity (MPI): $r = .33$, $p = .020$ and with perceived multitasking ability (PMA): $r = .31$, $p = .026$ (see Tables 5.5 and 5.6). This means that students with higher preference for multitasking answered more questions correctly from the video material, as did those with a higher perception of themselves as successful multitaskers.

Table 5.4

Standard Multiple Regression Analyses of the Number of Questions from the Article and the Video Answered Correctly in the Multitasking and Background TV Groups.

Group	Measure	B	SE	β	*t*
Multitasking: Article					
	OSPAN	.02	.03	.11	.49
	GPA	.25	.78	.06	.32
	MPI	.01	.04	.07	.35
	PMA	-.41	.55	-.16	-.75
	R^2 = .03, Adj R^2 = -.08; F(4, 39) = .29, p = .885				
Multitasking: Video					
	OSPAN	.08	.03	.55	3.08**
	GPA	-.56	.56	-.17	-1.01
	MPI	.02	.03	.10	.57
	PMA	.15	.39	.07	.37
	R^2 = .32, Adj R^2 = .24; F(4, 39) = 4.12, p = .008				
Background: Article					
	OSPAN	-.002	.003	-.01	-.05
	GPA	.54	.81	.13	.67
	MPI	.004	.04	.02	.11
	PMA	-.07	.46	-.04	-.16
	R^2 = .02, Adj R^2 = -.11; F(4, 37) = .12, p = .974				
Background: Video					
	OSPAN	-.07	.02	-.05	-.27
	GPA	.27	.58	.09	.46
	MPI	.04	.03	.28	1.56
	PMA	.07	.33	.05	.22
	R^2 = .104 Adj R^2 = -.004; F(4, 37) = .961, p = .422				

Notes. **$p < .01$; *$p < .05$. OSPAN = Operation Span; GPA = grade point average, MPI = Multitasking Preference Inventory, PMTA = Perceived Multitasking Ability

Table 5.5

Bivariate Correlations for the Number of Correct Questions from the Article and the Video and the Individual Difference Measures for the Multitasking Group (n=40)

	Article	Video	OSPAN	GPA	MPI	PMA
Article	--	.19	.11	.11	.03	-.07
Video	--	--	.53**	.14	.33*	.31*
OSPAN	--	--	--	.51**	.39	.36**
GPA	--	--	--	--	.14	.07
MPI	--	--	--	--	--	.59**

**$p < .01$; *$p < .05$. OSPAN = Operation Span; GPA = Grade Point Average; MPI = multitasking preference inventory; PMA = perceived multitasking ability

Table 5.6

Bivariate Correlations for the Number of Correct Questions from the Article and the Video and the Individual Difference Measures for the Background TV Group (n=40)

	Article	Video	OSPAN	GPA	MPI	PMA
Article	--	.13	.02	.12	.01	.03
Video	--	--	-.02	.11	.30	.19
OSPAN	--	--	--	.13	.01	.18
GPA	--	--	--	--	.02	.46**
MPI	--	--	--	--	--	.38*

**$p < .01$; *$p < .05$. OSPAN = Operation Span; GPA = Grade Point Average; MPI = multitasking preference inventory; PMA = perceived multitasking ability

In summary, analyses of the relationship between the individual difference factors and performance on the Study Task revealed that participants with higher OSPAN scores (*i.e.* better working memory) answered more videos questions correctly. Students with higher MPI scores (*i.e.* higher preference for multitasking) and those who considered themselves to be good at multitasking were also able to correctly answer more questions from the video.

5.5 Breakfast Task

To address the second part of the second research question 2(b), whether the individual difference factors predicted performance on the Breakfast Task, five standard multiple regressions were conducted. Bivariate correlations were also calculated to examine the relation between the individual difference factors and Breakfast Task measures.

The Breakfast Task program recorded five different measures of performance. The first measure was *range of stop times (range),* which is the difference (in seconds) between stopping the first and last foods. The second measure was *discrepancy*, which is how long participants let each food cook minus how long each food should have been allowed to cook. As there were five different foods, five different discrepancy scores were recorded for each participant. The third measure was *deviation of start times*, which is a measure of the deviation between when participants actually started a food versus when they should have started it in order for all foods to be finished cooking at the same time. This was an average measure, so there was only one score per participant. The fourth measure of interest recorded by the Breakfast Task was *number of clicks.* This was a measure of how many times each participant clicked on each food to monitor its cooking time. Participants had to switch back and forth between various screens in order to see how much time was left for each food, thus having a large *number of clicks* indicates that the person had to check the cooking times frequently. Finally, the last measure of importance from the Breakfast Task was the *table setting* data. This was a distractor task and a measure of how many table setting participants completed while waiting for the foods to cook. Descriptive statistics for these measures are shown in Table 5.7. Performance by the current sample of university students was comparable to the college student norms revealed by Craik and Bialystok (2006).

Table 5.7
Descriptive Statistics for Measures from the Breakfast Task from the Current Sample and Craik & Bialystok (2006)

	Mean	Means from Craik & Bialystok (2006)
Range	21.94 (19.11)	19.50
Discrepancy	11.51 (10.65)	15.00
Deviation of Start Times	10.39 (10.41)	11.00
Average Number of Clicks	5.14 (1.26)	17.00
Table Settings	45.03 (7.59)	48 (8.40)

Note: Standard deviations are in parentheses.

All of the data from the Breakfast Task, except *number of clicks* and *table settings,* were skewed so log10 transformations were done on each variable and the transformed data were used in the regressions.

Five standard multiple regressions were conducted to assess the contribution of working memory (OSPAN), GPA, polychronicity (MPI) and perceived multitasking ability (PMA) in predicting variation in the Breakfast Task measures — range, discrepancy, deviation of start times, average number of clicks and table settings — for all participants (N = 120). The assumptions of multiple regression including linearity, normality, and multicollinearity were checked and found to be acceptable. No outliers were identified.

Table 5.8 shows the results of the regression analyses. Only the effect of the predictor variables on the *average deviation of start times* measure yielded a significant model: $F(4, 117) = 3.22$, $p = .015$. Together, the individual difference measures accounted for 7.1% of the variability in deviation of start times during the Breakfast Task (adjusted $R^2 = .071$). Among the predictors, only OSPAN contributed uniquely to the model: $t(117) = -2.75$, $p = .001$. Students with higher OSPAN scores completed the Breakfast Task with lower deviations between the actual and ideal start times of the five foods. Lower deviation of start time scores indicates better performance.

Although the remaining predictors (GPA, MPI, PMA) did not contribute to the model, an examination of the bivariate correlations among them indicated that *deviation of start times* was significantly correlated with polychronicity (MPI): $r = -.184$, $p = .044$ (see Table 5.9). This means that students with a higher preference for multitasking had smaller deviations between the start times of the five foods.

Table 5.8

Standard Multiple Regression Analyses of the Individual Difference Factors Effect on Measures from the Breakfast Task.

BT Measure	ID Measure	B	SE	*β*	*t*
Range					
	OSPAN	-.01	.002	-.23	-2.33*
	GPA	-.03	.05	-.06	-.57
	MPI	-.001	.003	-.03	-.34
	PMA	.01	.03	.02	.23
	R^2 = .06, Adj R^2 = .03; F(4, 117) = 1.88, p = .119				
Discrepancy					
	OSPAN	-.003	.003	-.12	-1.19
	GPA	.05	.06	.08	.87
	MPI	-.002	.003	-.05	-.50
	PMA	-.05	.04	-.13	-1.33
	R^2 = .05, Adj R^2 = .01; F(4, 117) = 1.41, p = .234				
Deviation of Start Times					
	OSPAN	-.01	.004	-.26	-2.75**
	GPA	-.02	.07	-.03	-.27
	MPI	-.01	.004	-.12	-1.25
	PMA	.003	.05	.006	.06
	R^2 = .10, Adj R^2 = .07; F(4, 117) = 3.22, p = .015*				
Average Clicks					
	OSPAN	-.01	.01	-.08	-.77
	GPA	-.32	.24	-.13	-1.31
	MPI	-.014	.01	-.10	-1.04
	PMA	.08	.16	-.05	-.48
	R^2 = .05, Adj R^2 = -.02; F(4, 117) = 1.49, p = .210				
Table Settings					
	OSPAN	.004	.07	.005	.05
	GPA	1.76	1.46	.12	1.21
	MPI	.05	.08	.07	.65
	PMA	1.09	.98	.11	1.11
	R^2 = .04, Adj R^2 = .01; F(4, 117) = 1.22, p = .305				

Notes. $^{*}p < .05$, $^{**}p < .01$. OSPAN = Operation Span; GPA = grade point average, MPI = Multitasking Preference Inventory, PMTA = Perceived Multitasking Ability

Table 5.9

Bivariate Correlations for the Measures from the Breakfast Task and the Individual Difference Factors

	OSPAN	GPA	MPI	PMA	Range	Discrepancy	Deviation of Start Times	Clicks	Table Setting
OSPAN	--	.22*	.23**	.25**	-.24**	-.12	-.29**	-.15	.078
GPA	--	--	-.03	.20*	-.10	.03	-.08	-.15	.14
MPI	--	--	--	.34**	-.08	-.14	-.18*	-.13	.10
PMA	--	--	--	--	-.06	-.15	-.10	-.13	.16
Range	--	--	--	--	--	-.16	.65**	.16	-.29**
Discrepancy	--	--	--	--	--	--	-.09	-.23*	.21*
Deviation of Start Times	--	--	--	--	--	--	--	.06	-.36**
Clicks	--	--	--	--	--	--	--	--	-.23*

$**p < .01$; $*p < .05$. OSPAN = Operation Span; GPA = Grade Point Average; MPI = multitasking preference inventory; PMA = perceived multitasking ability

In summary, analyses of the relation between the individual difference factors and performance on the Breakfast Task revealed that OSPAN scores predicted performance in terms of the *average deviation of start times* measure from the task. Average deviation of start times reflects planning, prospective memory, and working memory. Students with larger working memory capacities had lower deviations between when each food should have started cooking and when participants actually started it. A similar relationship was found with polychronicity, such that students who had a higher preference for multitasking also had lower deviations between ideal and actual start times.

5.6 Comparison of the Study Task and Breakfast Task

The final research question was a comparison between multitasking successes on the two tasks. There were two parts to this question; (a) was there a relation between effective multitasking on the two tasks, and (b) do successful multitaskers on the tasks share any of the individual difference characteristics? To answer these questions a series of bivariate correlations were calculated to determine if, and how, number of questions correct (article and video) from the Study Task related to the outcome measures from the Breakfast Task for those in the multitasking group ($N = 40$). We only included the multitasking group as the background TV and control groups did not actually multitask. Bivariate correlations were also conducted between the individual difference factors and outcome measures from both tasks to determine if any of these factors influenced performance across tasks.

For part (a) the analyses revealed only that the number of questions answered correctly from the article was significantly correlated with *discrepancy*: $r = -.39$, $p = .014$, such that those who answered more article questions correctly had lower *discrepancy* scores (see Table 5.10). The number of video questions correct was not correlated with any of the Breakfast Task measures.

Table 5.10

Bivariate Correlations between Performance on the Study Task and Breakfast Task for the Multitasking Group (*n*=40)

	Questions Correct Article	Questions Correct Video	Dev. Start Times	Range	Discrepancy	Clicks	Table Settings
Questions Correct - Article	--	.19	-.02	-.22	.39*	-.23	.25
Questions Correct – Video	--	--	.03	-.07	-.18	-.30	.04
Dev. Start Times	--	--	--	.69**	-.05	-.07	-.31
Range	--	--	--	--	-.43**	.14	-.30
Discrepancy	--	--	--	--	--	.000	.23
Clicks	--	--	--	--	--	--	-.19

**p < .01; *p < .05.

For part (b) of the question the relationship between the individual difference factors and performance on both tasks was examined. Analysis of the individual difference factors revealed that OSPAN scores were significantly correlated with both *deviation of start times* and number of questions correct from the video: r = -.34, p = .002 and r = .27, p = .016, respectively. Participants in the multitasking group who had large working memory capacities started cooking the Breakfast Task foods closer to their ideal start times (had smaller deviations between cooking times) and answered more questions correctly from the video material (see Table 5.11).

Table 5.11

Bivariate Correlations between Number of Video Questions, Average Deviation of Start Times and Individual Difference Factors for the Multitasking Group (*n*=40)

	Questions Correct – Video	Dev. Start Times	OSPAN	GPA	MPI	PMA
Questions Correct – Video	--	-.15	.27*	.04	.23*	.17
Dev. Start Times	--	--	-.34**	-.18	-.10	-.11
OSPAN	--	--	--	.33**	.20	.26*
GPA	--	--	--	--	.08	.29*
MPI	--	--	--	--	--	.47*

**p < .01; *p < .05. OSPAN = Operation Span; GPA = Grade Point Average; MPI = multitasking preference inventory; PMA = perceived multitasking ability

In summary, comparison across the two experimental tasks revealed that students who answered more questions correctly from the article also had lower *discrepancy* scores when completing the Breakfast Task. The analyses also showed that OSPAN scores were related to both *deviation of start times* and the number of correct video questions, such that students with larger working memory capacities had smaller deviations between start times and answered more questions correctly from the video material.

Chapter 6: Discussion

The current research investigated individuals' multitasking success during two different types of situations — a study task and a cooking breakfast task — and the relationship of specified individual difference factors (working memory, polychronicity and perception of multitasking ability) with multitasking performance during the tasks. The individual difference factors were selected as they had been examined separately in past multitasking literatures and yielded inconsistent results. The research questions examined in the present study were intended to clarify the relation between these variables and multitasking success and to see if combining these factors accounted for more variance in multitasking performance than when examining each factor individually.

6.1 Study Task

The first research question addressed was how well students could recall text material that was studied under different levels of distraction from a competing video segment. In one condition they were told to attend to the video as best they could during reading (multitasking condition) and in a second condition they were told they could ignore the video (background TV condition). A number of important findings arose from the analyses of performance on the Study Task. First, students in the multitasking group performed more poorly than those in the control group on recall of both text and video information (see Table 5.1). Participants who multitasked were not able to recall as much material from either source as those who did not have divided attention, indicating that attending to both sources of information had a negative effect on performance. Furthermore, video analysis showed that the multitaskers spent most of their time attending to the article (see Table 5.2) but looked back and forth between the two media equally often. This implies that they prioritized information from the article over that from the video but were distracted by the video (which they may have considered a secondary source) and attempted to attend to both sources which resulted in performance decrements.

These findings lend further support to research that has shown that attending to two competing sources of information can lead to decrements in retention and subsequent task performance when working under a time constraint. The fact that participants had only 13 minutes to complete the Study Task pressured them to attend to both sources of information in order to learn as much as possible from each one. In the end, this competition resulted in poorer performance by the multitaskers during the task. Previous research has demonstrated that when there are no time constraints multitaskers are able to perform as well as single-taskers but required more time to reach the same level of performance (Bowman *et al.*, 2010). In the present study, students had a limited amount of time to learn information from both sources and therefore could not improve their performance simply by taking longer.

Secondly, the participants in the background TV condition were able to follow instructions extremely well and to successfully block out competing information from the video. Students in this group answered the fewest questions from the video correctly. Furthermore, they spent almost the whole 13 minutes allotted for the Study Task looking at or reading the article, suggesting they were primarily focused on this information (as instructed) and were able to block out the interfering video media. This may have important implications for university students and their study habits. Many students choose to study with TV or music on in the background, or live in dormitories where there are constantly other students around and numerous distractions present. The present results indicate that when students try to attend to information from a number of competing sources their learning can suffer, potentially meaning poor academic outcomes. However, some students appear to have the ability to block out distractor information when necessary and to perform as well as those who study under conditions of minimal to no distraction. Finally, it is important to note that participants in the control condition answered approximately the same number of questions correctly from the article as they did from the video (see Table 5.1). This demonstrates that there was no fundamental difference in difficulty between the sets of questions asked from each source.

Overall, our findings provide further support for previous research indicating negative outcomes related to multitasking (e.g., Ophir *et al.*, 2009; Wood *et al.*, 2012). In the current study, multitasking led to decrements in performance and response costs when trying to learn and recall material from two competing sources of information. However, we also uncovered a noteworthy finding that appears to demonstrate the ability of university students to tune out distractor information and successfully complete their focal task. As discussed below, this was especially likely in students with high working memory capacity.

The next research question that was whether or not there was a relationship, either conjointly or singly, between the individual difference factors of interest and performance during (a) the Study Task and (b) the Breakfast Task.

6.2 Perceived Multitasking Ability

Perceived multitasking ability is an individual's perception of their multitasking ability compared to their peers. Generally, when rating one's own abilities, people demonstrate a bias wherein they rate themselves to be above average ability when they actually are not. This has been termed the "better-than-average" effect and has been found across a wide variety of variables (Zell & Alicke, 2011). Participants in the current study did not demonstrate this bias when rating their own ability to multitask. The average rating from our sample was 2.93 (on a scale from 1–5) which indicated that participants considered their multitasking ability to be on par with their peers (see Table 5.3). The potential for these students to accurately judge their multitasking ability may have developed through their experience as a student. Years of feedback on reports and graded assignments allows students to make accurate assessments of how multitasking affects their work/performance.

6.3 Polychronicity

The second individual difference measure was polychronicity, also known as preference for multitasking. Polychronicity has been found to have a relationship with job performance in various occupations leading researchers to consider that there may be a job-person fit, such that individuals who prefer to complete tasks simultaneously perform better in situations that require multitasking than those who do not (Sanderson *et al.*, 2013). On average, participants in the current study indicated a slight preference for multitasking over single tasking (as seen in Table 5.3). As students, participants from the current sample may be aware that multitasking can have negative effects on the performance of a number of different tasks and thus, is not always the ideal option for completing schoolwork successfully. However, they are also aware of the pressures and time constraints presented by university programs and that multitasking is often the only work option if deadlines are to be met. As a result, students become flexible in their methods of completing work and they single task when necessary and multitask when necessary. As a result, they had no overwhelming preference for either method as both work in certain situations.

6.4 Working Memory

The final individual difference factor of interest was working memory capacity. Working memory plays a crucial role in one's ability to multitask as it determines the number of resources that can be held active in the mind at one time. It also plays a role in a number of important aspects of functioning including following directions (Foster *et al.*, 2015), planning, strategy use, greater ability to multitask but less frequent multitasking behavior (Sanbonmatsu *et al.*, 2013). The current sample demonstrated below average working memory capacity compared to the general population. This was rather unexpected given that our sample consisted of university students — a population where attending to multiple streams of media is common and who rely on multitasking as a method for meeting deadlines. Overall, working memory capacity proved to be an important factor in relation to multitasking ability and performance on the outcomes measures of both experimental tasks. These findings are discussed below.

When the individual difference factors were considered jointly in the regression analyses, only working memory capacity (*i.e.* OSPAN scores) was related to performance during the Study Task. The combination of all 3 factors added no predictive power above that accounted for by working memory. Students with larger working memory capacities recalled more information correctly from the video. This lends support to previous research linking working memory and multitasking ability (Sanbonmatsu *et al.*, 2013) and confirms the important role of working memory capacity in successful performance during multitasking contexts. When two or more tasks require the same cognitive resources, as in the Study Task, competition for these resources occurred which lead to an interference in the ability to complete both tasks. Previous research showed that if a particular resource can only be used by one task at a time, secondary tasks are put on hold until the resource becomes available again (Borst *et al.*, 2010). To be successful during the Study Task, participants had to attend to two conflicting sources of information, both of which required the use of language faculties. As a result, information from both sources could not be successfully processed simultaneously, leading to poorer performance on questions from one source. However, individuals with larger working memory capacities have the capability to hold more task-related information/resources active at one time and are able to process two competing sources of information more effectively. The results of the present study are consistent with this as those with larger working memory capacities were able to answer more questions correctly from the video than those with smaller working memory capacities. Video analysis provided further support as participants spent significantly more time attending to information from the article while the video appeared to serve as a secondary source of information, or a secondary task. This was true even for those in the multitasking condition who were told to treat both sources of information as equally important. Thus, students with larger working memory capacities were able to complete the "primary" task as well as focus on the "distractor" task most effectively.

Although they did not contribute to the regression model, there were also significant bivariate correlations between Study Task performance and the remaining individual difference factors. First, students who had a higher preference for multitasking answered more questions correctly from the video. Previous research on polychronicity suggested that there was a job-person fit, such that individuals who preferred multitasking performed better on jobs where multitasking was necessary than did those who do not (Sanderson *et al.*, 2013). In the current study, students who indicated the highest preference for multitasking were able to answer the most questions correctly from the video (that appeared to be considered a secondary task), indicating that when levels of polychronicity are congruent with task demands performance is superior. In this situation, multitasking was necessary in order to attend to both sources of information and to successfully answer questions from each. The fact that students who like to multitask outperformed their counterparts lends support to the job-person fit theory (which has had mixed findings in past research) and also extends it from the work world to an academic setting. If further support is found for this relationship, polychronicity may be an important trait to consider in determining how well students will fit within particular academic programs or job placements.

A bivariate correlation was also found between perceived multitasking ability and correct video questions, such that students who considered themselves to be better multitaskers also answered more video questions correctly. As previously discussed, the current sample of students demonstrated the ability to judge how well they would be able to perform when answering video questions and rated themselves accordingly compared to peers (Table 5.3). They did not display the widely demonstrated better-than-average effect. Thus, those who considered themselves to be better at multitasking appear to have made an accurate judgment (in terms of their performance when answering video questions during the Study Task) as they performed better than those who rated themselves to be of lower ability. However, this relationship was not found between participants' self-ratings and performance on article questions or on the Breakfast Task. This finding is important as it indicates that students can sometimes judge their abilities in certain contexts (e.g., attending to TV while reading) and accurately report them. Therefore, asking for such ratings from students may provide valuable information in terms of how they will perform on certain tasks.

Overall, the answer to part (a) of the second research question revealed a number of important findings. Working memory capacity was found to play a significant role in successful performance when answering questions from the video during the Study Task. Polychronicity and perceived multitasking ability also played a role such that higher scores/ratings on each of these factors predicted students' ability to answer more questions correctly (at least on the video) than those who had lower scores.

6.5 Breakfast Task

The next research question was whether or not there was a relationship between the individual difference factors of interest and performance on the Breakfast Task.

There were five outcome measures from this task — *range, discrepancy, deviation of start times, number of clicks* and *table setting* data. Performance by our sample of university students was comparable to the college norms found by Craik and Bialystok (2006) on all measures except *number of clicks* (see Table 5.7). The current sample of students clicked between the food screens an average of 5 times throughout the task, whereas those from Craik and Bialystok's sample checked an average of 17 times. Our participants needed to switch between the various food screens far less often to monitor the cooking times.

The results showed that students with larger working memory capacities performed better with regard to the *average deviation of start times* measure. The combination of individual difference factors did not further predict performance beyond that predicted by OSPAN scores. The *average deviation of start times* was the most challenging of the five measures, as completion required working memory, task switching, planning, monitoring and execution — all abilities that underlie multitasking (Craik & Bialystok, 2006). Participants had to monitor the cooking time of each food (by switching between them) in order to determine the subsequent starting times for the foods that followed. We found that students with larger working memory capacities had lower deviations between actual and ideal starts times, indicating better performance. They were better able to accurately monitor all five foods and start/stop them at the correct times.

This finding supports previous research indicating that individuals with larger working memory capacities are better able to follow directions (Foster *et al.*, 2015), to inhibit distracting information, to keep task requirements active in the mind and to multitask. As evident from our results, students with larger working memory capacities were able to handle the task demands more successfully than those with smaller working memory capacities. They were able to keep the main task goal (having all five foods ready at the same time) in mind and to prioritize this goal without becoming distracted by the secondary table setting task. This finding is important as it provides further support for the strong role of working memory capacity in multitasking performance and extends the relation to an everyday example of multitasking. The Breakfast Task simulated an activity that is common practice to many people. Our results showed that having a larger working memory capacity is beneficial even during conventional activities.

Among the remaining individual difference factors, we found that that students who preferred to multitask had lower *deviation of start times* scores, indicating better performance during the Breakfast Task. Similar to Study Task findings discussed above, this is also supportive of literature that has demonstrated the existence of a job-person fit between multitasking ability and performance. To be successful on the Breakfast Task, particularly with regard to the most challenging *deviation of start times measure*, multitasking was needed in order to monitor each food and keep track of when the next food should be started. Those who preferred to multitask performed better on this measure than those who did not as their preferred task completion style was not consistent with the task. This provides further support for the job-person fit theory of multitasking (Sanderson *et al.*, 2013) and extends it to routine forms of multitasking, such as that required by the Breakfast Task.

Overall, analyses of the Breakfast Task revealed further support for the role of working memory capacity in successful multitasking. Students with larger working memory capacities performed the best during this task, indicating that working memory plays a role in many forms of multitasking, including routine activities. The analyses also supported the job-person fit explanation of polychronicity and extended this relationship from the work world to more general multitasking situations.

6.6 Comparison between the Study Task and the Breakfast Task

Our final research question was to do a comparison between the Study and Breakfast Task performance to see whether (a) there was a relation between effective multitasking on the two tasks, and (b) successful multitaskers on both tasks shared any of the individual difference characteristics. To answer this question, performance by students in the multitasking group from the Study Task was compared to their performance on the Breakfast Task as those participants were the only ones to multitask throughout the whole experiment. The basic question of interest was whether successful multitasking might be a general individual characteristic or whether it was task specific.

A series of bivariate correlations between the Study Task measures (video, article) and the five Breakfast task measures revealed only that the number of questions students answered correctly from the article was related to *discrepancy* scores from the Breakfast Task. Students who answered more questions correctly were able to cook each food more precisely — they let each food cook the proper amount and over/under cooked the foods less often — than students who answered fewer questions from the article. What this relationship means is unclear and should be clarified in future work. Apart from that finding, there appeared to be no relationship between performance on the two types of multitasking. This suggested that multitasking may be task specific rather than a general characteristic.

The second part of the research question, revealed that students with larger working memory capacity performed better on both tasks; they answered more questions correctly from the video and had smaller deviations between the actual and ideal start times for each food from the Breakfast Task. This finding reaffirmed the importance of working memory for successful multitasking in a number of different contexts. To perform well on the Study Task participants needed to attend to two competing sources of information (both of which required the use of language) and to try to learn as much material from both sources as possible by alternating their attention between them. Working memory capacity is crucial in this situation as it enabled individuals to keep necessary task resources active in their mind allowing them to process the incoming information from each source more effectively. For success on the Breakfast Task, performance required working memory, task switching, planning, monitoring and execution. Participants needed to keep track of various cooking times and the progress of each food while also completing a distractor task of setting the table. Working memory was needed to keep the progress of each food active in students' minds and to aid in remembering to make the appropriate food checks to ensure task success. Both tasks relied upon working memory to provide the necessary resources for attending to multiple streams of information and to keep multiple task requirements active in the mind.

However, given that performance on both tasks relied heavily on the same executive function (working memory), it was surprising to find that there was no direct relationship between performance on the Study Task and Breakfast Task. In other words, those who performed well on one task did not necessarily perform well on the other task. The students did not appear to have a general ability to multitask. A possible explanation for this finding is that each task required different component skills that relied on working memory in different ways. For example, both tasks required use of the "problem state" resource of working memory that kept track of task-related information. However, the Study Task required students to keep track of two sources of information while the Breakfast Task required the monitoring of five sources, as well as the distractor task. From this perspective, some students may have found it easier to keep track of the two sources of information and thus performed well on the Study Task while struggling during the Breakfast Task, or vice versa. Furthermore, the Breakfast Task required significantly more planning than the Study Task as well as requiring the use of a more complex monitoring strategy. As a result, some students may have been more effective at multitasking when the cognitive requirements were less demanding or perhaps more challenging. It could also be the case that as the Breakfast Task was a novel, and therefore non-automatic, task with little prior practice it required close attention to be completed successfully, whereas the Study Task may have mimicked a more common scenario amongst students (e.g. blocking out background noise from a TV) and thus, was completed more automatically, requiring less attention and fewer resources (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977).

The results from the final research questions demonstrate that, while working memory capacity is important, not all task components involve working memory capacity in the same way. A large working memory capacity does not ensure that success during one multitasking activity will mean success on a different multitasking activity. For example, working memory is strongly related to academic success and also to an aptitude for air traffic control, but it is not necessarily the case that those who do well academically will also be good at air traffic control. This information is important for students to be aware of in order assess their ability to handle the demands of certain situations and to understand that other factors besides working memory can contribute to multitasking.

6.7 Limitations

There were a number of limitations to the current study. First of all, the gender distribution of our sample was exceptionally uneven; only 20 males participated compared to 100 females. As the majority of participants were recruited from the discipline of psychology (largely dominated by females) and were volunteers it was anticipated that there would be more female participants than males. However, we have no reason to believe that the gender imbalance limits the generalizability of the findings from this study. Past research indicates many studies in which researchers have found no differences between males and females in terms of their multitasking ability and performance (e.g., Buser & Peter, 2012; Hambrick *et al.*, 2010; Heathcole *et al.*, 2014; Redick *et al.*, 2012; Watson & Strayer, 2010). In fact, some researchers have gone so far as to claim that gender is "not a good predictor of multitasking ability" (Strayer, Medeiros-Ward & Watson, 2013, *p.* 809).

Next, our measure of GPA was self-reported by the participants rather than collected from their official transcripts and therefore may have been presented inaccurately. We did not find a correlation between GPA and OSPAN scores as has been previously established indicating that participants may have provided imprecise GPA scores. Third, the Breakfast Task was a novel task that has not been widely used and thus, its validity and reliability have not been well established. It may also have been more artificial than the Study Task, despite the intent to make the tasks as realistic as possible. Finally, in reality when students are multitasking during study they often do more than two things at once (see Kaiser Family Report in Rideout, Foehr, & Roberts, 2010). As a result, our study tasks may have represented an overly simplified situation. To accurately recreate the multitasking habits of today's youth it be necessary to include more distractions.

Chapter 7: Conclusion

In keeping with previous research on multitasking, the results from the current study provided support for the negative outcomes that have been associated with undertaking multitasking, specifically that it can lead to performance decrements in terms of the retention and recall of material. Students who multitasked during the Study Task answered fewer questions correctly from each source than student who did not multitask. However, the results also demonstrated that some students (those in the background TV condition) are able to tune out distractor information during a task and perform equally as well as students who were not faced with multiple information streams. This finding has implications for students' study habits and their ability to cope with interfering information.

Examination of the individual difference factors of interest revealed an important role for working memory in successful performance during both the Study and Breakfast Tasks. Students with larger working memory capacities were better able to handle the demands of each task and to perform better than those with smaller working memory capacities. Polychronicity also played a role in successful performance during both tasks such that students who preferred to multitask performed better than those who did not. This highlights an important relationship between preferred task completion methods (e.g., single tasking vs. multitasking) and task demands — when the two are congruent, performance outcomes are the highest.

Finally, although working memory predicted success during each task, there was no direct relationship between successful performance during the Study Task and that during the Breakfast Task. Although both tasks required the use of working memory, the tasks themselves may have drawn on it in different ways such that students who did well on one task did not necessarily do well on the other.

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Appendix A

Informed Consent Form (Non-PREP)

Title: *Individual and Task Factors Associated with Multitasking Success*

Researcher(s): Mary Courage, PhD and Megan Pollard, MSc candidate; Department of Psychology Memorial University, SN3086c, mcourage@mun.ca

This form is part of the process of informed consent. It will give you the basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study at any time.

To decide whether you wish to participate in the study, you should understand enough about its risks and benefits to be able to make an informed decision. Take time to read this carefully and to understand the information provided. Please contact Dr. Mary Courage if you have any questions about the study or need more formation before you consent.

It is up to you to decide whether to take part in this research. If you choose not to take part or if you decide to withdraw from the research once it has started, there will be no negative consequences for you at any time.

Introduction
As part of her Master's thesis, Megan Pollard is conducting this research project under the supervision of Dr. Mary Courage, a psychology professor at Memorial University. We are examining the different task factors and individual differences that are associated with successful multitasking performance in university students. This is important, as demands for multitasking are increasing and there is a debate about whether multitasking helps or hinders learning and performance.

Purpose of study:
Many current work and learning environments require multitasking. The pressure that multitasking places on our attention and metal resources has raised questions about how well we learn and perform under multitasking compared to single-tasking conditions. One view is that multitasking makes us more efficient and productive and can actually change the way we learn and remember. Others argue that because our attention capacity is limited, multitasking leads to interference, distraction, errors and mental stress. There is no simple answer. Successful multitasking seems to depend on various task, situation, and individual factors. Basically, the interference that occurs during multitasking depends on the amount of competition among the resources that the tasks require. When competition is low (e.g., reading and listening to music) interference will be less than when competition is high (e.g., driving and text messaging). It also seems that certain individuals are better able to multitask than are others. The goal of this study is to examine

several task and individual difference factors that might be related to successful multitasking performance among university students.

What you will do in this study:
You will be asked to perform two different types of multitasking activity -an academic reading task with background TV distraction and a familiar everyday Making Breakfast task (computerized). You will also be asked to do a computerized working memory task and complete 3 short, pencil-and-paper questionnaires on media multitasking, your preference for multi- over single-tasking, whether you see yourself as good at multitasking compared to others, and your level of self-control. You will also be asked how much action video gaming you do and to report your academic average.

Length of time:
Your participation will take about 60–90 minutes.

Withdrawal from the study:
You can decline to participate or you can discontinue participation at any time after the study has started without any consequences to you now or in the future. Remuneration will be provided at the agreed rate of $10.50 per hour. Any data collected before you decided to discontinue will be destroyed and thus not included in the study.

Possible benefits:
You may find the study interesting and relevant to you, as the effectiveness of multitasking has become a topical issue of cognitive and social importance. You are helping the scientific/scholarly community to answer important questions about multitasking so that individuals can make informed choices about whether multitasking is a good work/study strategy for them.

Possible risks:
There are no risks to you as a result of your involvement in this study.

Compensation:
You will receive remuneration for your participation at the standard MUN rate of $10.50 per hour of participation or part thereof.

Confidentiality and Storage of Data:
To maintain privacy, your identity and performance on all of the tests and measures will be kept confidential. Hard and/or electronic copies of your consent form, personal information, and the data collected will be kept under lock and key or on a password-protected computer in Dr. Mary Courage's office in the Psychology Department at MUN, as appropriate. Megan Pollard will be given access to the information but is aware of and will abide by the regulations regarding participant confidentiality as described on the SGS Integrity and Ethics Web page. The data will be kept for a

minimum of 5 years, as mandated by the MUN policy on Integrity in Scholarly research. When the data are no longer required they will be shredded, erased, or deleted.

Anonymity:
Anonymity of your participant information is assured, as a unique participant number will replace your name in the data file. Copies of the signed consent form and the video records will be kept separately under lock and key in the psychology department office space assigned to Dr. Mary Courage. No participant will be singled out, named or identified in any report or publication of the data.

Recording of Data:
Participants will be video recorded during the multitasking activities for the purpose of noting where the participant is directing his or her attention during the tasks.

Reporting of Results:
The data collected will be used initially in a thesis. Subsequently, it will be submitted to a peer-reviewed journal for publication and also presented at professional international conferences. No direct quotations and/personally identifying information will be revealed in those forums. Data and conclusions will be reported in an aggregated or summarized form.

Sharing of Results with Participants:
Summary information/feedback will be provided in written form to participants after the project is complete. Detailed information from publications can be obtained through a request to Dr. Mary Courage.

Questions:
You can ask questions at any time during your participation in this research. If you would like more information about this study, please contact: Dr. Mary Courage at mcourage@mun.ca or Megan Pollard at map723@mun.ca

ICEHR Approval Statement:
The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR by telephone at 709-864-2861 or e-mail at icehr@mun.ca

Consent:
Your signature on this form means that:

- You have read the information about the research.
- You have been able to ask questions about this study.
- You are satisfied with the answers to all your questions.

- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw from the study at any time, without having to give a reason, and that doing so will not affect you now or in the future.
- You understand that data collected from you up to the point of your withdrawal will be destroyed

If you sign this form, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

Your signature:

I have read and understood what this study is about and appreciate the risks and benefits. I have had adequate time to think about this and had the opportunity to ask questions and my questions have been answered.

I agree to participate in the research project understanding the risks and contributions of my participation, that my participation is voluntary, and that I may end my participation at any time.

I agree to be video-recorded during the study

A copy of this Informed Consent Form has been given to me for my records.

__________________________ ________________________

Signature of participant Date

Researcher' s Signature:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

__________________________ ________________________

Signature of Principal Investigator Date

Informed Consent: Psychology Research Experience Pool

Title: *Individual and Task Factors Associated with Multitasking Success*

Researcher(s): Mary Courage, PhD and Megan Pollard, MSc candidate;
Department of Psychology Memorial University, SN3086c, mcourage@mun.ca

This form is part of the process of informed consent. It will give you the basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study at any time.

To decide whether you wish to participate in the study, you should understand enough about its risks and benefits to be able to make an informed decision. Take time to read this carefully and to understand the information provided. Please contact Dr. Mary Courage if you have any questions about the study or need more formation before you consent.

It is up to you to decide whether to take part in this research. If you choose not to take part or if you decide to withdraw from the research once it has started, there will be no negative consequences for you at any time.

Introduction
As part of her Masters thesis, Megan Pollard is conducting this research project under the supervision of Dr. Mary Courage, a psychology professor at Memorial University. We are examining the different task factors and individual differences that are associated with successful multitasking performance in university students. This is important, as demands for multitasking are increasing and there is a debate about whether multitasking helps or hinders learning and performance.

Purpose of study:
Many current work and learning environments require multitasking. The pressure that multitasking places on our attention and metal resources has raised questions about how well we learn and perform under multitasking compared to single-tasking conditions. One view is that multitasking makes us more efficient and productive and can actually change the way we learn and remember. Others argue that because our attention capacity is limited, multitasking leads to interference, distraction, errors and mental stress. There is no simple answer. Successful multitasking seems to depend on various task, situation, and individual factors. Basically, the interference that occurs during multitasking depends on the amount of competition among the resources that the tasks require. When competition is low (e.g., reading and listening to music) interference will be less than when competition is high (e.g., driving and text messaging). It also seems that certain individuals are better able to multitask than are others. The goal of this study is to examine

several task and individual difference factors that might be related to successful multitasking performance among university students.

What you will do in this study:

You will be asked to perform two different types of multitasking activity -an academic reading task with background TV distraction and a familiar everyday Making Breakfast task (computerized). You will also be asked to do a computerized working memory task and complete 3 short, pencil-and-paper questionnaires on media multitasking, your preference for multi- over single-tasking, whether you see yourself as good at multitasking compared to others, and your level of self-control. You will also be asked how much action video gaming you do and to report your academic average.

Length of time:

Your participation will take about 60–90 minutes.

Withdrawal from the study:

You can decline to participate or you can discontinue participation at any time after the study has started without any consequences to you now or in the future. Course credit will be provided as per the PREP protocol. Any data collected after you decided to discontinue will be destroyed and thus not included in the study. You can have any data you provided removed from the results up to the point at which the thesis has been submitted (January 31st, 2015) or a paper has been submitted for publication (August 31st, 2015). There are no consequences to you now or in the future should you decide to withdraw your information from the study.

Possible benefits:

You may find the study interesting and relevant to you, as the effectiveness of multitasking has become a topical issue of cognitive and social importance.

You are helping the scientific/scholarly community to answer important questions about multitasking so that individuals can make informed choices about whether multitasking is a good work/study strategy for them.

Possible risks:

There are no risks to you as a result of your involvement in this study.

Compensation:

You will receive one credit point toward your Psychology course per hour or participation or part thereof.

Confidentiality and Storage of Data:

To maintain privacy, your identity and performance on all of the tests and measures will be kept confidential. Hard and/or electronic copies of your consent form, personal information, and the data collected will be kept under lock and key or on a password-protected computer in Dr. Mary Courage's office in the Psychology Department at MUN, as appropriate. Megan Pollard will be given access to the information but is aware of and will abide by the regulations regarding participant confidentiality as described on the SGS Integrity and Ethics Web page. The data will be kept for a minimum of 5 years, as mandated by the MUN policy on Integrity in Scholarly research. When the data are no longer required they will be shredded, erased, or deleted.

Anonymity:
Anonymity of your participant information is assured, as a unique participant number will replace your name in the data file. Copies of the signed consent form and the video records will be kept separately under lock and key in the psychology department office space assigned to Dr. Mary Courage. No participant will be singled out, named or identified in any report or publication of the data.

Please note that your course instructor will not have access to detailed participation details. He or she will only be able to view the total number of credit points earned by students, and will not know whether you have participated in this, or any other study, nor whether any credit points earned from participation in any study were earned from Research Participation, Research Observation, or completion of the alternative assignment.

Recording of Data:
Participants will be video recorded during the multitasking activities for the purpose of noting where the participant is directing his or her attention during the tasks.

Research Participation vs. Research Observation:
Your participation in this study is intended to be an educational Research Experience. You therefore have the choice of whether or not to provide data to researchers for inclusion in their analysis. If you consent to provide your data for analysis, please check the box below labeled "Research Participation". However, if you wish to observe the process of research participation without providing data to researchers for inclusion in their analysis, then you may choose to do so, without any loss of experience or credit. If you consent to observe the research experience without providing any data, please check the box below labeled "Research Observation". Please note that you may choose to change your Research Experience from Participation to Observation at any point in time, without loss of experience or credit.

Reporting of Results:
The data collected will be used initially in a thesis. Subsequently, it will be submitted to a peer-reviewed journal for publication and also presented at professional

international conferences. No direct quotations and/personally identifying information will be revealed in those forums. Data and conclusions will be reported in an aggregated or summarized form.

Sharing of Results with Participants:
Summary information/feedback will be provided in written form to participants after the project is complete. Detailed information from publications can be obtained through a request to Dr. Mary Courage.

Questions:
You can ask questions at any time during your participation in this research. If you would like more information about this study, please contact: Dr. Mary Courage at mcourage@mun.ca or Megan Pollard at map723@mun.ca

ICEHR Approval Statement:
The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR by telephone at 709-864-2861 or e-mail at icehr@mun.ca

Consent:
Your signature on this form means that:

- You have read the information about the research.
- You have been able to ask questions about this study.
- You are satisfied with the answers to all your questions.
- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw from the study at any time, without having to give a reason, and that doing so will not affect you now or in the future.
- You understand that any data collected from you up to the point of your withdrawal will be destroyed
- You understand the difference between Research Participation and Research Observation options, that you may choose which option you prefer, and that you are free to change your option at any time, without having to give a reason, and that doing so will not affect you now or in the future.

If you sign this form, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

Your Signature:

I have read and understood what this study is about and appreciate the risks and benefits. I have had adequate time to think about this and had the opportunity to ask questions and my questions have been answered.

☐ I agree to participate in the research project understanding the risks and contributions of my participation, that my participation is voluntary, and that I may end my participation at any time.

☐ I agree to be video-recorded during the study.

Research Participation vs. Research Observation

☐ Research Participation: I consent to provide data from my research experience to researchers for analysis.

☐ Research Observation: I do not consent to provide data from my research experience to researchers for analysis.

A copy of this Informed Consent Form has been given to me for my records.

____________________________ ____________________________

Signature of participant Date

Researcher's Signature:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

____________________________ ____________________________

Signature of Principal Investigator Date

Appendix B

Questions from the Study Task

Toucan Article Questions

Part One: Multiple Choice. Please circle the best response.

1) What is the largest toucan species?

a) Choco Toucan   b) Toco Toucan

c) Cuvier's Toucan   d) Green-billed Toucan

2) The inside of a toucan's bill is shaped like?

a) honeycombs   b) waffles

c) octagons   d) almonds

3) What other bird species is the toucan related to?

a) Woodpecker   b) Pelican

c) Parrot   d) Flamingo

4) What is the iron storage disease that killed many toucans called?

a) Hemophilia   b) Cirrhosis

c) Hemochromatosis   d) Galactosemia

5) Small toucanets fly from the nest when they are days old.

a) 56   b) 43

c) 50   d) 46

6) Toucans can be fed with cheap dog food if the dog food is made with______.

a) wheat-based products   b) meat-based products

c) grain-based products   d) soya-based products

Part Two: Fill-ins. Please fill in the blank space with the best answer (answers may be more than one word).

7) During nuptial display, toucans use their bills to _________________.

8) Toucans mainly inhabit the ____________ in South America.

9) In its native region, toucans are associated with evil spirits. The father of a new child must not _____________ as it might bewitch the newborn.

10) The Defenders of Wildlife, in conjunction with other organizations, spearheaded development of the ______________ (*you may use abbreviation*).

11) One method that helps, but does NOT confirm, the positive diagnosis of iron storage disease is _______________.

12) If an iron storage disease is diagnosed in humans, the primary drug to use is ______________.

Questions on the Nile Crocodile Video

Part One: Multiple Choice. Please circle the best answer.

1) How long can Nile crocodiles grow to be?

a) 15 feet b) 20 feet

c) 25 feet d) 30 feet

2) In the video, crocodiles are compared to what type of car?

a) Ferrari b) Camaro

c) Maserati d) Lamborghini

3) How do they take DNA samples from the crocodiles?

a) swab their mouth/teeth b) clip a piece of their claws

c) clip off a piece of their tail scale d) collect a blood sample

4) When is the only time it's possible to dive with crocodiles?

a) Winter b) Spring

c) Fall d) Summer

5) Why do the divers believe crocodiles don't attack people under water?

a) crocodiles can't see them

b) crocodiles can't recognize people as prey underwater

c) crocodiles are usually not hungry when they are underwater

d) crocodiles are afraid of people

6) When the divers are looking for crocodiles in the dark, what's the first thing they notice about them?

a) long tails b) air bubbles

c) they hear them first d) gleaming teeth

Part Two: Fill ins. Please fill in the blank with the best answer (answers may be longer than one word).

7) Crocodiles can weigh as much as a ___________.

8) Underwater, ___________ is sometimes only a few feet, making diving very dangerous.

9) Crocodiles kill and eat their prey by grabbing them, __________ and _________ them.

10) The metal rod they take when diving is used to _____________.

11) When entering the water for a dive it is crucial to ____________.

12) Crocodiles are able to stay under water for hours by slowing their __________

Appendix C

The Multitasking Preference Inventory and Measure of Perceived Multitasking Ability

A) Please circle the response that best fits how you relate to each statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I prefer to work on several Projects in a day, rather than completing one project and then switching to another.	1	2	3	4	5
2. I would like to work in a job where I was constantly shifting from one task to another, like a receptionist or an air-traffic controller.	1	2	3	4	5
3. I lose interest in what I am doing if I have to focus on the same task for for long periods of time, without thinking about or doing something else.	1	2	3	4	5
4. When doing a number of assignments, I like to switch back and forth between them rather than do one at a time.	1	2	3	4	5
5. I like to finish one task completely before focusing on anything else.	1	2	3	4	5
6. It makes me uncomfortable when I am not able to finish one task completely before focusing on another task.	1	2	3	4	5
7. I am much more engaged in what I am doing if I am able to switch between several different tasks.	1	2	3	4	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
8. I do not like having to shift my attention between multiple tasks.	1	2	3	4	5
9. I would rather switch back and forth between several projects than concentrate my efforts on just one.	1	2	3	4	5
10. I would prefer to work in an environment where I can finish one task before starting the next.	1	2	3	4	5
11. I don't like when I have to stop in the middle of a task to work on something else.	1	2	3	4	5
12. When I have a task to complete, I like to break it up by switching to other tasks intermittently.	1	2	3	4	5
13. I have a "one-track" mind.	1	2	3	4	5
14. I prefer not to be interrupted when working on a task.	1	2	3	4	5

B) Using the following scale, indicate how good (*i.e.* you can multitask without performing poorly on either task) you think you are at multitasking in comparison from your peers. Circle the most appropriate response.

1	2	3	4	5
Far worse than my peers	Slightly worse than my peers	On par with my peers	Slightly better than my peers	Far better than my peers

Appendix D

General Information Sheet

Name: ______________   **Participant ID#: ______________**

Please specify the following information by checking/ filling in the blank spaces:

A) Are you: Female______   Male______

B) How old are you?_______

C) What is your major? (If you are undecided write N/A)__________

D) What is your minor? (If applicable)________

E) How many years of post-secondary education (e.g., university, college, *etc*.) have you completed?___________

F) What is your **overall academic average?** (If you are in your first semester of your first year please provide your overall academic average from high school.