Investigating the Role of Personality on Prospective Memory Performance in Young Adults using a Multi-Trait Multi-Method Approach

by

Karley-Dale Talbot
B.Sc. Honours, University of Victoria, 2011
M.Sc., University of Victoria, 2015

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in the Department of Psychology

We acknowledge with respect the Lekwungen peoples on who traditional territory the university stands and the Songhees, Esquimalt, and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.

Supervisory Committee

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Abstract

Prospective memory (PM) refers to a person's ability to remember to do something in the future. It is a complex behaviour that is essential for the daily functioning of young and old alike. Despite its importance in everyday life, few studies have sought to examine the role of personality on PM performance using a multi-trait multi-method approach in young adults. The current study aimed to investigate the differential roles of the Big 5 personality traits on event- and time-based PM performance using multiple measurement methods. In addition, the study aimed to add to the current PM and personality literature by addressing several of the identified methodological limitations of the literature as outlined by Uttl and colleagues (2013). Results demonstrated few strong relationships between PM subtypes (event and time-based) performance indicators, though performance on the lab-based event-based PM task was stronger than on the lab-based time-based PM task even after controlling for ongoing task performance. Participants were also found to perform better on lab-based rather than naturalistic PM tasks. Naturalistic and self-report PM measures were significantly related to each other, but not to lab-based PM. Regarding personality, the relationship between specific personality traits and PM performance differed depending on the PM subtype and/or measurement method being investigated with conscientiousness, memory aid strategy use, and substance use engagement being found to best predict self-reported PM errors in daily life. The current study demonstrated that each PM measurement method taps into different aspects of behavioural and cognitive functioning. Without the use of all three measurement methods, whilst also considering the individuality of the client, researchers and clinicians may be doing a disservice to individuals with true PM difficulties as they may overlook important factors contributing to their poorer performance.

Prospective Memory, event-based prospective memory, time-based prospective memory, personality, CAPM, MAidQ, young adult, multi-trait multi-method approach, convergent validity, divergent validity, ecological validity, naturalistic task paradigm, lab-based task paradigm, self-report measure.

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Dedication

I would like to dedicate this thesis to my mother. She has taught me to be strong and persevere when things get tough. Without her unconditional love and support, I would not be where I am today. Though life has not always been fair or easy, I know we will make it through, as long as we continue to travel together.

Introduction

Prospective memory (PM) denotes the ability to remember to complete an intended action at some point in the future (Einstein & McDaniel, 1990). In essence, it is the ability to remember to remember. Whether it be remembering to take a life-saving medication, to pay bills on time, or to call a loved one on his birthday, PM is essential for successful independent daily functioning. Though largely believed to be a cognitively driven skill (Groot, Wilson, Evans, & Watson, 2001; Kliegel, Martin, McDaniel, & Einstein, 2001; Mackinlay, Kliegel, & Mäntylä, 2009; Martin, Kliegel, & McDaniel, 2003; Shum, Cahill, Hohaus, O`Gorman, & Chan, 2012), PM difficulties are often also associated with social ineptitudes (Graf, 2012; Smith, Persyn, & Butler, 2011). For example, individuals who frequently struggle with PM are often labelled as "flaky", unreliable, and/or scatterbrained. Clearly, such labels can negatively influence an individual's ability to both attain and maintain meaningful employment and ultimately interpersonal relationships. As such, struggles with PM have been associated with a decreased overall quality of life (Woods, Weinborn, Yanqi, et al., 2015). To-date, research has demonstrated cognitive deficits in higher-order executive functions are associated with PM deficits (Altgassen, Schmitz-Hübsch, & Kliegel, 2010; Raskin, Woods, Poquette, et al., 2011; Talbot, Müller, & Kerns, 2017). That said, individuals with generally intact executive functioning may also exhibit difficulties with PM (Kliegel, Jäger, Phillips, et al., 2005; Smith-Spark, Moss, & Dyer, 2016; Zamroziewicz, Raskin, Tennen, et al., 2017). For example, acute alcohol use (Smith-Spark, Moss, & Dyer, 2016; Zamroziewicz, Raskin, Tennen, et al., 2017), mood (Kliegel, Jäger, Phillips, et al., 2005), personality (Cuttler & Graf, 2007; Smith, Persyn, & Perlman, 2011), and lifestyle factors (Uttl & Kibreab, 2011) have all been found to impact PM performance in university students who do not have clinical or cognitive diagnoses. For this reason, researchers have begun to investigate non-executive factors that may also influence an individual's capacity to successfully carry out their intended actions. As mentioned, personality is one of these non-executive factors. The aim of the present study is to expand on previous research investigating the influence of personality on PM performance by using a methodologically rigorous multi-trait, multi-method (MTMM) experimental design. The secondary aim of the present study is to evaluate the validity of lab-based, self-report, and naturalistic PM paradigms. In the following pages, PM will first be defined, and its process outlined. Next, a critical review of the literature investigating the influence of personality on PM will be summarized. The process of validating lab-based, naturalistic, and self-report measures of PM using the MTMM method will then be discussed. Finally, a summary of the goals of the current study will be provided.

Differentiating PM from Retrospective Memory, Attention, and Executive Functions

It is generally accepted in the PM literature that the act of remembering to carry out an intended action (PM) is related, yet distinct, from retrospective memory (RM). In fact, the PM process is believed to consist of two components (1) a RM processing component and (2) a prospective processing component (Guynn, McDaniel, & Einstein, 2001; Simons, Scholvinck, Gilbert, Frith, & Burgess, 2006; West & Krompinger, 2004). For example, the RM processing component involves both the encoding and long-term memory storage of an intended action as well as the context for its retrieval. The prospective processing component of PM is the future-oriented component that requires one to remember to act upon one's own intentions.

An essential set of cognitive abilities suggested to contribute to the prospective component of PM is executive functions (Burgess, Gonen-Yaacovi, & Volle, 2011; Costa, Peppe, Zabberoni, et al., 2015; Deouell & Knight, 2009; Mahy, Moses, & Kliegel, 2014; West, 2010; Zöllig, West, Martin, et al., 2007). Executive functions are cognitive processes that are required for the conscious, top-down control of action, thought, and emotions, and are associated with the prefrontal cortex (see Zelazo & Müller, 2010). Specific executive functions including planning, monitoring, working memory, set-shifting, inhibition, and initiation have all been found to relate to PM and are believed to be required for its successful execution (Groot, Wilson, Evans, & Watson, 2001; Kliegel, Martin, McDaniel, & Einstein, 2001; Mackinlay, Kliegel, & Mäntylä, 2009; Martin, Kliegel, & McDaniel, 2003; Niedźwieńska, Janik, & Jarczyńska, 2013; Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010; Shum, Cahill, Hohaus, O`Gorman, & Chan, 2012). Importantly, specific executive functions have been hypothesized to play more important roles than others at certain stages of PM after children develop basic RM capacities (Mahy, Moses, & Kligel, 2014). Based on evidence accumulated from developmental studies of PM in children, Mahy, Moses, and Kliegel (2014) proposed an executive framework of PM development whereby working memory is important during the prospective intention formation, the delay interval between intention formation and ongoing task commencement, and the ongoing task (see Kretschmer, Voigt, Friedrich, et al., 2013; Mahy & Moses, 2011; Mahy & Moses, 2014). Similar to working memory, internal mind monitoring, or refreshing the prospective intention, is believed to be important during the prospective intention formation and the delay interval, but not during the ongoing task (Mahy & Moses, 2014). In contrast, set-shifting, external monitoring, and inhibition are believed to be important during the ongoing task and the appearance of the prospective cue (see Kerns, 2000; Mahy, Moses & Kliegel, 2014; Kliegel, Mahy, Voigt, et al., 2013; Kvavilashvili, Messer, & Ebdon, 2001; Wang et al., 2008).

Intact attentional abilities (e.g., sustained, selective, and divided attention) are also required for the successful completion of PM as one must be able to adequately attend to the immediate environment (i.e., sustained attention) to notice external PM cues (i.e., selective attention), and shift and/or divide their attention from their ongoing task to successfully execute the PM task. Attention is also important in monitoring internal memory contents (e.g., updating working memory) to maintain the PM intention in active memory (Cona, Scarpazza, Sartori, et al., 2015).

According to a review completed by Einstein and McDaniel (1996), the attentional requirements for the successful execution of PM can be subdivided into two different theoretical positions: the automatic activation (automatic retrieval) and the notice + search (strategic retrieval) models. Based on these positions, PM tasks are successfully executed either automatically or through strategic processing. The multiprocess model proposed by McDaniel and Einstein (2000) posits that the attentional or strategic demands of retrieval vary as a function of the characteristics of all of the components and phases of the PM task (including the retention interval and ongoing task) and of the person undertaking that task. For example, research has found that delay task difficulty (Mahy et al., 2018), PM cue focality (McDaniel & Einstein, 2000), and mood

(Altgassen, Kliegel, & Martin, 2009) all influence PM task performance (see below for a more comprehensive review). In contrast, the Preparatory Attentional and Memory (PAM) model assumes that resource-demanding preparatory attentional processes are required for successful performance (Smith, 2003). According to the PAM model, the attentional demands associated with the successful execution of the PM task can be observed by examining the costs of prospective remembering on ongoing task performance by contrasting accuracy and/or response latency on nontarget ongoing task trials with and without the PM task being embedded (e.g., monitoring costs). Significant differences in ongoing task performance between ongoing task only and ongoing + PM task trials are therefore believed to lend support to the PAM model of attentional allocation (see Jäger & Kliegel, 2010). The current study aims to identify whether individual differences in personality traits influence PM performance, lending further support to the multiprocess model.

Taken together, the overall process of PM is dependent on intact RM, PM, attention, and various executive functions for its successful completion.

The PM Process

Ellis (1996) outlined five different phases required to successfully execute a PM task: (1) formation and encoding, (2) a retention interval, (3) a performance interval, (4) initiation and execution of the intended action, and (5) evaluation of the outcome. Phase one represents the RM processing component and involves forming an intention, retaining the action, and encoding the retrieval context. Phases two to five represent the prospective and executive components. However, phase 5 also relies on RM to evaluate past performance. Phase two refers to the delay between initial encoding of the intent and the point of memory retrieval (phase three), which may vary considerably in its duration. Importantly, an associated memory for action may be retrieved at any point during these two phases; however, the delayed intention must be elicited when the retrieval context matches that which was encoded in the first phase to successfully progress to phase four. At that time, the intended action may be executed (phase four), and the outcome evaluated (phase five).

Subtypes of PM

According to Kvavilashvili and Ellis (1996), PM can be separated into several distinct subtypes depending on the context being used to trigger the retrieval of an intention. That said, most of the research on PM has typically differentiated between two main subtypes— event-based and time-based. Event-based PM is defined as a memory for an intended action in response to an external cue (Ellis, 1996). For example, when driving by the supermarket (external cue), you remember you need to pick up milk (intended action) and stop to buy some (successful PM task). Time-based PM, however, differs in that it is a memory for an action at a specific time or after a specific time has elapsed (Einstein & McDaniel, 1996). Therefore, a successful time-based PM task would be remembering to take your medication 12 hours after your previous dosage (time-based cue).

Over the years several other subtypes and/or variations of PM subtypes have been stipulated and described. The most common forms investigated in the PM literature include activity-based, episodic, habitual, short-term, long-term, general time-based, specific time-based, and vigilance/monitoring (Cavuoto, Ong, Pike, Nicholas, & Kinsella, 2015; Hannon, Adams, Harrington, Fries-Dias, & Gibson, 1995; Talbot, 2015; Uttl, et al., 2013). Because event- and time-based PM are the most widely accepted, differentiated, and investigated subtypes in the PM literature, these two subtypes will be the focus of the current study.

Differentiating Event-Based and Time-Based PM

In event-based PM, execution of the intended action is triggered by the detection of an external cue perceived by one or more senses (i.e., seeing an object or hearing a sound). In contrast, time-based PM task execution is triggered by the passage of time. Though both event-based and time-based PM rely on executive functions for their successful execution, time-based PM is believed to rely more heavily on them as it requires internal, self-generated monitoring or retrieval processes as well as self-initiated interruption for its successful execution. Therefore, time-based PM is believed to be more difficult to carry out than event-based PM (Einstein & McDaniel, 1996; Kliegel, Ropeter, & Mackinlay, 2006; Yang, Chan, & Shum, 2011). Consistent with this hypothesis, individuals with and without brain injury found time-based tasks to be more difficult than event-based tasks (Groot et al., 2001). Additionally, individuals with executive function deficits, like those with Attention-Deficit Hyperactivity Disorder (see Talbot, Müller, & Kerns, 2017 for a review), Autism Spectrum Disorder (Altgassen, Schmitz-Hübsch, & Kliegel, 2010), or Parkinson’s disease (Raskin, Woods, Poquette, et al., 2011), have also been found to exhibit specific difficulties with time-based, but not event-based PM. Lesion-based studies have found individuals with specific thalamic lesions demonstrate time-based PM impairment (Cheng, Tian, Hu, et al., 2010), whereas individuals with focal prefrontal lesions demonstrate event-based PM specific deficits (Cheng, Wang, Xi, et al. 2008). Additionally, Gonneaud and colleagues (2011) investigated the role of normal aging on event- and time-based PM performance. They found that normal aging was associated with declines in both event- and time-based PM, but that event-based PM performance was more sensitive to the effects of aging than time-based PM. The researchers also found that aging effects were differentially mediated depending on the PM subtype being evaluated. For example, event-based PM performance was found to be mediated by binding and RM processes whereas time-based PM was mediated primarily by inhibition processes. Relatedly, in a follow-up study, Gonneaud and colleagues (2014) found differential activation across PM subtypes in their neuroimaging study conducted with healthy adults. These researchers argued that this differential activation pattern best represented underlying differences across PM subtypes in strategic monitoring. For example, on event-based PM tasks, participants' occipital areas were more activated, suggesting that they tended to allocate their attentional resources more to facilitate external target monitoring. In contrast, on time-based PM tasks, a dorsolateral prefrontal cortex (PFC) network became activated. Gonneaud and colleagues (2014) argued that this activation may reflect internal time estimation processes (e.g., executive function) required for the successful execution of the PM task. Taken together, the findings suggest that event- and time-based PM engage different mechanisms likely reflecting monitoring strategies and brain systems specific to each subtype, with time-based PM relying more heavily on executive functioning processes than event-based PM. This therefore provides further support for the notion of distinct PM subtypes.

Non-Executive Factors Influencing PM Performance

Individuals are thought to allocate more higher-order cognitive resources to successfully execute time-based PM than event-based PM. Time-based PM is therefore believed to be more difficult to perform in everyday life. In spite of this, many individuals continue to struggle with PM in their daily lives despite intact executive functions (Cuttler & Graf, 2007; Kliegel, Jäger, Phillips, et al., 2005; McCabe, Woods, Weinborn, et al., 2018; Smith-Spark, Moss, & Dyer, 2016; Uttl & Kibreab, 2011; Zamroziewicz, Raskin, Tennen, et al., 2017), suggesting that other non-executive factors, like personality, may also play a role in successful PM performance. Further, of the few studies that have investigated the role of non-executive factors on PM performance, even fewer differentiate their influence based on PM subtype. The current study is therefore aimed at investigating the differential influence of the non-executive factor of personality on both event- and time-based PM in young adults.

To date PM performance has been found to be related to several non-executive factors that may be conceptually subdivided into three main areas: (1) task-related, (2) intraindividual-related, and (3) context-related. Task-related non-executive factors encompass factors associated with the PM task paradigm employed to measure PM performance. Cue salience (McDaniel & Einstein, 2000; Altgassen, Ariese, Wester, & Kessels, 2016), cue type (Levén, Lyxell, Andersson, & Danielsson, 2014; Yanqi, Weinborn, Loft & Maybery, 2013), delay interval (Hicks, Marsh, & Russell, 2000; Yanqi et al., 2013), delay task difficulty (Mahy et al., 2018), task importance (Hering, Phillips, & Kliegel, 2013; Niedźwieńska, Janik, & Jarczyńska, 2013), cue regularity (Cavuoto et al., 2015; Ellis, 1996), and the similarity of the cognitive processes required for the ongoing and PM tasks (Brunfaut, Vanoverberghe, & d'Ydewalle, 2000; Mäntyla, 1993, Maylor, 1996) are all factors that have been found to influence time- and event-based PM performance. For example, Altgassen and colleagues (2016) found PM performance to improve when individuals diagnosed with an intellectual disability were provided a visual vs. verbal PM retrieval cue. Similarly, Mahy, Moses, and Kliegel (2014) found participants to remember to complete more PM tasks when the tasks were more salient (e.g., more distinctive). Additionally, Levén and colleagues (2014) found that participants remembered more PM tasks when the task was to be completed regularly (habitual PM task) relative to a task required to be completed occasionally (episodic PM task).

Intra-individual non-executive factors encompass factors associated with the individual who is engaged in the PM task. For example, internal resource availability and personality factors have been found to influence PM performance (Kliegel, Altgassen, Hering, & Rose, 2011). For instance, an individual’s mood (Altgassen, Kliegel, & Martin, 2009; Jeong & Cranney, 2009; Li, Weinborn, Loft, & Mayberry, 2013), alcohol drinking pattern (Zamroziewicz et al., 2017), level of anxiety (Cuttler & Graf, 2007; 2009; Graf, 2012; Harris & Cumming, 2011; Scott, Woods, Wrocklage, & Shweinsberg, 2016) or impulsivity (Cuttler, Relkov, & Taylor, 2014), internal motivation (including social motivation) (Jeong & Cranney, 2009; Kvavilashvili & Fisher, 2007; Penningroth, Scott, & Freuen, 2011), and metamemory (Einstein & McDaniel, 2007; Graf, 2012; McDonald-miszczak, Gould, & Tychynski, 2010, Rummel, Kuhlmann, Touron, 2013) have all been found to influence PM performance. Li and colleagues (2013) found that undergraduate students who self-reported moderate to severe symptoms of depression on the Beck Depression Inventory – Second Edition (BDI-II) performed more poorly than undergraduate students who self-reported minimal to no symptoms of depression on the BDI-II on time-based, but not event-based PM, that could not be better explained by general attentional function, simple working memory performance, ongoing task/PM trade-offs, or RM functioning. Relatedly, Harris and Cumming (2003) found state anxiety, or one's current experience of acute anxiety symptoms, to be negatively related to event-based PM in their sample of non-clinical undergraduate students. That is, individuals with high levels of state anxiety were found to perform worse on a PM task than individuals with lower self-reported levels of state anxiety, independent of participants' working memory capacity and RM performance. Interestingly, trait anxiety, or one's baseline level of anxiety, was found to be unrelated to event-based PM. Rummel and colleagues (2013) found that individuals who were asked to predict their PM performance before completing an event-based PM task responded more slowly on the ongoing task when compared to controls. The authors suggested that their findings substantiated a role of metamemory in strategic attention-allocation for PM.

Context-related non-executive factors are those factors linked to the environmental context in which the PM task is carried out. The time of day when a PM task needs to be completed has been found to influence PM performance (Barner, Schmid, & Diekelmann, 2019; Ballhausen, Kliegel, & Rimmele, 2019; Cavuoto et al., 2015; Rothen & Meier, 2017). Cavuoto and colleagues (2015) found older adult participants remembered a habitual PM task (i.e., to press a button twice daily, once upon awakening and once before going to sleep) more readily when it was associated with their bed-time routine rather than their wake-time routine, and Barner and colleagues (2019) found young adults performed better on lab-based PM tasks when they were completed during the evening hours. Other environmental factors like testing environment (e.g., laboratory vs. naturalistic) have been found to influence cognition (see Bailey, Henry, Rendell, et al., 2010; Eysenck & Eysenck, 1985 & Matthew, Deary, & Whiteman, 2003;

Rendell & Craik, 2000; Schnitzspahn, Ihle, Henry, et al., 2011), suggesting that the testing environment may also influence PM performance. The current study will specifically focus on investigating the role of the intra-individual non-executive factor of personality on PM performance across different testing contexts.

Empirically evaluating PM

Laboratory-Based Research Paradigms

McDaniel and Einstein (2006) outlined a general approach for measuring PM in a controlled laboratory setting. The authors argued that if designed correctly, the measurable outcomes of such a measure would yield an accurate representation of an individual's PM functioning in daily life. McDaniel and Einstein (2006) described four key aspects that must be included within the PM measure to ensure its ecological validity: (1) participants must be kept busy with an ongoing task (e.g., pleasantness rating), (2) at the beginning of the ongoing task, participants must be asked to perform another task (e.g., key press) at a specific time (e.g., every two minutes or when they see the letter 'X') during the experiment, (3) a filler task between presentation of the initial task instructions and the commencement of the ongoing activity must be given to reduce the likelihood of the intention being maintained in working memory, and (4) performance should be measured by the proportion of trials in which participants remember to execute the PM task. The authors felt that the ecological validity of the task was high because the PM task was embedded within an ongoing task as this is similar to what would be expected of an individual carrying out a PM task within the "ongoing task" of their everyday life.

Consistent with other areas of psychological research, PM researchers have utilized several variants of the original experimental paradigm outlined by McDaniel and

Einstein (2006) to evaluate PM in adults. But, across PM studies, it appears that the main source of variation is generally applied to the nature of the ongoing task. For example, some researchers have used cognitive measures as their ongoing task (Kliegel et al., 2005; Mäntylä, Del Missier, & Nilsson, 2009; Mackinlay, Kliegel, & Mäntylä, 2009; Smith & Hunt, 2014), whereas others have used word rating tasks (Kominski & Reese-Melancon, 2016; McDaniel & Scullin, 2009; Rothen & Meier, 2017), or multiple-choice tests of general knowledge and trivia (McFarland & Glisky, 2012). Interestingly, the nature of the PM tasks often employed by PM researchers do not tend to vary as much as the ongoing tasks and usually consist of pressing a computer key at a specific point in time (see Mäntylä, Del Missier, & Nilsson, 2009), after a specified time interval (see Gonneaud, Kalpouzos, Bon, Viader, Eustache, & Desgranges, 2011), or in response to a specific visual or verbal cue (see Arnold, Bayen, & Böhm, 2013). Additionally, on time-based PM tasks, the time in which to respond is often facilitated by self-initiated checking of either a visible clock or gauge that can be accessed with a keystroke. The current study will utilize a traditional lab-based event- and time-based PM paradigm using a working memory *n*-back task as the ongoing task for both PM tasks to facilitate direct comparison of PM performance. This task paradigm was also chosen to compare current lab-based PM performance findings to those in the current literature.

Although laboratory PM tasks are conducted in a more controlled environment, can allow for more precise measurements of PM performance (i.e., self-initiated checking frequencies and response latencies), and follow the guidelines outlined by McDaniel and Einstein (2006), results obtained from these PM measures may only loosely reflect participants' everyday PM abilities (Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010;

Talbot, 2015). Consequently, lab-based PM tasks are argued to lack ecological validity. Ecological validity refers to the relationship between psychological test scores and a person's present and future functioning in real-world settings (Sbordone, 1996). It is therefore a critical property to evaluate as the main goal of psychological tests is to better elucidate individuals' difficulties and identify how they might translate into everyday life (Sbordone, 1996).

There are two main arguments against the ecological validity of lab-based PM measures. First, the lab-based PM tasks used to measure PM are not representative of typical daily PM tasks. Second, the experimental context (e.g., the laboratory) may unduly influence participants' performance. Because of these reasons, it is difficult to accurately interpret and predict future everyday PM functioning based on the results obtained from this method of measurement (Goldstein, 1996; Sbordone, 1996). Researchers have therefore begun to concentrate their efforts on both evaluating the ecological validity of current lab-based PM measures and developing new, more naturalistic paradigms to more accurately measure daily PM functioning.

Naturalistic PM Paradigms

Given the questionable ecological validity of lab-based PM measures, increasingly researchers are devising more naturalistic paradigms to investigate PM. Unfortunately, the degree of naturalism incorporated into these studies varies substantially from study to study. Overall, naturalistic PM paradigms appear to fall within three broad categories, encompassing a continuum of naturalism: (1) quasi-naturalistic, (2) experimenter-derived naturalistic, and (3) person-derived naturalistic. The least naturalistic form among these PM paradigms (quasi-naturalistic) can be exemplified by the "Virtual Week Task" developed by Rendell and Craik (2000). This task was designed to mirror the real life demands of PM and was carried out with adults between the ages of 18 and 87. The Virtual Week Task required participants to remember to carry out a series of everyday PM tasks (event-based, time-based, habitual and episodic) while they played a board game. Each revolution around the game board represented the course of one day and participants were required to 'live' five 'days' to complete the task. Examples of the PM tasks the authors asked participants to complete included remembering to 'take' an antibiotic at each 'day's' 'breakfast' and 'dinner' event (habitual PM), 'phone' the bank to make an appointment at 'noon time' (episodic PM), and take a 'lung capacity test' when the clock in the center of the game board read 2 minutes and 15 seconds (time-based PM) and after the start of each 'day' (event-based PM). While participants were required to physically carry out the lung capacity tests, they only had to demonstrate their performance of the other PM tasks by choosing the appropriate task from a list of PM tasks and distractors at the correct time.

While the Rose and colleagues (2010) study was an attempt to improve the arguably limited ecological validity associated with traditional lab-based PM task paradigms, its own ecological validity has also been called into question (see Talbot, 2015). Among other reasons, the fact that the Virtual Week Task was conducted in a controlled laboratory environment over a relatively short period of time makes the authors' findings vulnerable to the contextual effects associated with lab-based PM studies (see non-executive factors section above). Additionally, some of the PM tasks included in the paradigm (e.g., the lung capacity tests) were not representative of typical everyday PM tasks. Similarly, the number of PM tasks required to be remembered over the course of a ‘day’ (e.g., 10), the method of successfully completing them (e.g., picking from a list of PM tasks and distractors), and the lack of internal motivation associated with their successful completion, significantly compromises the paradigm’s ecological validity. Consequently, the Virtual Week Task may best be referred to as a quasi-naturalistic study of PM.

On the opposite end of the naturalistic PM paradigm spectrum are person-derived naturalistic PM tasks. In this type of task, the participant is the person who assigns the PM task they would like to complete and subsequently reports to the experimenter(s) as to whether they were successful in completing it. For example, Niedźwieńska, Janik, and Jarcsyńska (2013) randomly assigned younger (age M = 21.70), middle-aged (age M = 47.47), and older adult (age M = 68.33) participants to baseline or experimental assessment groups. Those who were in the baseline groups were asked to generate a list of tasks they intended to complete during the following week. One week later, these participants reported on the tasks they completed over the previous week and any reasons for non-completion. Participants in the experimental group, however, were given four minutes to generate a list of all the possible “jobs, appointments, and activities” (excluding habitual tasks) they intended to carry out over the next week. Following their list generation, they were asked to rate the importance of the intended activity (PM task) and to write down the expected circumstances in which the PM task would be performed according to four different categories (e.g., day of the week, time of day, activity immediately preceding the PM task, and activity immediately following the PM task). Like those in the baseline groups, participants in the experimental groups also returned one week later and reported the tasks they completed and any reasons for non-completion.

Unlike quasi-naturalistic PM paradigms described above, person-derived naturalistic paradigms ensure that the PM tasks used in the study are individualized and representative of typical daily PM tasks carried out within the context of participants' everyday lives. This therefore significantly improves the ecological validity of the obtained findings. In addition, these more qualitative research paradigms provide researchers with a better understanding of the circumstances behind PM failures and successes. For example, by asking participants to report on their non-completions using an open-ended response format, Niedźwieńska, Janik, and Jarcsyńska (2013) were able to identify two main reasons for typical PM task failures—participants either forgot the task altogether or another task took priority. Similarly, Szarras and Niedźwieńska (2011) used a person-derived naturalistic paradigm to identify the triggers or cues associated with successful completion of their PM task. Specifically, they found that accidental triggers were more often associated with memory retrieval than no apparent triggers. They also found that self-initiated rehearsals contributed significantly to the successful execution of a PM task. The qualitative information gleaned primarily from person-derived naturalistic paradigms is therefore invaluable as it can then be applied to the development of more ecologically valid PM interventions.

Although there are benefits to conducting person-derived naturalistic PM studies, there are also some limitations. The most important limitation is the lack of experimental control associated with a study being conducted over longer periods of time (e.g., weeks rather than hours) and outside the confines of a controlled laboratory environment. When a study is conducted in a real-life setting, other factors known to influence PM performance (e.g., metamemory, motivation, time of day, task importance, and cue salience) cannot be systematically measured or controlled. Unfortunately, this lack of control also muddies the interpretation of the findings as secondary factors may unduly influence PM performance. Further, PM tasks are individualized, meaning that not every participant will be asked to complete the same, or a similar, task. This suggests that secondary factors (e.g., motivation or cue salience) may unsystematically vary in their influence across tasks and participants, which significantly limits the generalizability of findings. It therefore stands to reason that developing PM paradigms with more naturalistic PM and ongoing tasks, but that are subject to more experimental control, may provide an assessment of PM that ideally balances experimental control and ecological validity.

In contrast to quasi-naturalistic and person-derived naturalistic paradigms, experimenter-derived naturalistic paradigms most often include PM tasks that are more representative of everyday life but are also predetermined by the experimenter. For example, Kvavilashvili and Fisher (2007) asked participants to remember to phone the researcher at a pre-arranged time within a one-week interval. Brown and Hux (2017) asked their participants to complete eight different naturalistic PM tasks (e.g., "call X at 2pm and tell her what you had for lunch that day and your plans for dinner") over the course of the next ten days and Au and colleagues (2018) asked their older adult participants to remember to complete eight hypothetical tasks (time- or event-based; regular or irregular) per day for five days. Unlike the studies conducted by Kvavilashvili and Fisher (2007) and Brown and Hux (2017), Au and colleagues (2018) did not generally require participants to follow through with the PM task apart from logging its completion. That said, they did ask participants to perform a daily telephone task whereby participants were required to call and leave a voicemail with the researcher in addition to logging task completion. Though slightly different in methodology, all three of these studies provided participants with specific tasks to complete while conducting their own daily activities. This makes the paradigms more representative of a typical PM task, yet they offer additional experimental control that participant-derived naturalistic tasks do not. On the other hand, because the PM tasks are experimenter-derived, and often are fairly arbitrary, providing the participant with little internal motivation to complete them, these paradigms are believed to be less naturalistic than a participant-derived paradigm, yet more naturalistic than a quasi-naturalistic paradigm. To more systematically evaluate the construct and ecological validity of PM tasks types, the current study will compare an experimenter-derived naturalistic PM task paradigm with a traditional lab-based PM task paradigm that meets McDaniel and Einstein's (2006) criteria for measuring PM in a controlled lab setting such that it yields an accurate representation of an individual's PM functioning in everyday life. This lab-based paradigm was chosen as it is consistent with those typically used in the field.

Self- and Other-Report Methods of Evaluating PM

Another, more controversial, method of measuring PM abilities more naturalistically is through the use of self- or other-report questionnaires. According to Herrmann (1983), memory questionnaires can involve self- or other-appraisals of memory in terms of forgetting or remembering, differences in memory ability over time, and the types of strategies implemented to enhance remembering. Over the years several different questionnaires have been developed to measure the types of everyday memory errors typically made by specific sub-groups of individuals (e.g., those who experienced a traumatic brain injury [TBI] during their daily lives). Some of these measures include the Everyday Memory Questionnaire (Sunderland, Harris, & Gleave, 1984), The Memory Functioning Questionnaire (Gilewski & Zalinski, 1988), and the Inventory of Everyday Memory Experiences (Hermann & Neisser, 1978). However, these measures were developed to assess more general memory ability and included only a small number of PM-specific items (Crawford et al., 2003; Shum et al., 2002). By the mid-1990s, there was a realization in the field that differentiating RM errors from PM errors provided useful and important information. As a result, there was a shift in focus towards developing PM specific assessment measures.

Hannon and colleagues (1995) developed the first PM-specific questionnaire called the Prospective Memory Questionnaire (PMQ). The PMQ consists of 52-items comprising four subscales: (1) long-term episodic PM, (2) short-term habitual PM, (3) internally cued PM, and (4) techniques to assist memory. It was found to have high internal consistency (Cronbach's $\alpha = 0.78 – 0.92$) and test-retest reliability (0.64 to 0.88), depending on the subscale investigated. It was also found to be able to discriminate significantly between the TBI and control groups (i.e., normal students and healthy retirees; Hannon et al., 1995). Relatedly, Smith and colleagues (2000) developed the Prospective Retrospective Memory Questionnaire (PRMQ), which aimed to assess the frequency of both retrospective and PM errors in everyday life or in clinical settings (Kliegel & Jäger, 2006). The PRMQ is a 16-item questionnaire that is equally divided into items measuring everyday retrospective and PM errors. A study conducted by

Kliegel and Jäger (2006) aimed to investigate how actual PM performance was related to scores on the PRMQ. The researchers found that the PM subscales of the PRMQ, but not the retrospective memory subscales, predicted PM performance as measured by objective PM tasks, suggesting that the PM subscales tap into the same skills as lab-based PM tasks.

The Comprehensive Assessment of Prospective Memory (CAPM) questionnaire was developed by Roche and colleagues (2002). Similar to the PMQ and PRMQ, the CAPM measures the frequency of daily PM failures. Unlike the PMQ and the PRMQ, the CAPM also evaluates the perceived amount of concern associated with the reported memory lapses as well as the reasons individuals feel they are successful or unsuccessful in carrying out their intended actions (Roche et al., 2002). Therefore, the CAPM yields information about an individuals' everyday PM, their beliefs and self-awareness into their memory ability, and their preferences for compensatory devices or strategies (Chau, Lee, Fleming, Roche, & Shum, 2007). The current version of the CAPM was designed for use with people with TBI, but it has been found to be a stable (adequate test-retest reliability) and reliable (adequate internal consistency) measure of individuals' self-reported PM failures in a non-clinical community sample of individuals aged 15 to 60 years old (Chau et al., 2007). Because the CAPM has been found to exhibit adequate internal consistency and test-retest reliability estimates in assessing individuals' perceived frequency of everyday PM failures it will be used as a self-report measure of PM in the current study.

Though the abovementioned self-report measures of PM failures have been found by some researchers to demonstrate adequate validity and reliability estimates, others have argued that they are neither reliable nor valid. Specifically, Uttl and colleagues

(2013) argue that self-report PM questionnaires do not represent valid measures of PM ability because they are unduly influenced by a variety of other factors that are unlikely to influence PM performance in a lab-based setting. The researchers state that because self-report measures of PM have been found to strongly relate to measures of busyness (Martin & Park, 2003), the number of activities and events an individual is engaged in (Uttl & Kibreab, 2011), and the frequency and quantity of memory strategies and external aids an individual employs (Uttl & Kibreab, 2011), they may not measure an individual's true PM ability. To investigate this claim, the current study will compare PM performance across self-report, lab-based, and naturalistic PM measures as the current PM and personality literature has focused primarily on these measurement contexts. In addition, as the population of interest is non-clinical in nature, it was decided to not use a clinical lab-based measure of PM.

Assessing the Validity of PM Measures

According to the Standards for Educational and Psychological Testing (2014), *validity* refers to the degree to which evidence and theory support the interpretations of test scores entailed by the proposed uses of tests. As previously identified, the validity of the various methods of measuring PM has been questioned in the literature. It is therefore important to systematically evaluate the construct validity of multiple PM measurement methods (e.g., lab-based, naturalistic, and self-report) to better understand the systematic relationships between these measures. According to Campbell and Fiske (1959), the best way to do this is by using a multi-trait multi-method (MTMM) matrix.

The MTMM matrix is used to evaluate both convergent and discriminant validity as it presents all the intercorrelations resulting when each of several traits is measured by each of several methods (Campbell & Fiske, 1959). A PM measure is thought to have high convergent validity if it is found to be highly correlated with other PM measures previously identified as exhibiting high construct validity (i.e., the measure has been found to be an accurate measure of PM [construct]). However, to establish construct validity, a PM measure must also be found to have high discriminant validity. That is, a PM measure must be found to have a low or zero-order correlation with valid measures of other constructs (e.g., working memory or attention). For example, if a lab-based PM measure is found to have a high correlation (e.g., Pearson $r = 0.5$ or more) with a valid measure of working memory or sustained attention, the lab-based PM task may not be measuring PM at all and may instead be measuring working memory/attention. As such, the lab-based PM measure would exhibit low discriminant validity and its construct validity would be in question. According to Campbell and Fiske (1959), a measure is considered to demonstrate strong construct validity only if it is found to have high convergent validity with more than one other measure of the same construct (e.g., PM) *and* high discriminant validity with more than one measure of a different construct (e.g., working memory). The current paper therefore aims to use the MTMM matrix to determine the validity of each of the three PM measurement methods (e.g., lab-based, naturalistic, and self-report methods) in measuring time- and event-based PM (e.g., multi-traits).

Ecological Validity

According to Sbordone (1996), ecological validity refers to the relationship between psychological test scores and a person's present and future functioning in *real-world settings*. It is a distinct form of validity in that its focus is on determining whether an outcome measure provides an accurate representation of an individual's real-world behaviour. In contrast, the ecological validity of PM measures has been largely ignored by PM researchers. Consequently, the relationship between current PM measures and everyday PM functioning is unclear. The current study also aims to evaluate the systematic differences between various PM measurement methods.

According to Franzen and Wilhelm (1996) there are two general aspects of ecological validity: (1) verisimilitude and (2) veridicality. Consideration of verisimilitude occurs during the design and development of a neuropsychological test measure. It refers to the similarity of the data collection method to the tasks and skills that are required of persons during their everyday lives. Conversely, the veridicality of a test measure is evaluated once the task has been designed. It refers to the extent to which the results of a test measure reflect or predict the behaviour in the open environment. As the naturalistic task and self-report measure are believed to best represent everyday tasks, it is thought that they will be more highly related to each other than to the lab-based PM task, increasing their ecological validity.

Personality, Personality Traits, and PM

According to the American Psychological Association (APA), personality refers to inter-individual variability in characteristic patterns of thinking, feeling, and behaving (APA, 2018). The study of personality is generally broken down into two broad areas: (1) understanding individual differences in specific characteristics (i.e., traits) and (2) understanding how personality traits come together to describe a person as an integrated whole (APA, 2018). The aim of the current study is to better understand how specific personality traits influence an individual's ability to successfully perform PM tasks. Although there are many different theories hypothesizing personality trait structures, the current study uses the Five Factor Model (FFM) of personality traits to better understand the influence of personality on PM performance. This is because the FFM is widely accepted and research on PM has predominately focused on this model (Cutler & Graf, 2007; McCabe et al., 2018; Pearman & Storandt, 2005; Smith, Persyn, & Butler, 2011; Uttl et al., 2013; Uttl & Kibreab, 2011).

Before describing the FFM, it is necessary to better understand what a personality trait is. Whereas *personality* refers to the overall characteristic patterns of thinking, feeling and behaving, *personality traits* are the specific distinguishing qualities or characteristics that best depict an individual and lead him/her to think, feel, and behave in a predetermined way (Denham, 2010). Personality traits are often described as trait adjectives (e.g., nervous, energetic, quiet, helpful, etc.) and there are thousands of such terms identified in the English language. Many personality traits overlap (e.g., nervous and jittery) and others are closely related (e.g., sad and scared). To summarize trait information into a manageable number of psychological constructs, factor analysis has typically been applied. Factor analysis is a statistical technique that sorts variables (i.e., personality traits) into groups of related traits that are generally independent of the other groups (McCrae & Costa Jr., 2008). Numerous psychology trait researchers have applied factor analysis and have yielded several competing theoretical personality trait structures (see McCrae & Costa Jr., 2008 and Matthews, Deary, & Whiteman, 2003 for a more comprehensive review).

Regardless of the theorized trait structure, contemporary personality trait conceptualizations make two key assumptions (1) that traits are stable over time and (2) that they directly influence behaviour (Matthews et al., 2003). For example, it is generally believed that although individuals' responses to situations may vary to a degree, most individuals will maintain a "core of consistency" (p. 3; Matthews et al., 2003) that is best defined as his/her/their 'true nature'. It is this stability that distinguishes personality traits from the more transient states of an individual (e.g., mood). Additionally, it is believed that it is the underlying physiological, psychological, and social bases of personality traits that exert causal influences on behaviour (Matthews et al., 2003).

Over the past 25 years the Five-Factor Model (FFM) of personality traits (see Tupes & Christal, 1961/1992) has risen to dominance in the field of personality trait research as it is the most widely accepted solution to the problem of describing personality trait structure (McCrae & Costa Jr., 2008). The FFM is sometimes referred to as 'The Big Five' (De Raad, 2000) and outlines five dimensions or 'domains' of personality traits which are composed of six facets – lower-level traits. Costa and McCrae (1990) defined the five domains of personality as Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (O, C, E, A, and N). Table 1 lists the six facets that encompass each of the five broad domains. Individuals are described as 'High' or 'Low' depending on the degree to which they identify with characteristics associated with each domain. That is, an individual who is high in neuroticism is believed to be highly anxious, tense, nervous, or fearful in most situations. In contrast, a person who is low in Extraversion is believed to lack energy, be shy, reserved, and non-dominant across most situations.

One may see how certain personality dimensions may exert either a positive or negative influence on PM. For example, those who are high in conscientiousness tend to be reliable and organized and may therefore be less likely to forget to carry out their intended actions compared to those who are low in this domain. Additionally, neuroticism may also influence an individual's ability to successfully perform daily PM tasks. Those who are highly anxious may be more likely to forget to carry out tasks due to their high level of distractibility (Cuttler & Graf, 2007; 2009; Graf, 2012; Scott et al., 2016). In contrast, individuals high in neuroticism may instead be better able to remember to carry out their intended actions because they are too fearful of the natural consequences associated with forgetting to do something important given that the perceived importance of a task has been associated with better PM performance (see Penningroth & Scott, 2013a; 2013b). This fear may be further heightened depending on the social motivation associated with the task and/or a person's perception of their own ability to accurately perform the task (e.g., metamemory). For example, a PM task may be more likely to be remembered by individuals who are high in neuroticism and/or low in extroversion when its completion affects others or they perceive themselves as being unable to carry out the task successfully. This is believed to be because the social motivation associated with the task and/or a person's metamemory ability increase the task's perceived importance (see Einstein & McDaniel, 2007; Penningroth, Scott, & Freuen, 2011).

Of course, the relationship between specific personality traits and PM may also be mediated and/or moderated by other intrinsic and extrinsic variables previously identified as influencing PM performance (i.e., strategy use, task importance, metamemory, social motivation). For instance, individuals with Obsessive Compulsive Disorder (OCD) who exhibit high levels of checking behaviours (i.e., are high in neuroticism) also demonstrate deficits in metamemory and PM compared to those with OCD who do not exhibit checking compulsions (Graf, 2012). Graf (2012) therefore hypothesized that there is a cyclical effect whereby the increased experience of PM failures contributes to lower metamemory which increases compulsions to check, thereby increasing their level of neuroticism. Relatedly, individuals who perceive a task as more important or who perceive their PM abilities to be weak are also more likely to use strategies to improve their memory for an action (McDonald-Miszczak, et al., 2010; Penningroth & Scott, 2013b).

Table 1. Trait facets associated with each of the Big Five factors in Costa and McCrae's (1990) FFM.

Neuroticism	Anxiety, impulsiveness, vulnerability, angry hostility, depression, self-consciousness.
Extraversion	Warmth, assertiveness, activity, excitement seeking, gregariousness, positive emotions.
Openness	Feelings, actions, ideas, values, aesthetics, fantasy
Agreeableness	Modesty, altruism, straightforwardness, tender-mindedness, trust, compliance
Conscientiousness	Order, dutifulness, deliberation, self-discipline, achievement striving, competence

Review of research on PM and Personality

A relatively recent systematic review and meta-analysis of the literature investigating the influence of personality on PM was conducted by Uttl and colleagues (2013). Results from their literature search yielded a total of 13 studies that assessed relationships between PM measures and personality factors. Of the 13 studies, seven reported relationships between objective measures of PM and the Big Five personality traits and four reported relationships between self-report PM measures and the Big Five. Three additional studies investigated the relationship between objective measures of PM and other, non-Big Five personality factors whereas one study investigated the relationship between non-Big Five personality factors and self-report measures of PM. Of note, studies using sub-clinical samples (i.e., compulsive checkers, schizotypal personality disorder) were excluded from their review.

Overall, results from Uttl and colleagues' (2013) meta-analysis indicated that the Big Five personality domains of openness, conscientiousness, and agreeableness are weakly positively related to performance on objective measures of event-based PM tasks measured in laboratory settings, with correlation coefficients (*r*s) ranging from 0.09 to 0.10. The authors also identified issues with power that they argue may have influenced the observed lack of relationship. In addition, the authors found self-report measures of PM failures to be negatively correlated with conscientiousness and agreeableness, meaning individuals with more frequent self-reported PM errors tended to have lower levels of conscientiousness and agreeableness. However, it is important to note that this conclusion was based primarily on only two large studies and the validity of self-report measures of PM failures has been questioned.

Following completion of their meta-analysis, Uttl and colleagues (2013) identified some methodological issues that they believed further complicated and limited the interpretation of previous findings as well as those of their meta-analysis. The first issue they identified was that previous researchers often did not report the reliabilities of either their PM measure or their personality measure. This makes it impossible to determine whether the small correlations observed between PM and personality measures were due to the use of inadequate measures or represent the true relationship between these abilities. Secondly, PM performance in a number of past studies was limited by ceiling effects, potentially reducing the observed correlation with personality. Thirdly, several studies calculated correlations between PM and personality factors across all study participants irrespective of the different experimental (e.g., compulsive checkers vs. non, individuals with high vs. low state anxiety) and/or age groups individual participants belonged to. Consequently, the correlations reported in these studies may better reflect group differences rather than associations between PM and personality. For these reasons, the current study will calculate and report reliability coefficients for each measure, limit the probability of ceiling effects on the PM measures, and will investigate the differential relationships of PM and personality factors across experimental contexts.

Following the results obtained from their meta-analysis, and considering the methodological limitations of past studies, Uttl and colleagues (2013) conducted a follow up study examining the relationship between episodic PM, Big Five personality factors, verbal intelligence, and retrospective memory in undergraduate students. To rectify the methodological limitations of past studies, the researchers assessed episodic PM using reliable continuous measures of PM and two different reliable measures of personality. Findings from their study were consistent with those obtained in their meta-analysis and indicated that event-based episodic PM assessed in a lab setting was not associated with any of the Big Five personality factors.

The limited observed relationship between personality factors and PM performance is surprising, as intuitively, it appears that personality traits, such as conscientiousness, should be strongly related to PM performance. For example, people who exhibit high levels of conscientiousness are generally believed to follow through with their intentions. They are reliable. They attend their appointments, are on time, remember and follow through with their promises, and are well-organized (Costa & McCrae, 1992; Cuttler & Graf, 2007; Goldberg, Johnson, Eber, Hogan, Ashton, Cloninger, et al., 2006). People who are more conscientious have also been found to engage in more careful planning of how to successfully execute their intentions, and, in so doing, are more likely to be successful in completing them (Cuttler & Graf, 2007). Similarly, Gondo and colleagues (2010) found conscientiousness to be associated with lower frequencies of self-reported everyday PM failures.

The weak relationship observed between PM and conscientiousness is argued to be influenced by the environmental context in which PM is being measured (Uttl et al., 2013). For example, Uttl and colleagues (2013) argue that the tightly controlled nature of lab-based experiments may limit the number of opportunities an individual's personality may have to influence performance on the PM task. The authors further posit that personality factors may be more influential when PM is assessed more naturalistically. More specifically, they argue that personality may indirectly influence PM performance by increasing the likelihood that an individual would employ external strategies to aid their memory. This hypothesis is supported by Uttl and Kibreab's (2011) finding that conscientiousness is correlated with self-reported use of PM strategies and aids. This hypothesis is further supported by interactionist perspectives of personality, which state that the association between personality traits and cognitive performance depends on environmental factors, including the amount of stimulation or threat present during testing (Matthew, Deary, & Whiteman, 2003). Depending on the trait, the environmental context may be advantageous or disadvantageous. For example, Eysenck and Eysenck (1985) found that individuals who were low in extroversion or high in neuroticism tended to perform more poorly on cognitive tasks when the testing environment was arousing or stressful (i.e., lab-based environment vs. busy daily life). To investigate the environment-sensitivity hypothesis further, the current study will compare the relationship between personality factors and PM performance across contexts (e.g., lab-based and naturalistic).

A similarly surprising finding is the lack of relationship observed between PM and neuroticism. As outlined above, neuroticism refers to the degree to which an individual is emotionally labile (McCrae & Costa Jr., 2008). Therefore, those who are high in neuroticism are prone to negative affect including anger, depression, and anxiety (Costa & McCrae, 1992). As identified above, anxiety and depression have been found to negatively impact individuals' performance on PM tasks (Harris & Cumming, 2003). However, this line of research has found differential effects of depression and anxiety on subtypes of PM. For example, Harris and Cumming (2003) found individuals high in state anxiety, not trait anxiety, to perform more poorly on event-based, but not time-based, PM tasks. Similarly, Arnold, Bayen, and Böhm (2015) found state anxiety to be negatively correlated with event-based PM. Additionally, Arnold and colleagues failed to find a relationship between trait anxiety or depression with event-based PM. In contrast, Yanqi and colleagues (2013) found individuals with high levels of self-reported depressive symptoms performed significantly worse on time-based, but not event-based PM tasks. Consequently, the lack of relationship observed between neuroticism and PM performance may be heavily influenced by the tendency for PM and personality researchers to not distinguish between the two subtypes of PM. It is possible that neuroticism may be more highly related to time-based PM and not event-based PM. In fact, a more recent study conducted by McCabe and colleagues (2018) found that after adjusting for demographics and general cognition, higher neuroticism and lower levels of openness were independently associated with decreased lab-based time- and event-based PM performance in older adults. Additionally, the authors found that lower conscientiousness was the only personality factor that predicted self-reported everyday PM failures. As this is the first known study to investigate the differential role of personality factors on event- and time-based PM, the current study aimed to determine whether neuroticism will be differentially related to event- and time-based PM across multiple PM measurement methods, including naturalistic, in a young adult population.

Limitations of Current Research on Personality and PM

As previously outlined, research investigating the role of personality on PM has yielded inconsistent findings. It has been hypothesized that such inconsistencies are attributable, at least in part, to several methodological issues associated with the experimental paradigms being used to investigate this relationship (Uttl et al., 2013). In particular, Uttl and colleagues (2013) identified five specific methodological shortcomings in past research, including: (1) the use of self-report measures of PM, (2) the use of binary outcome measures of lab-based PM, (3) the presence of ceiling effects, (4) the inconsistency of PM subtype investigated, and (5) ignoring the role of context in PM performance.

The first methodological issue identified by Uttl and colleagues (2013) was the tendency for researchers to use self-report measures of PM that lacked convergent and divergent validity. For example, Uttl and Kibreab (2011) found self-report measures of PM to show no or only weak correlations with reliable objective measures of PM and RM performance. Based on this finding, Uttl and colleagues (2013) and Uttl and Kibreab

(2011) argued that self-report measures of PM performance should not be considered valid measures of PM ability and should therefore not be used as a primary method to evaluate PM performance. To evaluate this claim, the current study will include a lab-based, naturalistic, and self-report measure of PM.

A second methodological issue is that PM measures employed to investigate the role of personality typically use non-continuous, binary success/failure outcome measures to represent PM performance (Uttl et al., 2013). This is argued to be unrepresentative of true PM abilities, which are believed to be continuous and likely normally distributed. Similarly, the use of a binary scale of measurement yields an imprecise and unreliable measure of PM ability that artificially attenuates its relationship with other variables concurrently being investigated. Relatedly, Uttl and colleagues (2013) identified that researchers also tend to use objective PM measures that suffer from ceiling effects. Ceiling effects occur when large proportions of the sample population perform the PM task perfectly. When this occurs the possible magnitude of correlations found between PM scores and measures of other constructs are reduced. The current study therefore will attempt to rectify these limitations by including PM outcome measures that better capture the variability of this ability in the sample population.

The fourth methodological issue outlined by Uttl and colleagues (2013) is that researchers rarely explicitly state the form of PM being investigated (i.e., episodic, habitual, etc.). By not collecting and/or separating data into PM subtypes, a potential confound is created because different forms of PM may relate differently to personality traits. To date, only one recent study investigated the independent influence of personality traits on the commonly differentiated subtypes of PM – time-based and event-based, but they did so, using an older adult population (McCabe et al., 2018). The current study will therefore investigate the differential relationships between the PM subtypes of time- and event-based PM and personality in young adults using PM measures that meaningfully separate these PM subtypes (event- and time-based).

The final methodological issue Uttl and colleagues (2013) identify is that researchers have not distinguished the differential influence of personality on PM performance in different testing contexts (e.g., naturalistic vs. lab-based environments). The researchers argue that it is possible that secondary factors (i.e., strategy use) may moderate the relationship between different personality traits and PM performance depending on the context used to measure it. The current study will therefore include lab-based and naturalistic PM measures to better elucidate the influence of context on the influence of personality on PM performance.

Current Study

Interest in the influence of personality on PM performance has increased as theories about the neuropsychology of personality have begun to emerge. However, the extant research on this relationship is argued by Uttl and colleagues (2013) to be methodologically flawed in several important ways, leading to inconsistent findings. One of the major criticisms of such studies is their use of "invalid" self-report measures of PM performance to investigate this relationship. Similarly, the ecological validity of lab-based measures of PM has also been called into question (see Talbot, 2015) and has not been adequately examined to-date.

The primary aim of the present study is to investigate the validity of lab-based, naturalistic, and self-report measures of PM performance using Campbell and Fiske's

(1959) MTMM approach. The MTMM approach allows for systematic evaluation of the discriminant, convergent, and ecological validity of each method of PM measurement by comparing them to other PM measures and contrasting them with measures of other constructs (e.g., working memory and attention). It is believed that the naturalistic and self-report measures of PM will be most highly correlated to each other, with the lab-based PM measure yielding little to no correlation with the other PM measures. This will provide evidence for both convergent and ecological validity of the naturalistic and self-report PM measures. As lab-based measures of PM have been argued to better represent working memory measures (see Talbot, 2015), it is hypothesized that the lab-based measure will be more highly correlated with the working memory measures, providing evidence against the convergent validity of the lab-based PM measure. It is also hypothesized that the naturalistic and self-report measures of PM will be more weakly, though significantly related, to both the working memory and attention measures as these processes have consistently been found to relate to, yet be distinct from, PM (Groot et al., 2001; Rose et al., 2010). This finding would therefore provide support for the divergent validity of these PM measurement methods. A sub-goal associated with the primary aim of the current study is to address several of the methodological issues associated with typical PM methods of measurement, as outlined by Uttl and colleagues (2013). Specifically, a more continuous method of measuring PM performance will be employed (where possible) to increase between- and within-subject variability and decrease the risk of ceiling and/or floor effects. It is felt that this will help increase the reliability (e.g., internal consistency) of each of the PM measures used in the study.

Given that previous studies investigating the influence of the Big Five personality traits on PM have generally not differentiated between PM subtypes (event- and time-based) despite evidence suggesting differences in the cognitive processes underlying their successful performance, the secondary goal of the present study is to investigate the differential influence of all five Big Five personality traits on both event-based and time-based PM performance across three different PM measurement methods (lab-based, naturalistic, and self-report). Since this is the first known study to do this, few specific predictions can be made. Given previous findings (see Arana, Meilan, & Perez, 2008; Cuttler & Graf, 2007; McCabe et al., 2018; Uttl et al., 2013; Pearman & Storandt, 2005; Smith, Persyn, & Butler, 2011), it is anticipated that the Big Five personality traits of neuroticism and conscientiousness will be most highly positively correlated with measures of PM. Although, it is unknown whether this relational pattern will remain stable across PM subtypes and/or measurement methods.

Method

Participants

Two-hundred and twenty healthy young adults (172 females, 45 males, 2 non-binary), predominately of European descent (71.8%), between the ages of 18 and 25 years (mean age 20.53 years) participated in all three parts of this study (e.g., lab-based, naturalistic, self-report). They were recruited primarily through the University of Victoria SONA psychology student participant recruitment website and via word of mouth. Each eligible participant received course credit and had their name put into a draw to win a $150 gift card to the university bookstore to be awarded at the end of the study.

Any adult (regardless of gender identity, race, ethnicity, class, or position), who was between the ages of 18 and 25 years, had access to a mobile device with camera capabilities, could demonstrate adequate proficiency in English (reading and writing), and did not have a pre-existing neurodegenerative condition [i.e., epilepsy] or moderate/severe acquired brain injury resulting in cognitive dysfunction was eligible to participate in the study (see Table 1 for further sample characteristics). These criteria were chosen to maximize generalizability of findings to a typical university student population. Based on inclusion criteria, only one participant was excluded from participation due to the acquisition of a moderate brain injury with persistent cognitive difficulties. All participants provided university-approved informed consent prior to commencing the study.

Materials

PM Tasks

Ongoing Task: n-back task. A 2-back working memory task, similar to that used by Jäger & Kliegel (2010), was used as the ongoing task for both the lab-based event- and time-based tasks so as to equate the demands and characteristics of the ongoing task for each PM task type Participants viewed pseudorandomized sequences of the Snodgrass and Vanderwart (1980) pictures displayed on a computer screen. Each object was displayed for a 1000-millisecond interval with a pause of 1500-milliseconds between stimuli. Participants were asked to press the "left arrow key" on the keyboard, marked with a green sticker, if the stimulus they observed was the same as that which had been presented two stimuli before. If the stimulus was not the same, participants were instructed to press the "right arrow key" with a corresponding red sticker on the keyboard. Participants did not receive any feedback about the accuracy of their responses. The 2-back task consisted of 144 trails in total and lasted a maximum of 6 minutes and 30 seconds. The order of the stimuli was pseudo-randomized, with "No" responses restricted to occur on 70% of the trials and "Yes" responses on only 30% of the trials. As per Verhaeghen and Basak's (2005) recommendations, performance on the n-back task was defined as the number of correct responses (correct rejections and hits) for each participant. Proportion accurate across all 144 trials was calculated and used for data analysis.

Prior to introducing the PM task, participants completed a shortened version consisting of only 48 trials (with 14 additional initial training trails), serving as a practice of the 2-back task. Following the completion of lab-based PM tasks, participants completed an additional 48-trial ongoing task only (without the PM tasks embedded) condition, which served as a measure of baseline ongoing task performance and provided an additional measure of working memory performance. To investigate the impact of the addition of the PM cue on ongoing task performance, *n*-back response accuracy (proportion of correct responses) was measured in the ongoing task only and lab-based PM tasks (event- and time-based).

Lab-based PM Task

Event-Based PM Task. The event-based PM task was to remember to press a target key each time a picture of a panda bear or elephant appeared on the screen during the ongoing n-back task. Similar to the n-back task, the target animals (e.g., panda, elephant) were pseudorandomized in that they appeared a total of 6 times over the course of the 6-minute ongoing task. The discrepancy between PM cue onset and participants' response time was recorded and served as a continuous measure for each PM cue. Additionally, the sum of discrepancies for the overall event-based task was computed to provide an overall measure of event-based PM performance. Higher discrepancies are associated with poorer event-based PM performance.

Time-Based PM Task. The time-based PM task is similar to that described by Kliegel and Jäger (2005). Participants were asked to remember to press a target key at 1-minute intervals starting at the commencement of the ongoing task. To monitor the passage of time, a digital timer was displayed for 3000-millisecond intervals every time a participant pressed the space bar on the computer keyboard. Consistent with the event-based PM task, discrepancy scores were recorded for each PM target (positive and negative values were permitted to correspond to responses occurring before or after the PM-related response was required) and a sum of the latency scores was computed and served as an overall measure of participants' time-based PM performance. As with the event-based task, higher discrepancies on the PM task corresponded to poorer time-based PM performance.

Naturalistic PM Task

This novel task was developed as a task for measuring both event- and time-based PM within a naturalistic setting. For this task, participants were asked to carry out a researcher-generated set of eight PM tasks (four event-based and four time-based) over the course of two weeks (see Appendix 1 for a list of PM tasks). Participants were asked to complete a predefined action either at a specific time (e.g., 12pm; time-based PM task) or in response to an external cue (e.g., seeing a coffee shop; event-based PM task). Each PM task was given to participants via email/text before 9am the day they were required to carry out the task. This resulted in different delay times between initial task formation and execution depending on the task requirement for that day. The general instructions were provided to the participants during the lab-based portion of the experiment. "Target days" and PM cue-types were randomly selected to minimize the chance of habitual remembering. Thus, participants may have been asked to engage in a PM task on any day and at any time between 8am and 9pm for the 14 days following completion of their lab-based tasks.

Following completion of a successful PM task, participants were asked to email/text the examiner with "proof" of completion (e.g., a picture with a time stamp). As an added incentive to complete the task, participants earned an extra ballot entry for the draw for each successfully completed PM task when the examiner received "proof" of completion (maximum of 8 tasks for a total possible ballot entry amount of 9). If the participant successfully carried out all 8 PM tasks, they earned an extra 3 ballot entries, taking the possible number of draw entries to 12 (with the initial ballot entry earned for completing the lab-based portion of the study). If the examiner did not receive confirmation of successful PM task execution by 9 pm on the target day, a follow-up e-mail/text was sent to the participant enquiring about the non-completed PM trial. If the participant forgot to complete the PM task for that day, the trial was recorded as failed and the participant did not receive a ballot entry for that task. This was done to mimic a natural consequence for not having remembered to complete the PM task.

The data collected from this task was the sum of the discrepancy in participants' response times from the indicated response time (in milliseconds) for the time-based PM tasks. Unlike the lab-based event-based tasks, there was no way to calculate when participants encountered the event-based cue that should trigger the PM intention to calculate the discrepancy in their response time. Therefore, the total number of accurately completed event-based PM tasks was the only available method for calculating naturalistic event-based PM performance.

Self-Report PM Task

Comprehensive Assessment of PM Questionnaire (CAPM). The CAPM is a self-report questionnaire that was originally designed to evaluate the frequency of PM failures in people with brain injury. It has also been found to provide a measure of PM failures in non-brain injured individuals between the ages of 15 and 60 (Chau, Lee, Fleming, Roche, & Shum, 2007) with acceptable internal consistency (total CAPM Cronbach's $\alpha = .94$) and good test-retest reliability (total CAPM ICC > 0.75). The CAPM consists of 54 items and takes approximately 10 to 15 minutes to complete. It is subdivided into three sections. Section A measures the frequency of PM failures (39 items), section B measures the perceived amount of concern about these memory lapses (same 39 items), and section C asks individuals to identify perceived reasons why they are successful or unsuccessful in performing PM tasks (15 items). Items are rated on a five-point scale ranging from "Never" to "Very Often," with lower scores corresponding to better PM functioning.

In the original study using the CAPM conducted by Waugh (1999), a principal component analysis of Section A yielded two components: basic activities of daily living (i.e., daily self-care activities) and instrumental activities of daily living (i.e., household management activities) with adequate internal consistency. This provides preliminary evidence to support the ecological validity of the CAPM.

Items in Section A of the questionnaire could not be subdivided into event- and time-based PM items. Therefore, the overall total score on Section A of the questionnaire will be used in the evaluation of the validity of PM measures.

Intelligence. The National Adult Reading Test (NART) was used as a crude measure of participants' intellectual functioning. For this task participants were asked to read aloud a list of 50 irregular words of increasing complexity. The number of errors made was calculated and used to predict a Full-Scale IQ (FSIQ), which was then recorded. The predicted FSIQ score was used to screen out individuals who were cognitively compromised and therefore not eligible to participate in the study. No participants were excluded from the study based on this criterion.

Strategy Use Questionnaire

Memory Aids Questionnaire (MAidQ). The MAidQ is a 27-item questionnaire developed by Uttl (2002) that measures the frequency of use of various memory aids and strategies. Memory aids and strategies are differentiated into two categories- internal (e.g., “I associate to-be-remembered information with other things”) and external (e.g., “I use built-in alarms in cars, ovens, etc. to remind me to do something”). Fifteen of the 27 items focus on aids and strategies aimed at promoting PM performance, eight items focus on aids and strategies aimed at promoting RM performance, and four items can be classified as promoting either PM or RM. Items are rated using a 7-point scale ranging from “Never” to “Always”.

Unlike Uttl (2002), responses on each item was summed to generate total scores for each scale (RM, PM, and total), with higher scores suggesting more frequent use of memory aids and strategies. Scores on each scale were compared to performance scores across lab-based, naturalistic, and self-report measures of PM to evaluate the role of strategy use on PM performance.

Personality Measure

Big Five Inventory (BFI). The BFI is a 44-item self-report inventory developed by John, Donahue, and Kentle (1991) that measures an individual on the Big Five Factors of personality. Participants were asked to evaluate the extent to which they agree or disagree with each item as a description of themselves using a 5-point Likert scale.

The BFI has been found to be a reliable (Cronbach’s α of .83), stable (test-retest reliability of .85), and valid (e.g., convergent and divergent relationships with other commonly used Big Five instruments; see John & Srivastava, 1999) measure of personality. Total scores on each of the factors for the self-report BFI were calculated and used to investigate the differential relationship between personality factors and PM measures.

Demographic Questionnaire. The demographic questionnaire consisted of questions aimed at identifying basic demographic variables (i.e., age, gender, ethnicity) and lifestyle variables hypothesized to impact prospective memory performance in everyday life (e.g., student/work status, number of classes taken, hours worked, involvement in extracurricular activities, mental health diagnosis, substance and alcohol use frequency).

Attention Tasks

Brief Attention. The Digit Span-Forward subtest of the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV) was used as a measure of brief attention (Cullum & Larrabee, 2010). Participants heard a sequence of numerical digits and were tasked to recall the sequence correctly. The length of the sequence increased by one digit after every two trials. Participants discontinued the task when they made two errors on both trials of a given sequence length (e.g., scored 0 on both trials of a 4-digit sequence). Participants received a score of 1 for every correctly recalled sequence. Scores across all trials were summed and the sum was used to evaluate the discriminant validity of the personality and PM measures used in the study.

Sustained and Selective Attention. The 12-minute, computerized Continuous Performance Test (CPT) from the NIH-sponsored Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research (EXAMINER) project was used as a measure of visual sustained and selective attention (Kramer, Kreuger, & Sinha, 2011). Participants were asked to respond by pressing a target key as quickly as possible whenever they saw a white five-pointed star (target image). When an alternative, non-target image, appeared on the screen (e.g., a white four-pointed star), participants were instructed to refrain from pressing the target key. This version of the CPT contained 100 trials (80% of trials consisted of the target image) and is designed to elicit false alarm errors (e.g., pressing the target key for a non-target image).

The total number of correct responses (e.g., participants accurately pressed/not pressed the target key), correct detections (e.g., participants correctly pressed the target key in response to seeing the target image), omissions (e.g., participants did not respond when a target image appeared), and commissions (e.g., participants pressed target key in response to non-target image) were calculated. Higher rates of correct detections indicate better visual attentional capacity. High omission rates indicate high levels of distractibility and/or slow responding, and high commission error rates indicate impulsive responding. These measures were used to evaluate the discriminant validity of the personality and PM measures used in the study. The EXAMINER project CPT has been found to have an internal consistency reliability coefficient of .78 in adults (Kramer, Kreuger, & Sinha, 2011).

Working Memory. In addition to the 2-back task that was used as the ongoing task for the lab-based PM tasks, the Digit Span-Sequencing subtest of the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV) was used as a measure of verbal working memory. Participants heard a sequence of numerical digits and were tasked to remember and recite the sequence in numerical order starting with the smallest number first. The length of the sequence presented to the participants increased by one digit after every two trials. Participants discontinued the task when they made two errors on both trials of a given sequence length (e.g., scored 0 on both trials of a 4-digit sequence). They received a score of 1 for every correct response. Scores across all trials were summed and this value was used to evaluate the discriminant validity of the PM measures used in the study.

Procedure

All participants included in the study completed and a brief eligibility screening questionnaire via email prior to being invited to participate in the full study (see Appendix 2). All eligible participants (i.e., did not have a pre-existing neurodegenerative condition [i.e., epilepsy] or moderate/severe acquired brain injury resulting in cognitive dysfunction) individually completed and submitted the demographic questionnaire and the Big Five Inventory (BFI) online prior to coming to the laboratory to complete the lab-based portion of the study. In the lab, participants individually completed the Digit Span Forward and Sequencing Subtests of the Wechsler Adult Intelligence Scale-IV (WAIS-IV), the Continuous Performance Test (CPT), and the lab-based event- and time-based PM measures with the researcher present in a quiet room at the University of Victoria. The order in which the tasks were administered was varied, with the event- and time-based PM tasks counterbalanced, to minimize any potential order or practice effects. Following this, participants were asked to complete the naturalistic PM tasks on their own on 8 different days over a two-week span. Following completion of the naturalistic PM measure, participants completed and submitted the Memory Aids Questionnaire (MAidQ) and the Comprehensive Assessment of Prospective Memory (CAPM) to ensure they received full course credit.

During testing, a counterbalanced number of participants first completed the 2-minute practice of the *n*-back ongoing task prior to receiving instructions on how to complete either the event-based or time-based PM task. Following adequate understanding of the instructions, participants completed the 10-minute PM task. Participants then completed the two digit span subtests of the WAIS-IV, the 20-minute CPT, the NART, and the second 10-minute PM task, taking approximately 50 minutes to complete depending on the participant's working memory ability. At the end of the lab session, participants were debriefed about the specifics of the experimental paradigm and the experimenter demonstrated and explained the instructions of the naturalistic PM task (see Appendix 3 for specific details on how participants were informed about the task).

Following the lab session, an email/text message was sent to the participant's computer/mobile device that contained an additional set of written instructions for the naturalistic task. The email/text also provided the first PM task (counterbalanced event- or time-based). After completion of the first PM task, participants received an email/text the morning that the PM trial was to be executed (sent anytime between 8 and 9am). Over the course of the naturalistic task, participants were asked to complete 8 different PM tasks on 8 different days over the span of two weeks. Each PM task trial was expected to take a maximum of five minutes to complete and involved only the participant. Following each individual PM trial execution, the participant was required to send an email/text with a picture denoting task completion with a time stamp. Following completion of the naturalistic PM task, participants were asked to complete and submit the MAidQ and CAPM.

Data Preparation. Based on rule-out criteria, only one participant was excluded due to a history of experience of a moderate to severe concussion with loss of consciousness. Additionally, participants with missing data were not included in the following statistical analyses (11 of 230, 4.8%). Of those 11 participants, 8 (72%) were missing data from the two final questionnaires (CAPM and MAidQ), 1 participant (9%) was missing data from the two initial questionnaires (Demographic questionnaire and BFI), and 2 participants (18%) voluntarily withdrew during the naturalistic task portion (on tasks 1 and 2) of the study. A final sample size of 220 was included in the below analyses except for the naturalistic time-based discrepancy scores, which included an N = 215 due to missing data required to calculate the discrepancy score. For explanatory purposes, for some analyses only those participants (N=108) were included who had the opportunity to carry out all four naturalistic event-based tasks (N = 108). See Table 3 for a summary of sample sizes.

All data was examined for univariate outliers, defined as scores falling more than three standard deviations away from their corresponding means. Nineteen univariate outliers (i.e. < .001%) were discovered and, similar to Cuttler and Graf (2007), were replaced with the nearest non-outlying value. This means that 19 values were found to be greater than $\pm$3 standard deviations from their respective mean and replaced with the next highest non-outlying value.

Results

Main Analyses

Overview. Based on the two-pronged goal of the current study, two sets of data analyses were completed. To systematically evaluate the convergent, discriminant, and ecological validity of the three different PM measurement methods in evaluating event- and time-based PM separately using the MTMM approach, descriptive statistics including the mean, range, and standard deviation of each of the variables were generated to help identify any possible problems (e.g., ceiling and/or floor effects or low variation) with any of the PM measurement methods. Next, a MTMM correlation matrix including time- and event-based PM measures was derived. The matrix included Pearson *r* correlation coefficients between the three PM measurement methods (lab-based, naturalistic, and self-report) as well as between the auditory (Digit Span Sequencing) and visual (*n*-back ongoing task) working memory tasks, and the sustained visual (CPT) and simple verbal (Digit Span Forward) attention tasks. Following this, a direct (or inferential) comparison of the correlation coefficients was conducted using Williams' procedure (p. 261-262 of Howell, 2007). This was used to help determine if the correlations between the PM measurement methods significantly differed depending on the type of PM being measured (e.g., event- vs. time-based). The comparison also helped to determine whether the relationships between PM subtype and attention and working memory differed, therefore informing the discriminant and/or convergent validity of each of the PM measurement methods.

In addition, a series of regressions using the two working memory tasks and two attention tasks were regressed onto the lab-based, naturalistic, and self-report PM scores. A comparison of R^2 coefficients and standardized beta coefficients were completed to determine if WM/attentional ability accounts for more of the variance in PM scores on the lab-based task than the naturalistic and self-report measurement methods.

Preliminary Analyses. Means, standard deviations, and ranges for all supplemental subtests are provided in Table 2. Means, standard deviations, ranges, and sample sizes for all time-based, event-based, and total PM tasks across lab-based, naturalistic, and self-report measurement contexts are provided in Table 3. A multi-trait multi-method correlation matrix of PM measurement subtypes across different measurement contexts is included in Table 4. It is worth mentioning that mean scores on the CPT, $\overline{X}_{\text{CPT}} = 79.82$, $SD = 0.85$, and both the lab-based event-, $\overline{X}_{\text{LabEB}} = 5.46$, $SD = 0.91$, and time-based total correct scores, $\overline{X}_{\text{LabTB}} = 5.12$, $SD = 1.29$, were near ceiling, suggesting limited variability in scores and decreased ability to detect significant effects in statistical analyses. However, to facilitate comparison across other studies using similar variables, CPT correct detection scores and lab-based total correct scores were still used in the below analyses.

Lab-based PM Tasks

Retrospective memory performance. All participants demonstrated intact retrospective memory for both the event-based and time-based task instructions following completion of the task.

Evaluating the reliability of the lab-based PM Tasks. Reliability analyses of the Lab-Based PM tasks yielded a Cronbach's alpha value of 0.66 for the total scale, 0.77/0.76 for the Time-Based PM Tasks total score/discrepancy scores, and 0.58/0.82 for the Event-Based PM Tasks total score/discrepancy scores, indicating limited internal consistency on the total scale and event-based PM task (using total scores), but adequate to good internal consistency using the time-based and event-based discrepancy scores and adequate internal consistency using the time-based total scores.

Delay between PM task instructions and task initiation. The delay period between the initial explanation of the event-based PM task and its initiation, $\overline{X}_{\text{LabEBdelay}} = 2.82$, $SD = 0.91$, was compared to that of the delay between the time-based PM task, $\overline{X}_{\text{LabTBdelay}} = 2.78$, $SD = 1.03$, to determine whether differences in delay period could explain differences in PM task performance. The delay period did not differ between the two PM subtypes, $t_{delay}(217) = -.625$, $p < .05$. Additionally, neither the time-based or the event-based delay periods were found to be significant predictors of time- or event-based PM performance, respectively, $F_{\text{LabEB}}(1, 216) = 2.48$, $p > .05$, $Adj\ R^2 = .007$; $F_{\text{LabTB}}(1, 216) = .113$, $p > .05$, $Adj\ R^2 = -.004$.

Ongoing task and PM performance. Percent accuracy was calculated for both ongoing task performance (event-based, time-based, and *n*-back only) and PM performance (event- and time-based). Mean percent accuracy scores in ongoing task (*n*-back task) and PM (event- and time-based PM) were compared using *t*-tests (see Figure 1). Ongoing task percent accuracy was not significantly different between the two PM subtypes, $\overline{X}_{\text{EBOngoing}} = 88.78$, $SD = 4.07$, $\overline{X}_{\text{TBOngoing}} = 88.58$, $SD = 4.79$, $t(219) = -.077$, $p > .05$, indicating that participants performed similarly well on the *n*-back ongoing task, regardless of which lab-based PM task they were completing. In contrast, participants performed significantly better on the *n*-back only task, $\overline{X}_{\text{Ongoing}} = 93.63$, $SD = 5.47$, than they did on the *n*-back task when the event-, $t(219) = 14.74$, $p < .001$, and time-based, $t(219) = 14.66$, $p < .001$, PM tasks were embedded within it, suggesting that the addition of the PM tasks came at a small, but significant cost to ongoing task performance (i.e., monitoring cost).

Prospective memory performance across PM subtypes was also evaluated (See Figure 2). Participants performed significantly better on the lab-based event-based PM task, $\overline{X}_{\text{LabEBtotal}}$= 91.06, *SD* = 15.14, than they did on the lab-based time-based PM task, $\overline{X}_{\text{LabTBtotal}}$= 85.30, *SD* = 21.46, performance (percent accuracy). This, together with the ongoing task accuracy data, suggests that though participants had more difficulty accurately completing the time-based PM tasks, their ongoing task performance was similar to that of their event-based. This indicates that the addition of the PM cue results in a similar decrease in ongoing task performance regardless of the PM subtype being embedded. Ongoing task performance, however, was found to be a significant predictor of time-based total correct scores, $F_{OG+TB}(1, 218) = 11.77$, $p < .05$, $Adj\ R^2 = .047$ but not event-based total correct scores, $F_{OG+EB}(1, 218) = 1.50$, $p > .05$, $Adj\ R^2 = .002$, suggesting that participants' working memory ability is a better predictor of lab-based time-based PM performance than it is for event-based PM.

Relationship between total scores and discrepancy scores. To evaluate the relationship of the two methods used to evaluate lab-based PM performance (e.g., total correct vs. total discrepancy [sum of the discrepancy in participants' response times from the indicated response time]), Pearson correlation coefficients were calculated for time- and event-based PM (see Table 3 and Figure 5). There was a statistically significant large negative relationship between time-based PM total correct and total discrepancy scores, $r = -.798$, $p < .001$, and a statistically significant moderate positive relationship between event-based PM total correct and total discrepancy scores, $r = .480$, $p < .001$. This means that for lab-based time-based PM, participants who had better overall performance (more PM tasks completed accurately) scores tended to perform tasks more closely to the time at which they were expected to perform the task (e.g., have smaller overall discrepancy scores). In contrast, participants who performed better on the lab-based event-based task tended to have higher discrepancy scores. A comparison of the two correlation coefficients using the modified version of the Pearson-Filon statistic (*ZPF)* indicated that the lab-based time-based PM performance measurements were more strongly related than the lab-based event-based PM ones, $ZPF = -17.46$, $p < .001$ (see Figure 5).

Naturalistic PM Tasks

Retrospective memory performance. Retrospective memory was not explicitly assessed during the naturalistic tasks. Performance on the below tasks may therefore be related to RM or PM failures. However, participants were asked at the end of the target day their reasoning for not completing the task. Errors were categorized as follows: forgot to complete task, forgot to send proof of task completion, forgot to check email for task instructions, performed the task late/early, did not have an opportunity to complete the task that day, and did not respond. Figure 3 demonstrates the percentage of errors based on error type separated by naturalistic event- and time-based tasks. Overall, individuals who did not complete the event-based tasks more often reported that it was due to forgetting to complete the task altogether, suggesting either a RM or PM failure. In contrast, individuals who scored '0' on the time-based task forgot to complete the event-based tasks

Evaluating the reliability of the Naturalistic PM Tasks. Reliability analyses of the Naturalistic PM tasks yielded a Cronbach's alpha value of 0.39 for the total scale, 0.32 for the Time-Based PM Scale, and 0.55 for the Event-Based PM Scale, indicating limited internal consistency across all scales.

PM Performance. Figure 2 demonstrates the observed differences in PM performance (percent accuracy) across PM subtypes. Paired samples *t*-test results indicated that participants performed similarly on the event-based PM task, $\overline{X}_{\text{NatEBtotal}}$= 65.57, *SD* = 27.54, as they did on the time-based PM task, $\overline{X}_{\text{NatTBtotal}}$= 62.72, *SD* = 26.87; $t(219) = -1.16$, $p > .05$.[1]

Relationship between time-based total scores and discrepancy scores. Because event-based discrepancy scores could not be calculated for the naturalistic paradigm, a single Pearson correlation coefficient depicting the relationship between the naturalistic time-based PM performance measurement methods (e.g., total correct vs. total discrepancy) was computed (see Table 3). There was a statistically significant moderate negative relationship between time-based PM total correct and total discrepancy scores, $r = -.304$, $p < .001$, indicating that participants who performed better on the naturalistic time-based PM task also tended to respond more closely to the appropriate time in which to respond (e.g., had smaller total discrepancy scores).

Self-Report PM Errors.

Evaluating the reliability of the CAPM. Reliability analyses of the CAPM yielded a Cronbach's alpha value of 0.90 for the total scale, 0.73 for the Basic Activities of Daily Living (BADL) Scale, and 0.85 for the Instrumental Activities of Daily Living (IADL) Scale, indicating excellent internal consistency on the overall scale. For the purposes of this study, the total scale score was used for analyses.

[1]*There was no significant difference in overall performance on naturalistic event-based PM scores when participants were excluded for missing data (e.g., did not have the opportunity to perform the event-based task on the target day;* N *= 108). Analyses using naturalistic event-based PM scores were therefore completed using all 220 participants to improve overall power of the study.*

Relationship between CAPM scores, lab-based, and naturalistic PM performance. Because the CAPM questions could not be easily separated into time- and event-based PM errors, comparisons between PM subtypes could not be completed. Instead, correlational analyses between the CAPM total scale score, total naturalistic PM tasks correct, and total lab-based PM tasks correct were obtained. CAPM total scale scores were found to have a small, yet statistically significant negative association with naturalistic time-based PM performance, $r_{NatTB} = -.200$, $p < .001$, but no association with naturalistic event-based PM, $r_{NatEB} = -.097$, $p > .05$, or lab-based PM (event- or time-based) performance, $r_{LabEB} = -.099$, $r_{LabTB} = -.078$, $ps > .05$. This indicates that participants who reported more daily PM errors on the CAPM tended to complete fewer naturalistic PM tasks. However, there was no observable relationship between the frequency of participants' self-reported PM errors and their performance on the lab-based PM tasks.

To investigate the relationship between the three PM measurement methods more closely, a series of regression models systematically using total and PM subtype specific performance measures as predictors and outcome variables was conducted. Overall, lab-based PM performance (total event- and time-based correct) was not found to be a significant predictor of naturalistic PM task performance (total event-and time-based correct), $F_{lab}(1,218) = 2.10$, $p > .05$, $Adj\ R^2 = .005$, or CAPM scores, $F_{lab}(1,218) = .008$, $p > .05$, $Adj\ R^2 = -.005$. In contrast, naturalistic PM performance was found to be a significant predictor of CAPM scores, $F_{Nat}(1,218) = 7.65$, $p < .05$, $Adj\ R^2 = .029$, but not of lab-based PM performance, $F_{Nat}(1,218) = 2.10$, $p > .05$, $Adj\ R^2 = .005$. When broken down further by subtype, the lab-based time-based discrepancy score was not a significant predictor of naturalistic time-based discrepancy, $F_{labTBdisc}(1,213) = .002$, $p >$

.05, *Adj* R^2 = -.005 and lab-based time-based total correct score was not a significant predictor of naturalistic time-based total scores, $F_{LabTBtotal}(1,218) = .793$, $p > .05$, *Adj* R^2 = -.001. Similarly, lab-based event-based total scores did not significantly predict naturalistic event-based total scores, $F_{LabEBtotal}(1,218) = 2.54$, $p > .05$, *Adj* $R^2 = .007$, yet naturalistic time-based, but not event-based, PM scores significantly predicted self-report CAPM scores, $F_{NatTB/EB}(2,217) = 5.20$, $p < .05$, *Adj* $R^2 = .037$; $t_{NatTB}(218) = -2.87$, $p<.05$, $t_{\mathrm{NatEB}}(218) = -1.13$, $p > .05$.

Evaluation of the MTMM Correlation Matrix

A comprehensive multi-trait multi-method correlation matrix was derived to investigate the interrelationships between PM performance subtypes, PM measurement methods, and measures of working memory, attention, and PM strategy use (see Table 4). Overall, few significant relationships amongst PM subtypes, measurement methods, and working memory and attention subtypes were found.

Time-based PM Performance Correlates. There were significant small negative correlations between naturalistic time-based performance scores (total correct and total discrepancy), $r = -.290$, $p < .001$, and between CAPM total scores (total error frequency) and naturalistic time-based total scores, $r = -.200$, $p < .001$, but not with naturalistic time-based total discrepancy scores, $r = .104$, $p > .05$. There were no other significant relationships between time-based PM scores. Therefore, participants who reported more frequent daily PM errors tended to complete fewer naturalistic time-based PM tasks.

Event-based PM Performance Correlates. There was a significant moderate positive relationship between event-based PM total correct and total discrepancy scores, $r = .480$, $p < .001$, and a significant, though weak, negative relationship between lab-based event-based discrepancy scores and naturalistic time-based total correct scores, $r = -.135$, $p < .05$. Conversely, no other significant relationships between event-based PM performance measures or CAPM scores were found. This means that participants who performed better on the lab-based event-based PM task tended to take longer to press the appropriate key in response to the event-based cue. Additionally, participants who performed better on the lab-based event-based task also tended to perform fewer naturalistic time-based tasks.

Self-Report Correlates. Apart from the significant relationship between CAPM total error scores and naturalistic time-based total correct scores, CAPM scores were only found to have a significant moderate positive relationship with MAidQ-PM subscale scores (frequency of PM strategy use), $r = .208$, $p < .001$. This indicates that participants who self-reported more daily PM errors also tended to use more PM-related memory strategies.

Working Memory Correlates. Performance on the *n*-back visual working memory task was found to be significantly positively related to lab-based time-based PM total correct scores, $r = .166$, $p < .05$, and negatively related to lab-based time-based total discrepancy scores, $r = -.208$, $p < .001$. *N*-back performance was not significantly related to any event-based PM tasks, naturalistic PM tasks, or the CAPM self-report measure. As expected, it was also significantly related to the other working memory task in the battery (DSS scores), $r = .155$, $p < .05$ and the visual sustained attention task (CPT), $r_{CPT} = .202$, $p < .001$, but not the simple verbal attention task (DSF scores), $r_{DSF} = -.045$, $p > .05$. This means that participants who performed better on the *n*-back task also tended to perform better on the lab-based time-based PM task as evidenced by higher total correct scores and lower total discrepancy scores, the verbal working memory task, and the sustained visual attention task. In contrast, DSS (verbal working memory) scores were found to be significantly positively related to DSF scores (simple verbal attention), $r = .256$, $p < .001$, and CPT scores (sustained visual attention), $r = .146$, $p < .05$, and negatively related to naturalistic time-based PM total correct scores, $r = -.169$, $p < .05$. This means that participants with stronger verbal working memory also tended to have stronger verbal and visual attention abilities. However, these participants also tended to perform fewer naturalistic time-based tasks.

Attention Correlates. Similar to the *n*-back task, scores on the sustained visual attention task (CPT) were significantly negatively related to lab-based time-based PM total discrepancy scores, $r = -.149$, $p < .05$. Although, CPT performance was not significantly related to any other PM performance measure. Taken together, participants with stronger visual sustained attention abilities tended to perform better on the lab-based time-based PM task as evidenced by lower total discrepancy scores. Conversely, DSF scores (simple verbal attention) were significantly positively related to DSS, $r = .256$, $p < .001$, but negatively related to naturalistic time-based performance scores, $r_{NatTBtotal} = -.133$, $p < .05$; $r_{NatTBdisc.} = -.157$, $p < .05$, and naturalistic event-based total scores, $r = -.135$, $p < .05$. This suggests that participants who exhibited stronger simple attention abilities tended to perform worse on naturalistic time- and event-based PM tasks (total correct), despite demonstrating less discrepancy in their naturalistic time-based responses.

Comparing TB and EB Correlations. Direct inferential comparisons of the correlation coefficients between time- and event-based PM subtypes using Williams' procedure were conducted (see Table 6). Overall, the majority of the correlation values between event-based PM tasks did not significantly differ from those obtained from correlations with time-based PM tasks suggesting few systematic differences between PM subtypes. Nonetheless, there were a few exceptions to this. The two PM subtypes significantly differed in the magnitude of their correlations between lab-based discrepancy scores and the n-back task, with lab-based time-based discrepancy scores being more strongly, though negatively, related to *n*-back task performance than the event-based discrepancy scores, $r_{TB} = -.208$, $r_{\text{EB}} = .034$, $t(217) = -2.57$, $p < .05$ (see Figure 4). Additionally, a direct comparison of the relationships between lab-based time- and event-based discrepancy scores and total scores using the modified version of the Pearson-Filon test statistic revealed that the time-based correlation was significantly stronger than the event-based correlation, $r_{TB} = -.819$, $r_{\text{EB}} = .480$, $ZPF = -17.46$, $p < .001$ (see Figure 5). This suggests that the lab-based time-based PM performance scores were more closely related to each other than the lab-based event-based PM performance measures were.

Evaluating role of IQ, working memory, and attention in predicting PM performance. A series of hierarchical regression analyses, controlling for IQ, were conducted to investigate the differential roles of working memory and attention measures on PM performance across contexts. IQ was controlled for because initial bivariate analyses indicated that IQ was significantly related to visual working memory (*n*-back task), $r = .204$, $p < .001$, verbal working memory (DSS), $r = .225$ $p < .001$, and simple verbal attention (DSF), $r = .234$ $p < .001$. Therefore, the effect of IQ was entered in block one and both working memory and attention tasks were entered simultaneously in block two (see Table 7 for partial correlations). It is noteworthy that IQ was not found to be a significant predictor of any PM performance measure when entered on its own or when entered simultaneously with the working memory and attention measures. Specifically, Block 1 *Adj* R^2 values ranged from -.004 on the lab-based event-based PM and self-report tasks to .009 on the naturalistic time-based PM task (see Table 8). This suggests that IQ on its own accounts for less than 1% of the variance in PM scores. Regression results indicated that the predictors that were significant varied depending on the PM performance subtype and measurement method being investigated. When IQ, working memory, and attention measures were entered simultaneously into Block 2 of the regression model, the overall regression equation was found to fit the pattern of lab-based time-based PM total discrepancy scores significantly better than the null hypothesis, $F_{LabTBDisc}(5,211) = 2.52$, $p < .05$, *Adj* $R^2 = .034$. Although the same simultaneous regression model demonstrated a tendency towards providing a better fit to the naturalistic time-based total correct scores, it did not reach significance, $F_{NatTBtotal}(5, 211) = 2.24$, $p < .055$, *Adj* $R^2 = .028$.

When looking at the specific roles of the working memory and attention measures in predicting PM performance, *n*-back and DSF scores were the only two measures found significantly predict PM performance, though their predictive abilities varied depending on the PM performance variable being investigated. For example, *n*-back scores were found to be a significant predictor of lab-based time-based PM discrepancy scores, $t(216) = -2.63$, $p < .05$, and demonstrated a trend towards significance in predicting lab-based time-based total correct scores, $t(216) = 1.92$, $p < .06$. In contrast, DSF was found to be a significant predictor of naturalistic time-based PM total discrepancy, $t(216) = -2.38$, $p <$

.05, and exhibited a trend towards significance in predicting naturalistic event-based PM total correct scores, $t(216) = -1.94$, $p < .055$. This suggests that those with stronger visual working memory abilities generally remembered to complete more lab-based time-based PM as evidenced by higher total scores and smaller overall discrepancy scores. Additionally, participants with stronger simple verbal attention abilities generally performed time-based tasks more accurately, as evidenced by smaller overall discrepancy scores. However, stronger verbal attention skills also tended to result in fewer accurately completed naturalistic event-based tasks.

Comparisons of *Adj* R^2 coefficients were completed to determine if IQ/WM/attentional ability accounted for more of the variance in PM scores on the lab-based task than the naturalistic and self-report measurement methods. IQ, working memory, and attention, when entered together in a single block, were found to account for between 0.4% to 3.4% of the variance in PM performance depending on the subtype and method of measurement being investigated, suggesting they play a limited role in predicting PM performance overall. Having said that, these cognitive variables were found to account for the most variance in lab-based time-based PM discrepancy scores, *Adj* R^2 =.034, and the least amount of variance in the naturalistic event-based total scores, *Adj* R^2 = .004. The highest amount of variance in naturalistic PM performance accounted for by the cognitive variables was in their prediction of naturalistic time-based PM total correct scores, *Adj* R^2 = .028. Taken together, this suggests that lab-based (particularly time-based) PM task performance is more reliant on WM/attentional ability than the naturalistic and self-report tasks are.

Comparisons of the unstandardized B values using 95% confidence intervals of each predictor variable when entered simultaneously into the regression model (e.g., Block 2) for each PM performance outcome variable were also completed (see Figures 6 to 13). This provided an indication of whether the working memory and attention variables systematically differ in their ability to predict PM performance. Though each pattern of prediction is different depending on the PM performance variable being used, there are some similarities across methods. For example, 1-unit changes in PM performance, regardless of subtype and/or measurement method used, most often resulted in the largest magnitude of change (from zero) in unstandardized B values on the CPT, except for in the prediction of lab-based event-based total correct scores. More specifically, when compared to the other cognitive measures, CPT scores were found to differentially predict lab-based time-based total scores and discrepancy scores, lab-based event-based discrepancy scores, naturalistic time-based total discrepancy scores and naturalistic event-based total scores. Performance on the *n*-back and DSS, but not DSF, tasks were found to differentially predict lab-based time-based total discrepancy scores. However, DSF, but not *n*-back or DSS tasks, differentially predicted naturalistic time-based total discrepancy scores and naturalistic event-based total scores. In contrast, DSS, but not DSF or *n*-back tasks, differentially predicted CAPM scores.

Study Goal 2.

The second goal of the study was to investigate the differential relationship between all five Big Five personality traits and event- and time-based PM separately. Similar to the above analyses, a series of regression analyses for each PM subtype were computed employing each personality trait as a predictor of each PM measurement method. For example, for time-based PM measured using the naturalistic PM task:

Model 1: openness only

Model 2: conscientiousness only

Model 3: extraversion only

Model 4: agreeableness only

Model 5: neuroticism only

Model 6: simultaneous regression employing all five personality traits entered as a single block

From there, the R^2 and y-intercepts for each of the regression models were compared. This was done to identify whether personality traits systematically differ in their ability to predict PM performance. In addition, it helped identify which personality trait(s) share(s) a stronger predictive relationship with each PM subtype and corresponding measurement type.

Evaluating the reliability of the BFI. Reliability analyses of the BFI yielded a Cronbach's alpha value of 0.70 for the total scale, 0.79 for the Openness Scale, 0.77 for the Conscientiousness Scale, 0.86 for the Extraversion Scale, 0.73 for the Agreeableness Scale, and 0.83 for the Neuroticism Scale, indicating adequate internal consistency on the total, openness, conscientiousness, and agreeableness scales and good internal consistency on the extraversion and neuroticism scales.

Bivariate relationships between PM Performance Measures, Lifestyle Variables, and Personality Traits. Exploration-based Pearson r (for relationships between continuous variables) and point-biserial (for relationships between dichotomous and continuous variables only) correlations were calculated between PM subtypes and demographic variables across lab-based, naturalistic, and self-report measurement contexts (see Table 9) to determine whether any demographic variables may help to explain some of the variation in the observed relationships between PM performance and personality traits. Small but significant, relationships were found between self-report PM and gender, rPB = -.134, p < .05, self-report PM and substance use, rPB = .175, p < .001, lab-based event-based discrepancy scores and work, rPB = .137, p < .05, and lab-based event-based discrepancy scores and mental disorder, rPB = .133, p < .05. This suggests that males or substance users tend to self-report more PM errors than females or non-substance users. Additionally, participants who performed worse on the lab-based event-based task (i.e., had higher discrepancy scores) tended to be those who worked or who had been diagnosed with a mental disorder. Age, IQ, extracurricular involvement, and alcohol use were not found to be significantly related to any type of PM performance, regardless of PM measurement method used.

Lab-based PM Performance. Regression analyses (see Table 10) indicated that for lab-based PM tasks, conscientiousness was a significant predictor of lab-based event-based PM total correct scores when entered on its own, $F_{LabEBtotalConsc.}(1,216) = 4.91$, $p < .05$, $Adj\ R^2 = .018$, and when entered simultaneously with the other personality traits, $F_{LabEBtotalAll}(5,212) = 1.74$, $p > .05$, $Adj\ R^2 = .017$; $t_{consc.}(216) = -2.60$, $p < .05$. However, no other personality traits were found to predict lab-based time- or event-based PM performance. This means that participants who reported lower levels of conscientiousness generally tended to accurately complete more lab-based event-based tasks.

Naturalistic PM Performance. Agreeableness was found to be a significant predictor of naturalistic time-based PM total correct scores when entered on its own, $F_{NatTBtotalAgree.}(1,216) = 4.67$, $p < .05$, $Adj\ R^2 = .017$, but not when it was entered together with the other four personality traits, $F_{NatTBtotalAll}(5,212) = 1.48$, $p > .05$, $Adj\ R^2 = .011$; $t_{agree}(216) = 1.71$, $p > .05$. In addition, neuroticism was found to be a significant predictor of naturalistic event-based PM total correct scores when it was entered simultaneously with the other personality traits, $F_{NatEBtotalAll}(5,212) = 1.36$, $p > .05$, $Adj\ R^2 = .008$; $t_{neuro}(216) = 2.12$, $p < .05$, but not when it was entered on its own [$F_{NatEBtotalNeuro.}(1,216) = 2.68$, $p > .05$, $Adj\ R^2 = .008$]. Notably, when participants with missing data were excluded (*N = 108)* from these analyses (e.g., did not have the opportunity to complete one or more naturalistic event-based tasks), no personality types were found to be significant predictors of naturalistic event-based PM when entered individually or simultaneously. No other personality traits were found to predict naturalistic time- or event-based PM performance. This suggests that once the interrelationships between neuroticism and the other personality traits have been controlled for, participants who self-reported higher levels of neuroticism generally performed better on the naturalistic event-based PM task.

Self-Report CAPM Errors. Conscientiousness, agreeableness, and neuroticism were found to be significant predictors of CAPM total scores when they were entered on their own, $F_{CAPMConsc.}(1,216) = 53.26$, $p < .001$, $Adj\ R^2 = .194$; $F_{CAPMAgree}(1,216) = 5.94$, $p < .05$, $Adj\ R^2 = .022$; $F_{CAPMNeuro}(1,216) = 15.75$, $p < .001$, $Adj\ R^2 = .064$. Of note, only conscientiousness and neuroticism remained significant predictors of CAPM total scores when all personality traits were entered simultaneously, $F_{CAPMAll.}(5,212) = 13.10$, $p < .05$, *Adj* R^2 = .017; $t_{consc.}(216) = -6.41$, $p < .001$; $t_{Neuro}(216) = 2.77$, $p > .05$; $t_{Agree}(216) = -0.41$, $p > .05$. This suggests that individuals who report more frequent PM errors generally have higher levels of conscientiousness or lower levels of neuroticism.

Comparisons of *Adj* R^2 coefficients for each personality trait across measurement methods were completed to determine if specific personality traits accounted for more of the variance in PM scores on the lab-based, naturalistic, and self-report tasks (see Table 10). Openness and extraversion, when entered as single predictors into the regression model, were found to account for less than .5% of the variance in PM performance. Conscientiousness accounted for between 0.0% (naturalistic event-based total scores) to 19.4% (self-report CAPM scores) of the variance whereas agreeableness was found to account for between 0.0% (naturalistic event-based total scores) to 2.2% (self-report CAPM scores). In addition, neuroticism was found to account for less than 1% of the variance in the majority of the PM performance measures, with the exception of self-report CAPM scores, where neuroticism was found to account for 6.4% of the variance. When all five personality traits were added into a single regression model, they accounted for the most variance in self-report CAPM scores (*Adj* R^2 = .218) and the least amount of variance in lab-based time-based total scores and naturalistic event-based total scores (*Adj* $R^2_{labTBtotal} = -.008$, *Adj* $R^2_{natEBtotal} = .008$). Overall, conscientiousness was the personality trait found to account for the most amount of variance (in self-report CAPM scores) when added independently, but the simultaneous addition of all five personality factors together accounted for the most variance overall (in self-report CAPM scores). This suggests that personality traits, on their own, play a limited role in lab-based and naturalistic PM performance.

Comparisons of the unstandardized B values using 95% confidence intervals of each predictor variable when entered individually and simultaneously into the regression model (e.g., Block 2) for each PM performance outcome variable were also completed (see Figures 14 to 21). This provided an indication of whether the personality traits systematically differed in their ability to predict PM performance. Openness was found to differ from conscientiousness and agreeableness in its prediction of lab-based time-based discrepancy scores, with openness predicting discrepancy scores in the negative direction and conscientiousness and agreeableness predicting scores in the positive direction. Conscientiousness was found to significantly differ from the other four personality traits in its prediction of lab-based event-based total correct scores, with conscientiousness and neuroticism predicting scores in the negative direction and the other personality traits predicting scores in the positive direction. Conscientiousness was also found to have a significantly larger (though negative) unstandardized B value suggesting it predicted significantly more of the variance in lab-based event-based total correct scores than the other personality traits. Neuroticism significantly differed from openness and extraversion in its prediction of naturalistic event-based total correct scores, predicting scores in the positive direction, whereas the other two personality traits predicted scores in the negative direction. For the naturalistic time-based total correct task, agreeableness significantly differed from openness and neuroticism, with agreeableness predicting scores in the positive direction and openness and neuroticism predicting scores in the negative direction. Neuroticism also significantly differed from conscientiousness and extraversion, with neuroticism and conscientiousness predicting naturalistic time-based total correct scores in the positive direction and extraversion predicting scores in the negative direction. Finally, for the self-report CAPM scores, conscientiousness, neuroticism, and agreeableness were all found to significantly differ from the other personality factors in their prediction, with conscientiousness and agreeableness predicting scores in the negative direction and neuroticism predicting scores in the positive direction. Notably, the unstandardized B value for conscientiousness was found to be significantly greater than the other personality traits, indicating that it predicts more of the variance in CAPM total scores than the other personality traits. In contrast, it was found that none of the personality traits systematically differed in their ability to predict lab-based time-based total correct scores, lab-based event-based discrepancy scores, and naturalistic time-based discrepancy scores. Overall, there were few systematic differences in the personality traits' prediction of PM performance across all PM measurement contexts and subtypes.

Evaluating the reliability of the MAidQ. Reliability analyses of the MAidQ yielded a Cronbach's alpha value of 0.77 for the total scale, 0.64 for the PM Only Scale, and 0.42 for the RM Only Scale, indicating adequate internal consistency on the overall scale, but limited internal consistency for the PM and RM only subscales. For the purposes of this study, the PM only scale scores were used for the analyses below.

Investigating the role of memory aid strategy use on the relationship between personality and PM performance. Given the significant relationship between CAPM total scores and MAidQ-PM scores, an additional series of regression analyses exploring the relationship between personality factors on lab-based, naturalistic, and self-report measures, controlling for strategy use (MAidQ-PM scores) were carried out. MAidQ-PM was a significant predictor of CAPM total scores, $F(1, 216) = 9.78$, $p < .05$, $Adj\ R^2 =$

.039, but not of any lab-based or naturalistic PM performance measures (see Table 12). MAidQ-PM remained a significant predictor of CAPM scores, regardless of the personality trait added into the second block of the model. The addition of MAidQ into each regression model increased *Adj* R^2 values and improved the overall fit of each model. Interestingly, the addition of MAidQ into the model with all five personality factors accounted for the most variance in CAPM scores, $F(6,211) = 13.67$, $p < .001$, *Adj* $R^2 = .259$, increasing the amount of variance accounted for from 21.8% to 25.9%. In contrast, for all other PM task performance measures, the addition of MAidQ-PM reduced the overall fit of the models as well as their overall *Adj* R^2 values, though it did not change the interpretation of the predictive roles of each personality trait. Taken together, individuals with higher levels of conscientiousness and who report more frequent use of PM enhancing strategies, generally had lower rates of self-reported PM errors.

Investigating the effect of lifestyle on the relationship between self-report PM errors and Personality. Given the significant bivariate relationships observed between various personality traits and measures of lifestyle (e.g., number of classes taken, employment status, extracurricular involvement, mental health diagnosis, alcohol use, substance use), another series of regression analyses exploring the relationship between CAPM scores and conscientiousness, agreeableness, and neuroticism, controlling for memory strategy use and lifestyle was conducted. Overall, MAidQ scores and lifestyle variables, when entered together, significantly improved the fit of the model when compared to the inclusion of MAidQ on its own, $F_{MAidQ+Lifestyle}(7, 209) = 3.37$, $p < .05$, *Adj* $R^2 = .071$; $F_{MAidQonly}(1, 216) = 9.78$, $p < .05$, *Adj* $R^2 = .039$. This was evidenced by an increased *Adj* R^2 value from .039 to .071, indicating that the addition of lifestyle into the prediction model accounted for an additional 3.2% of the variance in CAPM scores. More specifically, MAidQ scores and substance use were found to be the strongest predictors of CAPM errors, $t_{MAidQ}(216) = 3.40$, $p < .001$; $t_{SubUse}(216) = 2.50$, $p < .05$. When conscientiousness, agreeableness, and neuroticism were added individually into block 2, MAidQ scores, substance use, and all three personality traits remained significant predictors of CAPM scores (see Table 12). It is worth mentioning that when compared to agreeableness and neuroticism, the addition of conscientiousness into the regression model, improved the fit of the model the most, accounting for 25.0% of the variance in CAPM scores. In contrast, the addition of neuroticism and agreeableness only accounted for 12.4% and 9.1% respectively. However, the addition of all personality traits simultaneously into block 2 of the regression model was found to account for the most variability in CAPM scores (25.9%), though only slightly. Taken together, a person's level of conscientiousness, the frequency of their use of memory aid strategies, and whether they engage in substance use appear to be the strongest predictors of the frequency of PM errors they report experiencing in their daily lives.

Reinvestigating the role of naturalistic PM performance on self-report PM. Naturalistic PM performance, specifically naturalistic time-based PM performance (total correct), was still found to significantly predict self-report CAPM scores even after controlling for PM memory strategy use, level of conscientiousness, and substance use engagement, $F_{total}(4,212) = 22.71$, $p < .001$, *Adj* $R^2 = .287$, with the addition of naturalistic time-based PM performance significantly improving the model fit, $R^2_{change} = .027$, $F_{change} = 8.03$, $p < .05$.

Investigating group differences in PM performance. To determine whether PM performance differed across subgroups of participants (i.e., substance users, alcohol users, diagnosed with a mental health disorder), a multivariate analysis of variance (MANOVA) that included the fixed factors of substance use engagement, alcohol use engagement, and presence of a mental health disorder diagnosis was completed. Results from the MANOVA indicated that there was not a statistically significant difference in PM performance (time-based, event-based, lab-based, naturalistic, self-report, total scores, or discrepancy scores) between individuals who engaged in substance use, $F(7, 92) = .546$, $p > .05$, Wilk's $\lambda = .960$, partial $\eta^2 = .040$, alcohol use, $F(7, 92) = .191$, $p > .05$, Wilk's $\lambda = .986$, partial $\eta^2 = .014$, or who had a diagnosed mental health disorder, $F(7, 92) = .653$ $p > .05$, Wilk's $\lambda = .026$, partial $\eta^2 = .047$.

Discussion

The present study examined the relationship between personality and PM performance in young adults. Using a systematic multi-trait multi-method approach, the study aimed to address the methodological limitations associated with current PM and personality research as outlined by a meta-analysis completed by Uttl and colleagues (2015). The study also aimed to investigate the influence of the Big Five personality traits on event- and time-based PM performance across lab-based, naturalistic, and self-report PM measurement methods. It was hypothesized that there would be a stronger relationship observed between self-report and naturalistic measures of PM performance, and limited to no relationships observed between lab-based measures of PM and self-report and naturalistic measures of PM. It was also thought that lab-based measures of PM would be more strongly related to cognitive measures of working memory and attention than naturalistic and self-report measures. In addition, it was hypothesized that the personality traits of neuroticism and conscientiousness would be most strongly related with PM measures; however, it was unknown as to whether the relational pattern between personality traits and PM would remain consistent across PM subtypes and measurement methods.

Summary of Main Findings

MTMM Results. Comprehensive analyses including the use of an MTMM matrix suggested few strong relationships between PM subtypes, measurement methods, and cognitive measures. That said, the strongest relationships were observed between same PM subtype and measurement method (i.e., lab-based time-based) performance indicators (e.g., binary total correct scores and continuous total discrepancy scores). This means that individuals who performed better on each PM task, tended to have higher total correct scores and smaller total discrepancy scores, with the exception of lab-based event-based performance, where larger discrepancy scores were associated with more successfully completed event-based PM tasks. These relationships were not so strong as to suggest that the PM performance measurement methods were similarly sensitive to changes in PM performance. Despite near perfect average percent accuracy rates on the lab-based PM tasks, considerable differences were still observed with participants performing significantly better on the event-based PM task than the time-based task. The addition of the PM task to the lab-based ongoing working memory task resulted in a similar decrease in accuracy in the ongoing task, irrespective of the PM task type (e.g., event- or time-based) that was embedded. In contrast, no significant differences between time- and event-based PM accuracy on the naturalistic tasks were found. As predicted, self-reported PM error frequency was moderately related to naturalistic, but not lab-based, PM task performance. Participants tended to perform significantly better on the lab-based PM tasks than they did on the naturalistic PM tasks, both overall and when looked at for each subtype.

The correlations observed between lab-based event-based PM, naturalistic event-based PM, self-report PM, working memory, and attention measures were generally similar to those observed between time-based PM, naturalistic time-based PM, self-report PM, working memory, and attention measures with a couple of exceptions. There was a significant difference in the strength of the relationship between lab-based PM discrepancy scores and lab-based total correct scores, with time-based performance measures being more strongly related than event-based. Additionally, the relationship between lab-based time-based PM and visual working memory was stronger than the relationship between lab-based event-based PM and visual working memory, with visual working memory being a significant predictor of lab-based time-based, but not event-based, PM performance.

There were significant, though weak-to-moderate relationships observed between all the cognitive measures included in the study, though few significant relationships were found between these measures and those of PM performance. After controlling for IQ, only visual working memory was found to be a significant predictor of lab-based time-based PM performance. Brief attention was also found to be a significant predictor of naturalistic time-based PM performance. However, comparison of *Adj* R^2 values suggested that lab-based (particularly time-based) PM task performance is more reliant on working memory/attentional ability than naturalistic and self-report measures were. Then again, a closer investigation of each of the prediction models indicated that the pattern of prediction varied depending on the PM performance subtype and measurement method being predicted. The only consistent pattern observed pertained to visual sustained attention scores in that 1 unit of change in CPT performance tended to correspond to larger magnitudes of change in the PM performance measure being predicted compared to the other cognitive predictors.

PM and Personality Results. Overall, the relationship between specific personality traits and PM performance tended to differ depending on the PM subtype and/or measurement method being investigated. Conscientiousness was found to be the strongest predictor of lab-based event-based PM performance, with those with lower levels of conscientiousness tending to perform better on lab-based event-based tasks. Agreeableness was the strongest predictor of naturalistic time-based PM performance, with individuals with higher levels of agreeableness tending to perform more naturalistic time-based PM tasks. In contrast, neuroticism was a better predictor of naturalistic event-based PM performance, with individuals who report higher levels of neuroticism tending to perform more naturalistic event-based PM tasks. In contrast, conscientiousness, neuroticism, and agreeableness were all found to significantly predict self-report PM errors, even after controlling for frequency of PM-specific memory strategy use and other lifestyle variables (i.e., number of classes being taken, employment status, extracurricular activity involvement, mental disorder diagnosis, alcohol use, and substance use). This means that individuals with lower reported levels of conscientiousness and agreeableness, but higher levels of neuroticism tended to report more frequent PM errors in their daily lives. Upon comparison of each of the prediction models, conscientiousness, PM memory strategy use, and engagement in substance use were found to be the strongest predictors of self-report PM error frequency. Memory aid strategy use and lifestyle variables were not found to be significant predictors of any lab-based or naturalistic PM performance measures. Notably, naturalistic time-based PM performance remained a significant predictor of self-report PM, even after controlling for memory aid strategy use, substance use engagement, and level of conscientiousness.

Overall Effect Sizes. Despite adequate power to detect significant effects for even small to moderate effect sizes, many of the effect sizes reported in the current study were weak to moderate in magnitude. This suggests that the following results should generally be interpreted with caution.

Differences in Binary vs. Continuous PM Performance Outcomes. According to Uttl and colleagues (2013, 2018), one of the major methodological shortcomings of current

PM and personality research is its reliance on binary, success/failure PM outcome measures. The authors argue that binary coding is imprecise, inefficient, unreliable, and provides an underestimate of the true population correlation. However, it is important to note that Uttl and colleagues (2013, 2018) were primarily referring to the use of *episodic* lab-based event-based tasks. The authors differentiate *episodic* from *vigilance/monitoring* lab-based PM tasks whereby *episodic* PM tasks occur once per testing session and *vigilance/monitoring* tasks may occur multiple times per session. It is therefore evident as to why the use of binary coding measures of a single episodic PM task would yield limited meaningful information about PM ability. The current study, conversely, utilised a more traditional *vigilance/monitoring* lab-based PM task paradigm whereby participants were asked to complete six event-based and six time-based PM tasks in one sitting. By doing this, a total score can be calculated, which permits more variability in responding. Although, like many other lab-based monitoring/vigilance PM task paradigms, meaningful interpretation of PM performance is limited by the presence of ceiling effects. To attempt to correct for these limitations, the current study implemented both a binary measure (total correct) as well as continuous measure of lab-based event- and time-based PM (total discrepancy time between PM cue initiation and PM task completion). Lending support to previously expressed criticism, the current study found average lab-based PM performance, as measured by total correct scores, to be near ceiling (especially the event-based PM task), with limited variability, and positively skewed sample distributions. This is further emphasized by the reduced internal consistency reliability value associated with the lab-based event-based PM total correct score ($\alpha = 0.58$) as compared to that of the lab-based time-based PM total correct score (α

= 0.77). In contrast, the continuous measures of lab-based and naturalistic time-based PM exhibited more variability, higher internal consistency reliability values ($\alpha_{event\text{-}based}$ = 0.82; $\alpha_{time\text{-}based}$ = 0.76), but they continued to demonstrate significant deviations from normality. Correlations between total scores and discrepancy scores were also found to be moderately, though significantly, correlated with each other suggesting that the continuous PM measurement method may provide a more precise and efficient measurement of PM performance. Unlike the lab-based PM measures, the naturalistic PM measures were limited in their measurement precision due to the decreased experimental control associated with them. For example, the naturalistic time-based PM discrepancy scores were recorded based on the difference in time (in minutes) between when the task was to be completed (e.g., 3:30pm) and when the experimenter received the email confirmation from the participant indicating that the task had been completed. The total sum of discrepancy scores across all four time-based tasks were then summed and converted to milliseconds (to allow for comparison with the lab-based time-based discrepancy scores) yielding a total discrepancy score. Due to the *vigilance/monitoring* nature of the lab-based PM task, discrepancy scores could be "maxed out" (e.g., assigned 60,000 ms) if the PM task was not completed before the next PM task needed to be executed. Unfortunately, this could not be done for the naturalistic time-based PM tasks due to their *episodic* nature. As a result, participants who forgot to complete one of the PM tasks were given a 0 for that task, which artificially limited the total overall discrepancy score, further limiting the precision and sensitivity of the overall naturalistic time-based PM task discrepancy scores. This is likely why the correlation between the naturalistic time-based total scores and discrepancy scores was much smaller (r = -.290) than the correlation between the lab-based scores (*r* = -.798), despite both correlations being statistically significant. It is also important to note that naturalistic event-based PM scores could not be generated as there was no way to know when the event-based cue was presented, further limiting comparisons between lab-based and naturalistic event-based tasks and decreasing the overall sensitivity of the naturalistic event-based PM performance measure, which also likely contributed to the marked decrease in reliability (internal consistency) of the naturalistic tasks overall ($\alpha_{NatEB} = 0.55$; $\alpha_{NatTB} = 0.32$).

Although there are benefits associated with the implementation of a more continuous measure of PM performance on the lab-based PM tasks, it is important to note that the current study found few interpretational differences between the two lab-based PM performance measures. However, the naturalistic time-based PM performance measures differed in their observed relationships with lab-based event-based total scores and with self-report PM error frequency scores. There was also a difference observed in the role of the cognitive factors (working memory and attention) on lab-based total and discrepancy scores such that the visual working memory test was a significant predictor of the time-based discrepancy scores, but not total scores. Relatedly, simple attention was found to be a significant predictor of naturalistic time-based discrepancy scores, but not total scores and agreeableness was found to be a significant predictor of naturalistic time-based total scores, but not discrepancy scores. In contrast, conscientiousness was found to be a significant predictor of lab-based event-based total scores, but not discrepancy scores. These observed differences may best reflect the limitations in measurement precision, sensitivity, and reliability or they may relate to familywise error rates resulting in cumulative type 1 error.

Differentiating Event- and Time-Based PM. The current study found significant differences between lab-based event- and time-based PM performance, with participants performing significantly better on event-based PM tasks than they did on time-based PM tasks. As observed by Jäger and Kliegel (2010), a cost effect was found with performance on the ongoing task decreasing slightly, though significantly, because of the addition of the PM task. Notably, ongoing task performance was similarly affected by the addition of the time- and event-based PM tasks, suggesting the presence of an interference effect. Unlike findings by Jäger and Kliegel (2010), but consistent with those of Logie and colleagues (2004) and Maylor and colleagues (2002), the observed interference effect was greater for time-based PM than event-based PM performance, suggesting that the time-based PM task was more difficult than the event-based task to perform while also completing a cognitively demanding visual working memory task. This, combined with the finding that the lab-based time-based PM task was more heavily reliant on intact visual working memory ability than event-based PM, lends support to theories suggesting time-based PM is more difficult to perform because of its higher reliance on the allocation of more higher-order cognitive resources.

Closer investigation of the differences between lab-based event- and time-based PM using the discrepancy score PM performance measures revealed that longer reaction times (as evidenced by larger total discrepancy scores) on the event-based PM task corresponded to better overall lab-based event-based PM performance (total correct scores). This finding is consistent with those observed by Marsh and colleagues (2002) and Jäger and Kliegel (2010) and provides support for the preparatory attentional and memory (PAM) processes view of PM proposed by Smith (2003). Based on this view, the increased discrepancy time in event-based PM task execution, accompanied by the decreased accuracy in ongoing task performance, suggests that attentional monitoring resources needed to be allocated to successfully execute the event-based PM task. Conversely, neither attention measure in the current study was found to significantly predict lab-based event-based PM performance (total discrepancy or total scores), though this may also be a result of ceiling effects on the sustained attention task.

Participants were found to perform significantly worse on naturalistic time- and event-based PM tasks compared to their performance on the lab-based PM tasks. This suggests that PM tasks are more difficult to complete in daily life, which is consistent with findings from several other studies (Fleming et al., 2009). According to Fleming and colleagues (2009), this is because real life places higher demands on executive functions and one's ability to perform dual tasks as compared to lab-based measures. Cauvin and colleagues (2019) have also argued that in naturalistic tasks, the PM task is unconstrained and distractions and impediments to performance are potentially infinite. For example, the level of perceived importance of the PM tasks may have influenced participant's motivation to perform both the lab-based and naturalistic tasks. On the lab-based task, participants are asked to complete a set of tasks with the experimenter present in the room, which may have increased their social motivation to perform the task accurately, thereby increasing the perceived importance of the task, resulting in better overall performance (Penningroth, Scott, & Freuen, 2011). In contrast, the naturalistic PM tasks were designed to be of neutral importance, with the only motivational factor related to being awarded an extra ballot entry into the draw for a $150 university bookstore gift card. As an experimenter was not physically observing participants while they carried out their daily tasks, the social motivation may have been less than that of the lab-based tasks. Then again, the experimenter did follow up with participants if she had not received confirmation of the PM task performance, suggesting there may have been some increased motivation for participants to not receive the follow up email. In a study conducted by Penningroth and Scott (2013a), participants were found to assign higher levels of importance to PM tasks that are related to their own personal goals or concerns. As the current study used naturalistic tasks that were unlikely to be related to participants' own goals, it is possible that they felt less motivation to complete them. Then again, this possible role may have been mitigated by the predominantly female population sample (females have been found to assign higher importance ratings to PM tasks than males overall [Penningroth & Scott, 2013a]) and/or the personality traits of the individual.

It is also important to note that the lab-based PM tasks were more consistent with *vigilance/monitoring* PM tasks whereas the naturalistic PM tasks are more consistent with *episodic* PM tasks. It is therefore possible that the significant differences in PM performance across tasks may be related to the type of PM being measured and not necessarily due to the context in which it was measured.

Naturalistic PM performance in the current study was not found to differ across PM subtypes. This is inconsistent with previous research conducted by Schnitspahn, Kavavilashvili, and Altgassen (2020), who found event-based performance in both lab-based and naturalistic PM tasks to be better than time-based PM performance in their sample of young adults. Based on initial theories of time-based PM and the current lab-based PM findings, it is surprising that performance was similar across both PM subtypes. One possible explanation for the lack of difference in performance is that performance on the event-based PM task may have been influenced by the lack of opportunity to encounter the PM cue (e.g., did not walk past a coffee shop or make a purchase that day). Anecdotally, some participants reported this when the experimenter followed up on their lack of response on the PM task day. However, when these participants were excluded from analyses, no significant changes in overall performance were observed. A second possible explanation may be that individuals employed memory aid strategies (e.g., reminders) to remember to carry out their time-based PM tasks, artificially increasing their time-based PM performance to a level comparable to their event-based PM performance. As strategy use during the naturalistic tasks was not recorded, this cannot be verified. Nevertheless, strategy use frequency was not found to be significantly related to naturalistic time- or event-based PM performance, so it is unlikely to provide the full explanation for the unexpected finding.

Contrary to theories and studies supporting the differentiation of event- and time-based PM, inferential comparisons between PM subtypes in terms of their relationships with the other measures in the study revealed few systematic differences between time- and event-based PM. There were only two significant differences found between time- and event-based PM performance. The first was found in their respective correlation with the visual working memory task, with lab-based time-based PM performance being more strongly related to visual working memory than event-based. This finding is consistent with previous research that demonstrate weaker relationships between event-based PM tasks and measures of executive functioning (Gonneaud et al., 2011, 2014). The second difference was in the respective relationships between lab-based discrepancy scores and total correct scores, with lab-based time-based performance scores being more strongly related than lab-based event-based performance scores. One possible reason for the smaller correlation between the event-based performance measures is related to ceiling effects. The average total score on the lab-based event-based PM task was 5.46 out of 6 (*SD* = .91), suggesting that the total score may provide a less accurate/precise and/or efficient indication of event-based PM performance. If the discrepancy score provided a more precise and accurate indication of event-based PM ability, a weaker relationship between the performance measures would be expected. It is also possible that the cognitive measures included in this study fail to adequately capture the systematic differences between the two PM subtypes. Based on previous studies, it is possible that other measures of set-shifting, inhibition, or self-monitoring may better capture differences between time- and event-based PM subtypes. Overall, there appears to be some evidence to support the differentiation of time- and event-based PM.

Differentiating PM Measurement Contexts. Consistent with initial predictions and previous findings (see Uttl & Kibreab, 2011; Raskin, Shum, Ellis, Pereira, & Mills, 2018; Talbot, 2015), the current study found self-report PM errors to be significantly related to, and predictive of, naturalistic PM task performance, but not lab-based PM performance. This is believed to be because the ecological validity of the lab-based tasks is much lower than the other two PM task types (Delprado, Kinsella, Ong, et al., 2012). It has been proposed that lab-based/standardized clinical cognitive measures may not be ecologically valid due to the strict circumstances in which they are carried out. Since a laboratory/clinical environment is so different from real-world situations, researchers have argued that there is little correspondence between the cognitive resources being tapped into in the laboratory condition and those allocated in real life (Burgess, Alderman, Evans, & Emslie, 1998; Fleming, Doig, & Katz, 2000; Franzen & Wilhelm, 1996). Fleming and colleagues (2009) also proposed that real life places higher demands on executive functioning and the ability to perform dual tasks when compared to lab-based measures. Relatedly, they similarly found a lack of concurrent validity between the CAPM (self-report PM error frequency) and other neuropsychological measures. This finding is consistent with that of the current study which also found cognitive measures of working memory and attention to be unrelated to self-report CAPM scores and, to a smaller extent, related to naturalistic PM task performance. According to Raskin and colleagues (2018), this may be because the three PM measurement methods are capturing unique and not entirely overlapping attributes of PM. It may also be because the methods in which PM, working memory, and attention were measured in the current study were limitedly related to how they are being tapped into in everyday life (see Toplak, West, & Stanovich, 2012), and therefore less ecologically valid. This may be further elucidated by the high frequency with which executive functioning impairments are not observed on standardized tests, but individuals and/or collateral informants report significant difficulties related to executive functioning impairments in their daily lives (Fleming et al., 2009; Franzen & Wilhelm, 1996; Toplak, West, & Stanovich, 2012). According to Raskin and colleagues (2018), this may be observed because self-report PM measures are, in essence, a subjective report of PM error frequency and are likely to be tapping more into metacognitive awareness (i.e., metamemory), which is mediated by other executive functions not being evaluated. Based on this idea, self-report PM errors would be more strongly related to other standardized measures of executive function (e.g., those that evaluate metamemory processes). As self-report measures of PM error frequency do not systematically differentiate the source of the error being made (e.g., RM failure or PM failure), they may also artificially attenuate the relationship with lab-based PM measures that provide a more precise measure of PM ability. In contrast, another possible explanation for the lack of relationship between lab-based and self-report measures of PM has been posited by Toplak and colleagues (2012). They argue that lab-based and self-report measures are tapping into different cognitive levels. They propose that lab-based measures provide an algorithmic analysis of the efficiency of the construct being measured (e.g., PM/working memory/attention ability) whereas, self-report measures provide a reflective analysis of the construct that is concerned more with the individual's goals, beliefs relevant to their goals, and their rational choice of action given those beliefs and goals (see also Stanovich, 2009 & 2011). Toplak and colleagues (2012) argue that the lack of relationship between lab-based and self-report measures of executive function is also related to a distinction between maximal/optimal performance (i.e., measured using lab-based tasks) and typical performance (i.e., measured using self- or other- reports) whereby lab-based measures examine questions of the efficiency of the goal pursuit (e.g., PM ability in a structured, highly controlled environment) and self-report measures more typical performance that provides insight into an individual's critical thinking abilities and cognitive style (i.e., PM ability without the provided structure of an examiner). According to Toplak and colleagues (2012), like self-report ratings of PM, ratings of executive function, provide a measure of typical performance as the interpretation of the task is left up to the rater, who must decide on instances from their everyday lives that map onto questions or constructs (e.g., PM) probed, and provide an estimate on the frequency of such events. As is highlighted above, this is heavily influenced on an individuals' metamemory (see Raskin et al., 2018), context effects, and differences in the way individuals judge behaviour (Toplak, West & Stanovich, 2012). Taken together, it appears there is merit in the use of a combined approach of assessing PM using lab-based, naturalistic, and self-report methods as each measurement method provides nonredundant information about an individual's efficiency and success in achieving goals (Toplak, West, & Stanovich, 2012). Researchers may therefore be failing to capture specific aspects of PM ability if they rely solely on one measurement method.

Assessing the Differential Roles of Working Memory and Attention on PM Performance Across PM Measurement Contexts. The relationships between PM and the cognitive measures of working memory and attention used in the study were found to differ depending on the PM measurement context, performance indicator (e.g., total scores vs. discrepancy scores), and PM subtype that was being investigated. This finding lends further support to the argument put forth by Toplak and colleagues (2012) suggesting that lab-based and self-report measures assess different aspects of cognitive functioning. However, unlike specific executive functions (e.g., planning), the construct of PM is, by definition, multi-faceted, requiring components of PM, RM, and various executive functions for its successful completion, it may be that specific executive functions and/or RM abilities play stronger roles in the successful execution of a PM task in daily life vs. during a lab-based PM task. It is also possible that lab-based PM tasks more closely represent lab-based working memory and/or sustained attention tasks and as such, are not truly measuring the efficiency of the PM process (see Talbot, 2015). Based on the current regression findings, it is difficult to provide concrete evidence to support either argument as visual, but not verbal, working memory was found to significantly predict lab-based time-based total scores and simple attention was found to be the only significant predictor of naturalistic time-based discrepancy scores. Overall, the addition of the cognitive measures was only found to account for a maximum of 3.4% of the variance in PM performance. Like Smith and colleagues (2011) and Rose and colleagues (2010), working memory was found to be the strongest predictor of lab-based time-based PM scores, suggesting that strong executive functioning abilities are most important for the successful execution of the more cognitive resource demanding time-based PM task in a highly constrained lab-based setting. This finding is similar to that of Groot and colleagues (2001), who found attention, working memory, and RM to be related to better lab-based PM performance. Unlike their findings, the current study found limited relationships between measures of attention and PM performance. This may be due to the presence of ceiling effects on the sustained attention task, or it may be because lab-based PM performance is more related to inhibitory control and not sustained attention (see Kerns, 2000; Mahy, Moses, and Kliegel, 2014). Other non-executive factors may also play stronger roles in everyday PM performance. For example, the current study found personality factors (especially conscientiousness), substance use engagement, and the frequency of a person’s use of memory aid strategies (e.g., reminders, notifications, etc.) to account for the most variance in participants’ self-report PM ability.

PM and Personality. According to Uttl and colleagues (2013, 2018), there are several methodological shortcomings associated with the current PM and personality research that limits our understanding of the true relationship between PM and personality. The first limitation was the general use of binary success/failure measurements of lab-based

PM performance with generally high incidence of ceiling effects, arguably leading to imprecise, inefficient, and unreliable estimates of PM ability. The second methodological shortcoming was related to the lack of differentiation between PM subtypes being investigated, which is believed to possibly cloud the potential relationship between PM subtype and personality traits. The third methodological limitation is the tendency for researchers to not consider the role of the PM measurement context, making it impossible to determine if personality has a differential influence on PM in different contexts (e.g., lab-based, naturalistic). The final methodological shortcoming is that most researchers use self-report methods with arguably questionable validity to evaluate PM ability, making it difficult to determine whether personality is related to PM or another construct unintentionally being measured by the self-report measure used. To address these research limitations the current study used two different measurements of PM performance (total correct and total discrepancy scores) to investigate the differential role of personality on both event- and time-based PM using lab-based, naturalistic, and self-report measures of PM. As hypothesized by Uttl and colleagues (2013, 2018), the role of personality was found to differ depending on the PM subtype, measurement method, and context being investigated. Even though the current study had sufficient power to detect significant differences in even weak correlations, very few personality traits were found to relate to and/or predict PM performance overall.

On the lab-based tasks, participants who reported lower levels of conscientiousness were found to perform better on event-based PM tasks as measured by total correct scores, but not discrepancy scores. As identified earlier, performance on the lab-based PM task was near ceiling and therefore this relationship may not represent a true relationship with conscientiousness as the more sensitive measure of event-based PM performance did not yield a similar significant relationship. Still, it is possible that individuals with lower conscientiousness are more likely to rely on spontaneous retrieval processes to complete the lab-based event-based task, given the high attentional demands of the ongoing working memory task and the high focality/discriminability of the event-based PM cues (e.g., elephant/tiger). This may also provide additional support for the multiprocess view of PM proposed by Einstein, McDaniel, Richardson, Guynn, and Confer (1995). Although it is important to note that a similar relationship with conscientiousness was not found with lab-based time-based tasks, which are believed to be more resource demanding. This finding is consistent with that of Uttl and colleagues (2018). They suggested that personality, especially conscientiousness, may not play as much of a role in a controlled lab-based setting and proposed that it may be more influential if it were to be assessed in naturalistic settings. Alternatively, individuals with lower conscientiousness levels may have performed better on the event-based PM task at the expense of their performance on the ongoing task, suggesting a performance trade-off effect.

Unlike previous studies that have found conscientiousness to play at least a small role in determining PM performance on both lab-based (Cuttler & Graf, 2007; Pearman & Storandt, 2005; Smith, Persyn, & Butler, 2011) and naturalistic tasks (Smith, Persyn, & Butler, 2011), the current study found only agreeableness to relate significantly to naturalistic time-based total correct, but not total discrepancy scores. According to the meta-analysis completed by Uttl and colleagues (2013), agreeableness has most often been positively (though weakly) associated with lab-based measures of *episodic* PM (most often event-based PM) and negatively associated with self-reported PM errors. It is not immediately apparent why agreeableness was found to uniquely relate to naturalistic time-based PM performance and not other lab-based or self-report measures. Perhaps it was because individuals high in agreeableness are more likely to comply with authority figures (i.e., the experimenter) and/or volunteer to participate in psychological research studies. Despite likely minimal motivation and/or perceived importance to perform the PM task, individuals with high levels of agreeableness may have felt the need to follow through and comply with experimenter requests. The limited relationship observed between naturalistic event-based PM and agreeableness may have therefore been an artifact of limited exposure to event-based task cues.

Uttl and colleagues (2013) hypothesized that conscientiousness would be more strongly related to naturalistic PM tasks because conscientious people would be more likely to use external reminders in naturalistic, but not lab-based PM settings to help them remember to carry out plans (see also Uttl and Kibreab, 2011). The authors also believed personality factors would play a larger role in time-based tasks than in event-based tasks because of greater opportunities to set up external reminders for specific times vs. events. Contrary to their hypotheses, the current study did not find conscientiousness or memory aid strategy use to relate to either time- or event-based naturalistic PM performance outcomes. A possible explanation for the lack of relationship between memory strategy use and naturalistic PM performance could be related to participants overestimating their ability to perform the naturalistic tasks, leading them to be less likely to employ such strategies to aid in PM task execution. This hypothesis is supported by a study conducted by Cauvin and colleagues (2019) who found young adults to be overconfident in their naturalistic time-based PM task performance and underconfident in their lab-based PM performance.

Consistent with the personality and PM literature, self-report PM error frequency was found to yield the strongest relationships with conscientiousness and agreeableness. However, neuroticism was also found to be significantly related to self-report PM errors. This means that participants who reported higher levels of conscientiousness and agreeableness, and lower levels of neuroticism reported fewer PM errors in their daily lives. Surprisingly, this finding remained significant, even after controlling for participants' reported frequency of PM aid use and various lifestyle variables, including indicators of busyness, gender, and alcohol and other substance use. This, combined with the significant relationship observed between naturalistic PM task performance and self-report PM errors, suggests that self-report measures may provide a more valid estimate of PM ability than initially suggested. As stated above, it may be that the self-report measure is better capturing a unique attribute of PM that is more predictive of a person's everyday PM ability (Raskin et al., 2018).

Consistent with previous research, PM strategy use was found to significantly predict self-report PM errors. Yet contrary to previous findings by Martin and Park (2003), indicators of busyness were not found to predict event- or time-based PM ability on lab-based, naturalistic, or self-report measures. Interestingly, substance use engagement was found to significantly predict self-report PM errors, but not lab- or naturalistic PM task performance. Though other researchers have also found drug use to be related to self-report measures of PM errors (Fisk & Montgomery, 2008; Montgomery & Fisk, 2007), it is surprising that deficits were not also observed in lab-based PM measures given previous research indicating even recreational drug users demonstrate deficits in lab-based event- and time-based PM (Hadjiefthyvoulou, Fisk, Montgomery, & Bridges, 2010; Rendell, Gray, Henry, & Tolan, 2007; Rendell, Mazur, & Henry, 2009). The lack of relationship observed between lab-based PM performance and drug use, may have been mediated by the high proportion of infrequent, cannabis-only drug users in the current sample. Although cannabis has been associated with slightly decreased lab-based time- and event-based PM performance, PM appears to be markedly affected by poly-drug use (i.e., those who use cannabis in addition to another illicit drug; Hadjiefthyvoulou, Fisk, Montgomery, & Bridges, 2011). It is also unexpected that a stronger relationship was not observed between drug use and memory aid strategy use given previous studies that have found non-users to be more likely to use external memory aid strategies (Hadjiefthyvoulou, Fisk, Montgomery, & Bridges, 2011). This may also be related to the demographics of the current study sample as the sample consisted of predominately high-achieving, female undergraduate psychology students, who are simultaneously juggling full-time studies, at least part-time employment, and participation in at least 1-hour of extra-curricular activity.

Limitations and Future Research. As has been highlighted throughout the discussion, there are potential limitations to the current study. First, many of the PM outcome variables were not normally distributed, requiring findings to be interpreted with caution. Second, the lab-based event-based PM task and the sustained attention task demonstrated ceiling effects, which may have limited the precision and sensitivity of the measures, thus reducing the possibility of finding significant relationships between these and other variables included in the study. Third, the continuous score of the time-based naturalistic task was much less precise and sensitive than the lab-based time-based task. Similarly, a continuous score could not be obtained for the naturalistic event-based task, requiring the use of a total score only for this task. Fourth, performance on the naturalistic tasks may have been unduly influenced by a lack of opportunity to complete some of the event-based tasks and limited internal and external motivation to complete the tasks consistently and/or in a timely manner. There is also concern that the naturalistic tasks included in the current study may not be as representative of the types of PM tasks young adults would be expected to carry out in their daily lives, limiting the ecological validity of the task. Fifth, the study sample consisted predominately of high-achieving female undergraduate psychology students from the University of Victoria, BC, significantly limiting the generalizability of the current findings to other institutions or demographics. Finally, though no statistically significant group differences were observed based on whether individuals engaged in substance use, alcohol use, or had a diagnosed mental health disorder, findings were collapsed across different groups, which may have overlooked important group differences not explicitly investigated.

Future research should be aimed at improving the generalizability of the current findings by including a more ethnically diverse, gender balanced sample with larger age ranges, and education levels. It would also be beneficial to investigate the role of intraindividual differences in the relationships between personality, PM, RM, and executive function. Relatedly, it would be interesting to investigate whether a combination of personality traits better predicts PM performance and whether that differs depending on the PM measurement context, PM subtype, or PM strategy use. Given the questionable representativeness of the naturalistic tasks incorporated into the current study, it would be important to replicate the current study using more representative naturalistic tasks, including more *general* time-based PM tasks as these have been argued to better represent everyday time-based PM tasks than *specific* time-based PM tasks (see Talbot, 2015). Finally, it may be informative to differentiate between participants with high/low levels of a personality trait to determine if the two groups systematically differ in their PM abilities and whether this may inform their responsiveness to PM interventions.

Conclusion

The current study aimed to better understand the role of personality on PM performance by attempting to rectify several of the methodological shortcomings associated with current research in this area. Overall, the relationship between personality traits and PM performance was found to differ depending on the PM subtype, measurement context, and performance indicator used, with conscientiousness, memory aid strategy use, and substance use engagement being found to best predict self-reported PM errors in daily life. This study also demonstrated that lab-based, naturalistic, and self-report measures of PM each tap into different aspects of behavioural and cognitive functioning. Lab-based PM measures provide an algorithmic level of analysis that offers important information about the efficiency of a person's PM ability, but self-report PM measures provide the reflective level of analysis that informs a person's ability to successfully carry out PM tasks in their daily lives. Life is messy and chaotic and as the results of the current study show, many different factors (internal and external, short-term and long-term) come together, with varying levels of importance, to increase or decrease the likelihood that a person will remember to carry out their intentions. Instead of criticizing the ecological validity of lab-based PM measurement methods, one should view them as indicators of optimal PM performance under highly structured conditions. If PM performance is low in such conditions, this may best serve as an indication of a potential PM processing weakness in an individual (Toplak, West, & Stanovich, 2012). In contrast, if an individual's PM performance on a lab-based PM task is at least average, but their naturalistic PM performance is low and/or their self- or other- reported frequency of PM errors is high, this has important intervention implications as it suggests that an individual benefits from the added structure and support provided by the lab-based context. It is therefore imperative to not assume that all measurement methods are capturing the same level of PM analysis. Instead, they each provide useful information in their own way from both a research and clinical perspective. Self- and other-report methods may best serve as an indication of the need for the implementation of an intervention whereas lab-based PM tasks may best help to inform the nature of the deficit and identify the most appropriate intervention to successfully target that area. From there, naturalistic tasks can be used to provide evidence of the effectiveness of the interventions being implemented. Nevertheless, without consideration of the within- and between-subject variability inherent across individuals, important factors may be overlooked that could lead to decreased intervention success. Without the use of all three measurement methods, whilst also considering the individuality of the client, researchers and clinicians may be doing a disservice to individuals with true PM difficulties. Herein lies the importance and necessity of implementing a scientist-practitioner model of care. Future research should therefore be aimed at identifying the additional factors contributing to a person's PM ability to increase the development and sensitivity of clinical measures of PM as well as the development and appropriate implementation of comprehensive PM interventions to improve overall quality of life.

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Appendix 1

Naturalistic Task List

Event-Based Tasks:

1. When you make a purchase, send me a picture of the receipt.
2. Text me a picture of the classroom when you attend your first class of the day.
3. When you walk past a coffee shop, take a picture and send it to me.
4. Before you eat dinner, send me a picture of what you are about to eat.
5. When you see someone you know on campus, text me his/her/their first name.

Time-Based Tasks

1. When you read this text, take a picture of the time (screenshot of your phone's clock is ok), then send me the photo 5 minutes from the time you took the photo.
2. At noon, call/text the examiner and let her know what your plans are for the rest of the day.
3. At 6:15pm, send me a picture of where you are.
4. At 3:30pm, call/text a friend/family member to say hi, then text me the name of the person you texted.

Appendix 2

Brief Screening Email Questionnaire

Hello,

Thank you for your interest in participating in our study that is investigating the way that young adults remember to remember. This research will be used as a way of satisfying my doctoral degree requirements and I really appreciate your interest in the study.

I would like to ask you a few questions to determine whether you are eligible to participate in the current study.

Because of the specific research questions that we are investigating, we need to ask a few questions about your developmental history.

1) Have there ever been any concerns about your development? For example, have you ever had any services through the Infant Development Program, or had any difficulty with motor problems, language or speech, or vision?

2) Do you have any diagnosed medical, genetic or neurologic conditions?

3) Have you ever had a significant blow to the head (a fall or in an accident) that resulted in loss of consciousness, concern about concussion, or warranted medical investigation (such as an ER visit or visit with a doctor?)

This data will not be used in the study and will be destroyed.

If you could please respond to the below questions as soon as you can, we can determine your eligibility and go on to the next steps.

Sincerely,

--
Karley Talbot, M.Sc.
Doctoral Clinical Neuropsychology Student
Child Development Lab
Department of Psychology
University of Victoria

Appendix 3

Naturalistic Task Instructions

Hi [participant’s name]

Please **[naturalistic task]** at any point after 8am this morning.

Also please remember to email me/text me back with documented evidence (e.g., time-stamped photo or screenshot) when you have completed the required task.

If I don’t hear from you by 9pm tonight, I will send another email/text asking whether you have forgotten to complete the task.

If it happens that you have forgotten, it is ok. Not everyone can remember to complete all the tasks they set out to in a day. This just means that you will not receive a ballot for this task, but you will still have other opportunities to earn additional ballots for the draw to win a UVic Bookstore Gift Card at the end of the study.

Please remember to check your phone/email before 9 am for the duration of the study to ensure that you do not miss receiving the next task.

Finally, as always, please ensure that you are not participating in this study to make me happy. For ethical reasons, you must be choosing to participate voluntarily without any due enticement or pressure.

Thanks so much and have a great day!

Karley

Table 2. Demographic Descriptive Statistics

General Information	
N	220
Percent female	78.20
Average age (*SD*[1])	20.53 (1.99)
Ethnicity	
Percent Caucasian	71.8
Percent Asian	18.2
Student Status	
Average year in university (*SD*)	2.71 (1.24)
Percent in ≥4 classes	70.4
Employment Rate	
Percent employed	53.4
Percent of those working ≥ 16hr/week	24.4
Extracurricular Activity Involvement	
Percent enrolled in extracurricular activities	55.3
Percent of those who participated in extracurricular activities ≤5hrs/week	72.7
Mental Health Status	
Percent with a diagnosed mental illness	17.8
Percent of those with an affective[2] disorder	11.8
Percent of those with a neurodevelopmental[3] disorder	2.7
Alcohol Consumption	
Percent who consume alcohol	76.4
Average number of drinks consumed/sitting	1-2 drinks
Percent who consume alcohol <1x/week	70.5
Substance Use	
Percent who use other substances	16.4
Percent of those who use marijuana	91.7
Percent who use substances <1x/week	55.9

Note:

[1] Standard deviation

[2] Diagnosed with an anxiety- or mood-related disorder (e.g., Generalized Anxiety Disorder, Major Depressive Disorder, Bipolar I Disorder)

[3] Diagnosed with Attention-Deficit Hyperactivity Disorder, Fetal Alcohol Spectrum Disorder, Autism Spectrum Disorder, Specific Learning Disorder, Genetic Disorder, communication disorder, or motor disorder

Table 3. Means, Standard Deviations, and Ranges for Supplemental Subtest Measures

Measure	Mean (SD)	Range
Predicted FSIQ[1]	115.25 (7.25)	40
CPT Score[2]	79.82 (.85)	8
Digit Span Forward[3] Score	10.50 (2.15)	12
Digit Span Sequencing[4] Score	9.84 (1.95)	10
n-Back[5] Score	93.63(5.47)	27
MAidQ[6] Total	91.78 (16.95)	96
PM only[7]	47.82 (9.76)	56
RM only[8]	27.14 (6.17)	31
Personality Traits[6]:		
Openness	35.94 (6.11)	31
Conscientiousness	32.98 (5.53)	26
Extraversion	25.83 (6.80)	29
Agreeableness	35.74 (5.13)	26
Neuroticism	24.54 (6.53)	31

Note:

[1]Predicted Full-Scale IQ score based on total error score on National Adult Reading Test.

[2]Total correct detections (pressing button for target image) on the Continuous Performance Test (sustained attention), out of a total of 80.

[3]Total score on the WAIS-IV Digit Span Forward (simple verbal attention) subtest, out of a total of 16.

[4]Total score on the WAIS-IV Digit Span Sequencing (verbal working memory) subtest, out of a total of 16.

[5]Total accuracy (in percentage) on the 2-back (visual working memory) task, out of a total of 100.

[6] Total score on the Memory Aids Questionnaire, out of a total of 189.

[7] Total score on the Prospective Memory Strategy subscale on the MAidQ, out of a total of 105

[8] Total score on the Prospective Memory Strategy subscale on the MAidQ, out of a total of 56

Table 4. Means, Standard Deviations, and Ranges for Naturalistic, Lab-Based, and Self-Report Prospective Memory Measures.

	Lab-Based			**Naturalistic**			**Self-Report**		
	Mean (SD)	*Range*	*N*	*Mean (SD)*	*Range*	*N*	*Mean (SD)*	*Range*	*N*
Total	10.53 (1.73)[5]	9.00	220	5.22 (1.66)[1]	8.00	220	69.17 (15.76)[10]	95.00	220
EBPM	5.46 (0.91)[6]	6.00	220	2.62 (1.10)[2]/ 2.22(1.11)[13]	5.00	220/108			
EBPM Discrepancy	4694.67 (893.3)[7]	5750.00	220						
TBPM	5.12 (1.29)[8]	6.00	220	2.51 (1.08)[3]	5.00	220			
TBPM-Discrepancy	$2.92x10^{4}$ (7.25×10^{4})[9]	$4.77x10^{46}$	220	$5.98x10^{6}$ ($9.19 x10^{6}$)[4]	$8.86x10^{7}$	215			
IADL							51.50 (12.10)[11]	67.00	220
BADL							17.66 (5.15)[12]	28.00	220

Note:

[1] Total number of correct naturalistic PM tasks completed, out of a total of 12
[2] Total number of correct naturalistic EBPM tasks completed, out of a total of 4
[3] Total number of correct naturalistic TBPM tasks completed, out of a total of 4
[4] Total sum of response discrepancies across all naturalistic TBPM tasks, in milliseconds
[5] Total number of correct lab-based PM tasks, out of a total of 12
[6] Total number of correct lab-based EBPM tasks completed, out of a total of 6
[7] Total sum of response discrepancies across all lab-based EBPM tasks, in milliseconds
[8] Total number of correct lab-based TBPM tasks completed, out of a total of 6
[9] Total sum of response times across all lab-based TBPM tasks, in milliseconds
[10] Total score on the CAPM, out of a total of 170
[11] Total score on the CAPM IADL scale, out of a total of 120
[12] Total score on the CAPM BADL scale, out of a total of 50
[13] Total number of correct naturalistic EBPM tasks completed, out of a total of 4 (excluding participants who did not have the opportunity to complete one or more naturalistic task)

Table 5. Correlations and Significance Values Associated with Prospective Memory Performance Across Demographic Variables.

	Age	IQ	Gender	Work[6]	EC[7]	Mental D/O[8]	Alc.[9]	Sub.[10]
IQ	.018							
Gender	-.015	.107						
Work	.267**	.050	-.087					
EC	-.033	.017	.145*	-.085				
Mental D/O	.074	.169*	-.047	.004	-.085			
Alc.	.120	.163*	-.039	.092	-.061	-.026		
Sub.	.092	.104	.055	.019	.027	.116	.186**	
Lab[1] TB[2] Total	.057	.033	.125	-.031	.030	-.032	-.044	-.011
Lab TB Disc.[3]	-.066	-.049	-.104	.036	-.073	.007	.021	-.021
Nat[4] TB Total	.007	-.064	-.066	.032	-.020	.025	-.112	-.095
Nat TB Disc.	.025	-.076	-.013	.111	.103	-.051	-.028	.044
Self-Report	-.067	.018	-.134*	-.001	-.090	.053	.060	.175**
Lab EB[5] Total	-.094	.030	.059	-.015	.037	-.015	.057	-.010
Lab EB Disc.	-.094	.052	-.078	.137*	.011	.133*	-.021	.022
Nat EB Total	-.075	-.064	-.099	.086	.091	.084	-.092	-.004
MAidQ[11] Total	.008	-.111	-.119	.018	.040	.017	-.076	-.060

* $p < .05$; ** $p < .001$

[1]Lab-based prospective memory (PM) task [2]Time-based PM task [3]Discrepancy score [4]Naturalistic PM task [5]Event-based PM task [6]Employed [7]Extracurricular Involvement [8]Diagnosed Mental Illness [9]Alcohol Use [10]Substance Use [11]Total score on the Memory Aids Questionnaire

Table 6. **Multi-Trait Multi-Method Correlation Matrix with Significance Values Associated with Prospective Memory Performance.**

	Lab[1] TB[2] Total	Lab TB Disc.[3]	Nat[4] TB Disc.	Nat TB Total	Self-Report	Lab EB[5] Total	Lab EB Disc.	Nat EB Total	*n*-Back[6]	DSS[7]	CPT[8]	DSF
Lab TB Dis.	.798**											
Nat TB Disc.	.032	-.003										
Nat TB Total	-.060	.033	-.290**									
Self-Report	-.078	.114	.104	-.200**								
Lab EB Total	.105	-.082	.124	-.135*	-.099							
Lab EB Disc.	-.046	-.005	.043	-.074	-.019	.480**						
Nat EB Total	-.051	-.058	.027	.113	-.097	-.098	-.046					
n-Back	.166*	-.208**	.006	-.070	-.015	.013	.034	.011				
DSS	.066	-.008	.027	-.169*	.084	.040	.020	-.036	.155*			
CPT	.124	-.149*	.036	-.124	.074	.003	-.087	.070	.202**	.146*		
DSF[9]	.018	-.063	-.157*	-.133*	-.030	.068	.037	-.135*	.078	.256**	.149*	
MAidQ - PM[10]	-.059	.006	-.002	.083	.208**	-.006	-.007	.008	-.045	-.042	-.059	-.173*

* $p < .05$; ** $p < .001$
[1]Lab-based PM task [2]Time-based PM task [3]Discrepancy score [4]Naturalistic PM task [5]Event-based PM task [6]n-back visual working memory task performance [7]Digit Span Sequencing verbal working memory task performance [8]Continuous Performance Test visual sustained attention task performance (number of correct detections) [9]Digit Span Forward simple verbal attention task performance [10]Memory Aid Questionnaire – PM strategy use score

Table 7. Statistical Comparisons of Event- and Time-Based Prospective Memory Multi-Trait Multi-Method Correlation Matrices.

Comparison Type	r_{12}	r_{13}	r_{23}	r_{34}	*t(217)*	ZPF
Lab Total v Age	.057	-.094	.105		1.67	
Lab Total v IQ	.033	.030	.105		.033	
Lab Discrepancy v Age	-.066	-.075	-.005		.094	
Lab Discrepancy v IQ	-.049	.052	-.005		-1.05	
Nat Total v Age	.007	.075	.113		-.476	
Nat Total v IQ	-.064	-.064	.113		.000	
Self-Report v Lab Total	-.078	-.099	.105		.233	
Self-Report v Lab Discrepancy	.114	-.019	-.005		1.39	
Self-Report v Nat Total	-.200	-.097	.113		-1.16	
n-Back v Lab Total	.066	.013	.105		.585	
n-Back v Lab Discrepancy	-.208	.034	-.005		-2.57*	
n-Back v Nat Total	-.169	-.036	.113		-1.49	
CPT v Lab Total	.124	.003	.105		1.34	
CPT v Lab Discrepancy	-.149	-.087	-.005		-.652	
CPT v Nat Total	-.124	-.070	.113		-.602	
DSS v Lab Total	.066	.044	.105		.243	
DSS v Lab Discrepancy	-.008	.020	-.005		-.291	
DSS v Nat Total	-.169	-.036	.113		-1.49	
DSF v Lab Total	.018	.068	.105		-.552	
DSF v Lab Discrepancy	-.063	.037	-.005		-1.04	
DSF v Nat Total	.133	-.135	.113		.022	
MAidQ v Lab Total	-.059	-.006	.105		-.584	
MAidQ v Lab Discrepancy	.006	-.007	-.005		.135	

MAidQ v Nat Total	.083	-.008	.113		1.01	
Lab Discrepancy v Lab Total	-.819			.480		-17.46**
Lab Total v Nat Total	-.070			-.107		.392
Lab Discrepancy v Nat Total	.023			-.107		1.36

**p*<.05; ***p*<.001

Note: Lab: lab-based PM; TB: time-based PM; EB: event-based PM; Nat: naturalistic PM task; Total: total correct scores; Discrepancy: discrepancy scores; *n*-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.

Table 8. Partial Correlations and Significance Values Associated with Prospective Memory Performance Controlling for Predicted IQ.

	Lab[1] TB[2] Total	Lab TB Disc.[3]	Nat[4] TB Disc.	Nat TB Total	Self-Report	Lab EB[5] Total	Lab EB Disc.	Nat EB Total	2-Back[6]	DSS[7]	CPT[8]	DSF
Lab TB Dis.	-.779**											
Nat TB Disc.	.042	.085										
Nat TB Total	-.107	.020	-.296**									
Self-Report	-.035	.082	.098	-.194**								
Lab EB Total	.125	-.087	.124	-.154*	.090							
Lab EB Disc.	-.022	-.026	.039	-.044	-.022	.442**						
Nat EB Total	.021	-.020	.028	.006	-.085	-.096	-.025					
2-Back	.112	-.151*	.023	-.095	.007	.003	.053	-.019				
DSS	.044	.024	.047	-.136*	.079	.032	.011	.004	.114			
CPT	.057	-.075	.050	-.155*	.106	-.003	-.086	.049	.138*	.111		
DSF[9]	.018	-.068	-.144*	-.133*	-.049	.075	.030	-.099	.028	.199**	.132	
MAidQ - PM[10]	-.052	-.010	-.007	.066	.223**	.011	.021	.000	-.030	-.016	.019	-.159*

*** p < .05; ** p <.001**

1Lab-based PM task 2Time-based PM task 3Discrepancy score 4Naturalistic PM task 5Event-based PM task 6n-back working memory task 7Digit span sequencing working memory task 8Continuous Performance Test sustained attention task 9Digit span forward simple attention task 10Memory Aids Questionnaire – PM aids only.

Table 9. Multiple Regression Results of Cognitive Measures in Predicting Prospective Memory Across Prospective Memory Measurement Contexts After Controlling for IQ.

	Adj R^2	*F*	ΔR^2	ΔF	*B*	*SE B*	*β*
Lab TB Total							
Model							
Block 1	-.002	.494	.002				
Constant					4.12	1.4	
IQ					.009	.012	.048
Block 2	.012	1.52	.033	1.78			
Constant					-.926	8.27	
IQ					.001	.013	.004
n-Back					.065	.034	.136
DSS					.020	.048	.031
CPT					.141	.106	.093
DSF					-.010	.043	-.016
Lab TB Disc.							
Model							
Block 1	-.001	.685	.003				
Constant					$9.50x10^4$	$7.98x10^4$	
IQ					$-5.72x10^2$	$6.91x10^2$	-.056
Block 2	.034	2.52*	.053	2.97*			
Constant					$1.03x10^6$	$4.66x10^5$	
IQ					-44.12	$7.21x10^2$	-.004
n-Back					$-5.00x10^3$	$1.90x10^3$	-.183*
DSS					$1.25x10^3$	$2.68x10^3$	.051
CPT					$-9.66x10^4$	$6.00x10^3$	-.112
DSF					$-1.50x10^3$	$2.42x10^3$	-.044
Lab EB Total							
Model							
Block 1	-.004	.164	.001				
Constant					5.12	.905	
IQ					.003	.008	.028
Block 2	-.018	.216	.004	.230			
Constant					5.39	5.42	
IQ					.001	.008	.009
n-Back					.001	.022	.003
DSS					.008	.031	.019
CPT					-.005	.070	-.005
DSF					.024	.028	.061
Lab EB Disc.							
Model							
Block 1	-.002	.674	.003				

Constant					3.94×10^{3}	9.43×10^{2}	
IQ					6.70	8.17	.056
Block 2	-.008	.674	.013	.675			
Constant					1.21×10^{4}	5.62×10^{3}	
IQ					6.23	8.70	.052
n-Back					14.0	22.9	.044
DSS					6.20	32.3	.014
CPT					-1.12×10^{2}	72.4	-.110
DSF					14.5	29.2	.036
Nat TB Total							
Model							
Block 1	.009	2.94	.013				
Constant					4.47	1.16	
IQ					-.017	.010	-.116
Block 2	.028	2.24	.037	2.05			
Constant					13.6	6.80	
IQ					-.008	.011	-.055
n-Back					-.006	.028	-.015
DSS					-.069	.039	-.126
CPT					-.110	.088	-.088
DSF					-.037	.035	-.075
Nat TB Disc.							
Model							
Block 1	.001	1.14	.005				
Constant					1.679×10^{7}	1.00×10^{7}	
IQ					-9.26×10^{4}	8.69×10^{4}	-.073
Block 2	.013	1.55	.031	1.85			
Constant					-3.79×10^{7}	6.07×10^{7}	
IQ					-8.02×10^{4}	9.19×10^{4}	-.064
n-Back					5.12×10^{4}	2.47×10^{5}	.015
DSS					3.48×10^{5}	3.44×10^{5}	.073
CPT					6.91×10^{5}	7.78×10^{5}	.063
DSF					-7.37×10^{5}	3.10×10^{5}	-.171*
Nat EB Total							
Model							
Block 1	-.001	.737	.003				
Constant					3.64	1.19	
IQ					-.009	.010	-.058
Block 2	.004	1.19	.024	1.30			
Constant					-5.62	7.04	
IQ					-.006	.011	-.042
n-Back					.004	.029	.010
DSS					.001	.040	.001
CPT					.119	.091	.093
DSF					-.071	.037	-.139

Self-Report							
Model							
Block 1	-.004	.119	.001				
Constant					63.5	17.1	
IQ					.051	.148	.024
Block 2	-.005	.795	.018	.964			
Constant					-41.5	101.4	
IQ					.031	.157	.014
n-Back					-.282	.414	-.049
DSS					.818	.584	.101
CPT					1.47	1.31	.079
DSF					-.481	.527	-.066

Note: Lab: lab-based PM; TB: time-based PM; EB: event-based PM; Nat: naturalistic PM task; Total: total correct scores; *n*-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.

Table 10. Correlation and Significance Values Associated with Personality Traits, Prospective Memory Performance, and Demographic Variables.

	Openness	Conscientiousnes s	Extraversion	Agreeableness	Neuroticism
Lab TB Total	-.049	.094	-.015	.057	.028
Lab TB Disc.	.061	-.132	-.039	-.039	-.014
Nat TB Total	-.004	.106	.100	.145*	-.061
Nat TB Disc.	.076	-.034	-.039	.009	-.002
Self-Report	.074	-.445**	.030	-.164*	.261**
Lab EB Total	.053	-.149*	.055	.062	-.052
Lab EB Disc.	.010	.038	.014	.054	-.007
Nat EB Total	-.062	.065	-.026	.064	.111
Gender	.123	.062	-.023	-.096	-.327**
Work	-.046	.130	.123	.143*	-.069
EC	-.135*	.159*	.091	.055	-.115
Mental D/O	.151*	-.035	-.071	-.032	.351**
Alc.	-.020	-.065	.162*	.115	-.040
Sub.	.074	-.119	-.018	-.037	-.056
MAidQ	.056	.097	.196**	.032	.154*

* $p < .05$; ** $p < .001$

Note: Lab: lab-based PM; TB: time-based PM; EB: event-based PM; Nat: naturalistic PM task; Total: total correct scores; Disc.: discrepancy scores Work: employed; EC: extracurricular activity involvement; Mental D/O: mental health disorder diagnosis; Alc: alcohol use; Sub: substance use; MAidQ-PM: Memory Aids Questionnaire – Prospective Memory Aids only.

Table 11. Multiple Regression Results of Personality Traits Predicting Prospective Memory Performance Across Prospective Memory Measurement Contexts.

	Adj R^2	*F*	ΔR^2	*B*	*SE B*	*β*
Lab TB Total						
Model 1	-.002	.515	.002			
Constant				5.49	.523	
Openness				-.010	.014	-.049
Model 2	.004	1.93	.009			
Constant				4.40	.528	
Conscientiousness				.022	.016	.094
Model 3	-.004	.000	.049			
Constant				5.19	.345	
Extraversion				-.003	.013	-.015
Model 4	-.002	.634	.003			
Constant				4.63	.616	
Agreeableness				.014	.017	.054
Model 5	-.004	.168	.001			
Constant				4.98	.341	
Neuroticism				.005	.013	.028
Model 6	-.008	.663	.015			
Constant				3.93	1.16	
Openness				-.008	.015	-.036
Conscientiousness				.022	.017	.095
Extraversion				-.001	.014	-.007
Agreeableness				.013	.018	.052
Neuroticism				.012	.015	.063
Lab TB Disc.						
Model 1	-.001	.812	.004			
Constant				2.31×10^3	2.98×10^4	
Openness				7.35×10^2	8.16×10^2	.061
Model 2	.013	3.85	.018			
Constant				8.67×10^4	3.00×10^4	
Conscientiousness				-1.76×10^3	8.96×10^2	-.132
Model 3	-.003	.336	.002			
Constant				3.98×10^4	1.96×10^4	
Extraversion				-4.26×10^2	7.34×10^2	-.039
Model 4	.007	2.63	.012			
Constant				8.49×10^4	3.50×10^4	
Agreeableness				-1.57×10^3	9.68×10^2	-.110

Model 5	-.004	.042	.000			
Constant				3.26×10^4	1.94×10^4	
Neuroticism				-1.56×10^2	7.65×10^2	-.014
Model 6	.011	1.47	.034			
Constant				1.44×10^5	6.55×10^4	
Openness				7.10×10^2	8.39×10^2	.058
Conscientiousness				-1.59×10^3	9.39×10^2	-.120
Extraversion				-5.26×10^2	7.68×10^2	-.049
Agreeableness				-1.45×10^3	1.03×10^3	-.102
Neuroticism				-9.08×10^2	8.25×10^2	-.081
Lab EB Total						
Model 1	-.002	.608	.003			
Constant				5.28	.369	
Openness				.008	.010	.053
Model 2	.018	4.91*	.022			
Constant				6.27	.371	
Conscientiousness				-.025	.011	-.149*
Model 3	-.002	.659	.003			
Constant				5.27	.243	
Extraversion				.007	.009	.055
Model 4	-.001	.834	.004			
Constant				5.07	.435	
Agreeableness				.011	.012	.062
Model 5	-.002	.594	.003			
Constant				5.64	.241	
Neuroticism				-.007	.009	-.052
Model 6	.017	1.74	.039			
Constant				5.85	.810	
Openness				.004	.010	.028
Conscientiousness				-.030	.012	-.183*
Extraversion				.006	.010	.044
Agreeableness				.014	.013	.081
Neuroticism				-.008	.010	-.059
Lab EB Disc.						
Model 1	-.005	.020	.000			
Constant				4.65×10^3	3.63×10^2	
Openness				1.39	10.0	.010
Model 2	-.003	.309	.001			
Constant				4.50×10^3	3.68×10^2	
Conscientiousness				6.13	11.0	.038
Model 3	-.004	.044	.000			
Constant				4.65×10^3	2.39×10^2	

Extraversion				1.89	8.97	.014
Model 4	-.002	.637	.003			
Constant				4.36×10^3	4.28×10^2	
Agreeableness				9.47	11.9	.054
Model 5	-.005	.011	.000			
Constant				4.72×10^3	2.37×10^2	
Neuroticism				-.981	9.24	-.007
Model 6	-.019	.174	.004			
Constant				4.06×10^3	8.11×10^2	
Openness				1.73	10.4	.012
Conscientiousness				4.93	11.6	.030
Extraversion				.952	9.52	.007
Agreeableness				9.17	12.78	.053
Neuroticism				2.52	10.2	.018
Nat TB Total						
Model 1	-.005	.003	.000			
Constant				2.54	.436	
Openness				-.001	.012	-.004
Model 2	.007	2.47	.011			
Constant				1.84	.439	
Conscientiousness				.021	.013	.106
Model 3	.005	2.20	.010			
Constant				2.11	.286	
Extraversion				.016	.011	.100
Model 4	.017	4.67*	.021			
Constant				1.43	.509	
Agreeableness				.030	.014	.145*
Model 5	-.001	.811	.004			
Constant				2.77	.284	
Neuroticism				-.010	.011	-.061
Model 6	.011	1.48	.034			
Constant				.832	.957	
Openness				-.003	.012	-.016
Conscientiousness				.014	.014	.072
Extraversion				.014	.011	.087
Agreeableness				.026	.015	.123
Neuroticism				.002	.012	.011
Nat TB Disc.						
Model 1	.001	1.21	.006			
Constant				1.92×10^6	3.77×10^6	
Openness				1.14×10^5	1.03×10^5	.076
Model 2	-.004	.244	.001			

Constant				$7.88x10^6$	$3.84x10^6$	
Conscientiousness				$-5.67x10^4$	$1.15x10^5$	-.034
Model 3	-.003	.329	.002			
Constant				$7.39x10^6$	$2.50x10^6$	
Extraversion				$-5.37x10^4$	$9.35x10^4$	-.039
Model 4	-.005	.017	.000			
Constant				$5.43x10^6$	$4.45x10^6$	
Agreeableness				$1.61x10^4$	$1.23x10^5$	.009
Model 5	-.005	.001	.000			
Constant				$6.07x10^6$	$2.47x10^6$	
Neuroticism				$-2.60x10^3$	$9.69x10^4$	-.002
Model 6	-.014	.430	.010			
Constant				$4.34x10^5$	$8.41x10^6$	
Openness				$1.32x10^5$	$1.07x10^5$	.088
Conscientiousness				$-5.03x10^4$	$1.21x10^5$	-.030
Extraversion				$-8.34x10^4$	$9.90x10^4$	-.061
Agreeableness				$3.30x10^4$	$1.32x10^5$	.018
Neuroticism				$-1.84x10^4$	$1.06x10^5$	-.013
Nat EB Total						
Model 1	-.001	.821	.004			
Constant				3.02	.446	
Openness				-.011	.012	-.062
Model 2	.000	.906	.004			
Constant				2.20	.452	
Conscientiousness				.013	.014	.065
Model 3	-.004	.145	.001			
Constant				2.73	.294	
Extraversion				-.004	.011	-.026
Model 4	.000	.892	.004			
Constant				2.13	.526	
Agreeableness				.014	.015	.064
Model 5	.008	2.68	.012			
Constant				2.16	.290	
Neuroticism				.019	.011	.111
Model 6	.008	1.36	.031			
Constant				1.05	.983	
Openness				-.009	.013	-.047
Conscientiousness				.015	.014	.076
Extraversion				.000	.012	.001
Agreeableness				.020	.015	.094
Neuroticism				.026	.012	.156*
Self-Report						

Model 1	.001	1.19	.005			
Constant				62.37	6.37	
Openness				.191	.175	.074
Model 2	.194	53.26**	.198			
Constant				110.94	5.80	
Conscientiousness				-1.27	.173	-.445**
Model 3	-.004	.200	.001			
Constant				67.40	4.20	
Extraversion				.070	.157	.030
Model 4	.022	5.94*	.027			
Constant				87.14	7.43	
Agreeableness				-.503	.206	-.164*
Model 5	.064	15.75**	.068			
Constant				53.81	4.01	
Neuroticism				.628	.158	.261**
Model 6	.218	13.10**	.236			
Constant				90.50	12.47	
Openness				.078	.160	.030
Conscientiousness				-1.15	.179	-.403**
Extraversion				.231	.146	.100
Agreeableness				-.081	.197	-.026
Neuroticism				.435	.157	.181**

Note: Memory Aids Questionnaire – Prospective Memory Aids only; Lab: lab-based PM; TB: time-based PM; EB: event-based PM; Nat: naturalistic PM task; Total: total correct scores; Disc.: discrepancy scores

Table 12. Multiple Regression Results of Personality Traits Predicting Prospective Memory (PM) Performance Across PM Measurement Contexts, Controlling for Memory Aid Strategy Use.

	Adj R^2	*F*	ΔR^2	ΔF	*B*	*SE B*	*β*
Lab TB Total							
Model 1							
Block 1	-.001	.719					
Constant					5.48	.436	
MAidQ-PM					-.008	.009	-.058
Block 2	-.004	.002	.719	.002			
Constant					5.81	.658	
MAidQ-PM					-.007	.009	-.055
Openness					-.010	.014	-.046
Model 2							
Block 1	-.001	.719					
Constant					5.48	.436	
MAidQ-PM					-.008	.009	-.058
Block 2	.004	1.45	.010	2.18			
Constant					4.77	.649	
MAidQ-PM					-.009	.009	-.067
Conscientiousness					.023	.016	.101
Model 3							
Block 1	-.001	.719					
Constant					5.48	.436	
MAidQ-PM					-.008	.009	-.058
Block 2	-.006	.359	.000	.003			
Constant					5.50	.506	
MAidQ-PM					-.007	.009	-.057
Extraversion					-.001	.013	-.004
Model 4							
Block 1	-.001	.719					
Constant					5.48	.436	
MAidQ-PM					-.008	.009	-.058
Block 2	-.003	.698	.003	.678			
Constant					4.99	.740	
MAidQ-PM					-.008	.009	-.059
Agreeableness					.014	.017	.056
Model 5							
Block 1	-.001	.719					
Constant					5.48	.436	
MAidQ-PM					-.008	.009	-.058

Block 2	-.005	.507	.001	.298			
Constant					5.34	.512	
MAidQ-PM					-.008	.009	-.063
Neuroticism					.007	.014	.038
Model 6							
Block 1	-.001	.719					
Constant					5.48	.436	
MAidQ-PM					-.008	.009	-.058
Block 2	-.006	.776	.018	.788			
Constant					4.12	1.17	
MAidQ-PM					-.011	.009	-.083
Openness					-.007	.015	-.034
Conscientiousness					.025	.017	.105
Extraversion					.002	.014	.011
Agreeableness					.014	.018	.057
Neuroticism					.017	.015	.084
Lab EB Total							
Model 1	-.005	.005					
Block 1					5.48	.309	
Constant					.000	.006	-.005
MAidQ-PM							
Block 2	-.006	.309	.003	.613			
Constant					5.21	.466	
MAidQ-PM					-.001	.006	-.008
Openness					.008	.010	.053
Model 2							
Block 1	-.005	.005					
Constant					5.48	.309	
MAidQ-PM					.000	.006	-.005
Block 2	.013	2.46	.022	4.91			
Constant					6.24	.457	
MAidQ-PM					.001	.006	.010
Conscientiousness					-.025	.011	-.150*
Model 3							
Block 1	-.005	.005					
Constant					5.48	.309	
MAidQ-PM					.000	.006	-.005
Block 2	-.006	.355	.003	.705			
Constant					5.33	.357	
MAidQ-PM					-.002	.006	-.016
Extraversion					.008	.009	.058
Model 4							
Block 1	-.005	.005					
Constant					5.48	.309	

MAidQ-PM					.000	.006	-.005
Block 2	-.005	.420	.004	.835			
Constant					5.01	.523	
MAidQ-PM					-.001	.006	-.007
Agreeableness					.011	.012	.062
Model 5							
Block 1	-.005	.005					
Constant					5.48	.309	
MAidQ-PM					.000	.006	-.005
Block 2	-.007	.297	.003	.589			
Constant					5.63	.362	
MAidQ-PM					.000	.006	.003
Neuroticism					-.007	.010	-.053
Model 6							
Block 1	-.005	.005					
Constant					5.48	.309	
MAidQ-PM					.000	.006	-.005
Block 2	.012	1.45	.039	1.73			
Constant					5.83	.820	
MAidQ-PM					.001	.007	.010
Openness					.004	.010	.028
Conscientiousness					-.030	.012	-.184*
Extraversion					.006	.010	.042
Agreeableness					.014	.013	.080
Neuroticism					-.009	.011	-.062
Nat TB Total							
Model 1							
Block 1	.003	1.61					
Constant					2.07	.363	
MAidQ-PM					.009	.007	.086
Block 2	-.002	.808	.000	.016			
Constant					2.12	.548	
MAidQ-PM					.009	.007	.086
Openness					-.001	.012	-.008
Model 2							
Block 1	.003	1.61					
Constant					2.07	.363	
MAidQ-PM					.009	.007	.086
Block 2	.008	1.87	.010	2.12			
Constant					1.49	.540	
MAidQ-PM					.008	.007	.076
Conscientiousness					.019	.013	.099
Model 3							

Block 1	.003	1.61					
Constant					2.07	.363	
MAidQ-PM					.009	.007	.086
Block 2	.005	1.60	.007	1.58			
Constant					1.80	.419	
MAidQ-PM					.008	.008	.069
Extraversion					.014	.011	.087
Model 4							
Block 1	.003	1.61					
Constant					2.07	.363	
MAidQ-PM					.009	.007	.086
Block 2	.019	3.07*	.020	4.51*			
Constant					1.02	.610	
MAidQ-PM					.009	.007	.081
Agreeableness					.030	.014	.143*
Model 5							
Block 1	.003	1.61					
Constant					2.07	.363	
MAidQ-PM					.009	.007	.086
Block 2	.004	1.42	.006	1.24			
Constant					2.31	.425	
MAidQ-PM					.011	.008	.098
Neuroticism					-.013	.011	-.076
Model 6							
Block 1	.003	1.61					
Constant					2.07	.363	
MAidQ-PM					.009	.007	.086
Block 2	.010	1.36	.030	1.31			
Constant					.711	.968	
MAidQ-PM					.007	.008	.063
Openness					.013	.014	.064
Conscientiousness					.012	.012	.073
Extraversion					.025	.015	.120
Agreeableness					-.001	.012	-.004
Neuroticism							
Nat EB Total							
Block 1	-.005	.017					
Constant					2.57	.373	
MAidQ-PM					.001	.008	.009
Block 2	-.005	.425	.004	.833			
Constant					2.96	.563	
MAidQ-PM					.001	.008	.012
Constant					-.011	.012	-.062
Openness							

Model 2							
Block 1	-.005	.017					
Constant					2.57	.373	
MAidQ-PM					.001	.008	.009
Block 2	-.005	.452	.004	.887			
Constant					2.18	.557	
MAidQ-PM					.000	.008	.003
Conscientiousness					.013	.014	.064
Model 3							
Block 1	-.005	.017					
Constant					2.57	.373	
MAidQ-PM					.001	.008	.009
Block 2	-.008	.094	.001	.171			
Constant					2.66	.433	
MAidQ-PM					.002	.008	.014
Extraversion					-.005	.011	-.029
Model 4							
Block 1	-.005	.017					
Constant					2.57	.373	
MAidQ-PM					.001	.008	.009
Block 2	-.005	.017	.004	.881			
Constant					2.09	.633	
MAidQ-PM					.001	.008	.007
Agreeableness					.014	.015	.064
Model 5							
Block 1	-.005	.017					
Constant					2.57	.373	
MAidQ-PM					.001	.008	.009
Block 2	.003	1.34	.012	2.67			
Constant					2.20	.436	
MAidQ-PM					-.001	.008	-.008
Neuroticism					.019	.012	.112
Model 6							
Block 1	-.005	.017					
Constant					2.57	.373	
MAidQ-PM					.001	.008	.009
Block 2	.004	1.15	.032	1.38			
Constant					1.10	.995	
MAidQ-PM					-.003	.008	-.026
Conscientiousness					-.008	.013	-.047
Extraversion					.001	.012	.007
Agreeableness					.021	.016	.096
Neuroticism					.027	.013	.162*

Self-Report							
Model 1							
Block 1	.039	9.78*					
Constant					53.24	5.22	
MAidQ-PM					.334	.107	.208*
Block 2	.038	5.33*	.004	.883			
Constant					47.71	7.86	
MAidQ-PM					.329	.107	.205*
Openness					.161	.172	.063
Model 2							
Block 1	.039	9.78*					
Constant					53.24	5.22	
MAidQ-PM					.334	.107	.208*
Block 2	.255	38.07**	.218	63.53**			
Constant					93.78	6.85	
MAidQ					.407	.095	.254**
Conscientiousness					-1.34	.168	-.469**
Model 3							
Block 1	.039	9.78*					
Constant					53.24	5.22	
MAidQ-PM					.334	.107	.208*
Block 2	.035	4.88*					
Constant					53.72	6.05	
MAidQ-PM					.338	.109	.210*
Extraversion					-.025	.157	-.011
Model 4							
Block 1	.039	9.78*					
Constant					53.24	5.22	
MAidQ-PM					.334	.107	.208*
Block 2	.064	8.38**	.029	6.73*			
Constant					71.50	8.72	
MAidQ-PM					.343	.106	.214*
Agreeableness					-.523	.201	-.170*
Model 5							
Block 1	.039	9.78*					
Constant					53.24	5.22	
MAidQ-PM					.334	.107	.208*
Block 2	.088	11.53**	.054	12.75**			
Constant					.276	.105	2.62*
MAidQ-PM					.564	.158	.234**
Neuroticism							
Model 6							

Block 1	.039	9.78*					
Constant					53.24	5.22	
MAidQ-PM					.334	.107	.208*
Block 2	.259	13.67**	.237	13.87**			
Constant					84.26	12.26	
MAidQ-PM					.354	.099	.221**
Openness					.064	.155	.025
Conscientiousness					-1.23	.175	-.431**
Extraversion					.116	.146	.050
Agreeableness					-.120	.192	-.039
Neuroticism					.303	.157	.126

Note: Memory Aids Questionnaire – Prospective Memory Aids only; Lab: lab-based PM; TB: time-based PM; EB: event-based PM; Nat: naturalistic PM task; Total: total correct scores

Table 13. Multiple Regression Results of Personality Traits in Predicting Self-Report PM Error Frequency, Controlling for Memory Aid Strategy Use and Lifestyle.

	Adj R^2	*F*	ΔR^2	ΔF	*B*	*SE B*	*β*
Self-Report							
Model 1							
Block 1	.071	3.37*					
Constant					59.00	6.92	
Classes					-1.63	.959	-.115
Work					-1.11	2.09	-.035
EC					-2.98	2.09	-.095
Mental D/O					.647	2.71	.016
Alc					.869	2.49	.024
Sub					7.17	2.86	.170*
MAidQ-PM					.360	.106	.224**
Block 2	.250	10.02**	.177	50.87**			
Constant					91.28	7.69	
Classes					-.455	.877	-.032
Work					1.25	1.90	.040
EC					-.794	1.90	-.025
Mental D/O					.730	2.44	.018
Alc					.419	2.24	.011
Sub					5.54	2.58	.132
MAidQ-PM					.416	.096	.259
Conscientiousness					-1.26	.177	-.444**
Model 2							
Block 2	.091	3.71**	.023	5.56*			
Constant					74.59	9.52	
Classes					-1.62	.949	-.114
Work					-.424	2.08	-.014
EC					-2.62	2.08	-.083
Mental D/O					.543	2.68	.013
Alc					1.56	2.48	.042
Sub					6.77	2.83	.161*
MAidQ-PM					.370	.105	.231**
Agreeableness					-.479	.203	-.156*
Model 3							
Block 2	.124	4.83**	.055	13.57**			
Constant					46.00	7.59	
Classes					-1.47	.933	-.104
Work					-.408	2.03	-.013
EC					-2.28	2.04	-.073
Mental D/O					-3.02	2.82	-.074
Alc					.981	2.42	.027
Sub					9.08	2.80	.192*
MAidQ-PM					.296	.104	.184*
Neuroticism					.616	.167	.257**

Model 4							
Block 2	.259	7.28**	.198	11.55**			
Constant					81.04	13.04	
Classes					-.570	.884	-.040
Work					1.43	1.93	.046
EC					-.591	1.93	-.019
Mental D/O					-1.49	2.65	-.037
Alc					.373	2.29	.010
Sub					6.14	2.60	.146*
MAidQ-PM					.359	.100	.224**
Openness					.041	.162	.016
Conscientiousness					-1.14	.184	-.401**
Extraversion					.116	.153	.050
Agreeableness					-.113	.196	-.037
Neuroticism					.369	.171	.154*

Note: Classes: number of classes currently enrolled in; Work: employed; EC: extracurricular activity involvement; Alc: alcohol use; Sub: substance use; MAidQ-PM: Memory Aids Questionnaire – Prospective Memory Aids only.

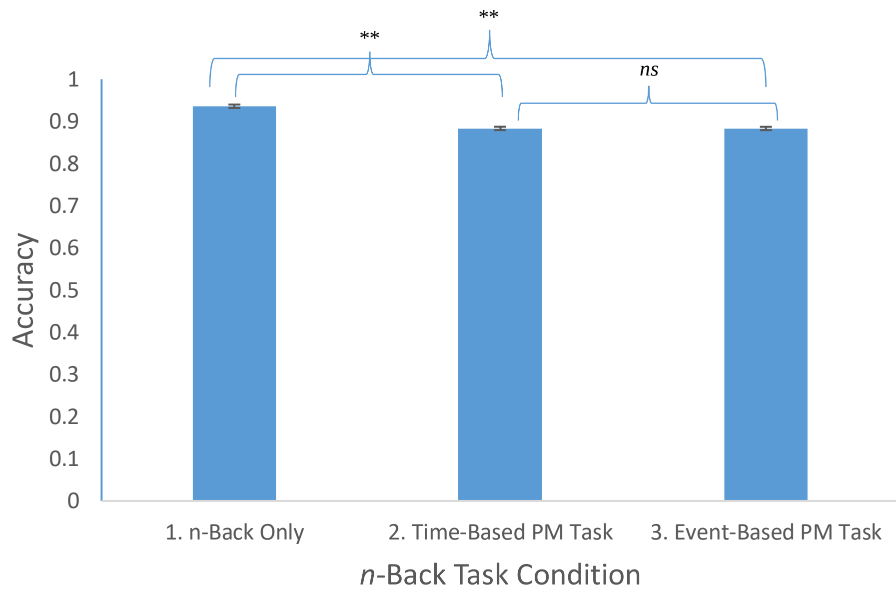


Figure 1. Accuracy on ongoing *n*-back (working memory) task performance by prospective memory (PM) task condition.

Note:

[1] proportion correct on *n*-back task only, out of 48 (N = 220)
[2] proportion correct on *n*-back task during lab-based time-based PM task, out of 144 (N=220)
[3] proportion correct on *n*-back task during event-based PM task, out of 144, (N = 220)
** significant to the $p < .01$ level

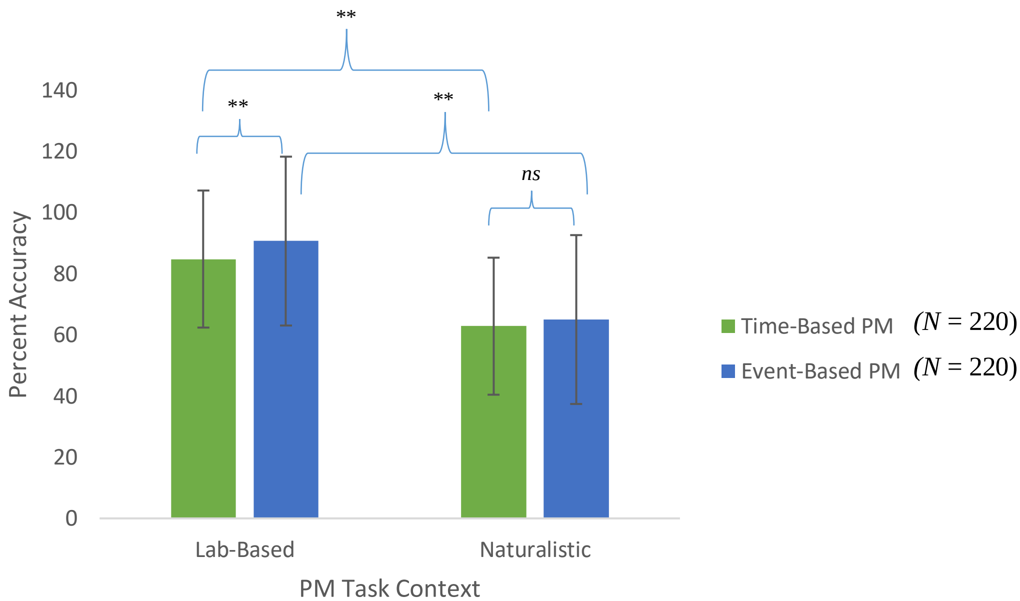


Figure 2. Percent accuracy on time- and event-based prospective memory (PM) tasks across naturalistic and lab-based PM measurement contexts.

Note:

** significant to the $p < .001$ level

ns not significant

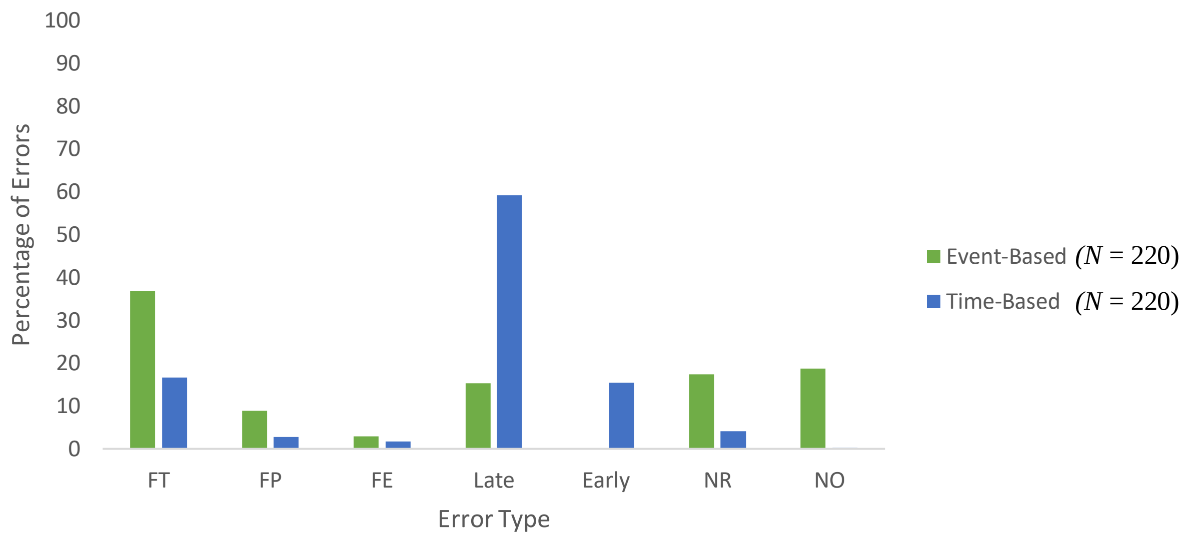


Figure 3. Distribution of errors on naturalistic time- and event-based prospective memory (PM) tasks based on error type.

Note: FT: forgot to complete task; FP: forgot to send proof; FE: forgot to send email; Late: performed task late; Early: performed task early; NR: did not respond; NO: no opportunity to carry out task

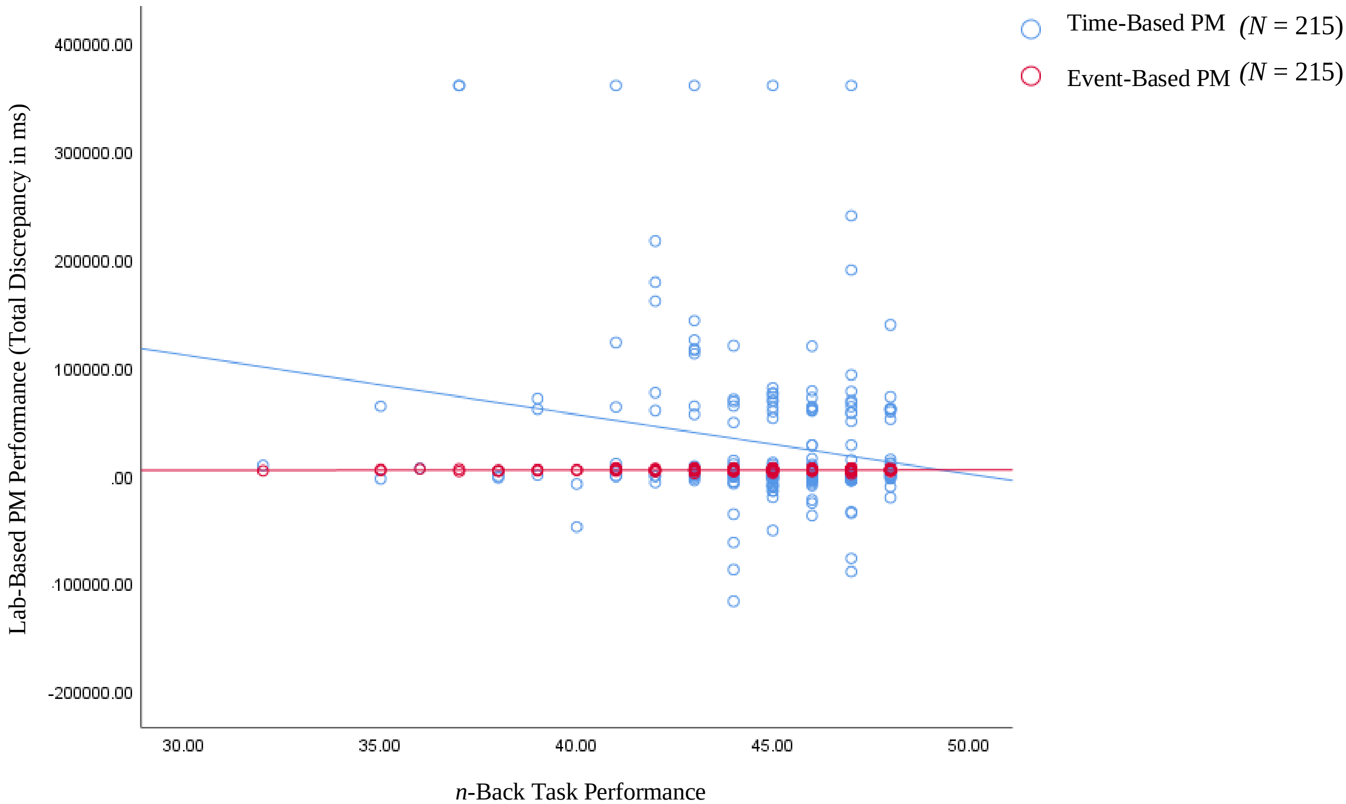


Figure 4. Comparison of correlations between *n*-back task performance and lab-based prospective memory (PM) performance (total discrepancy scores).

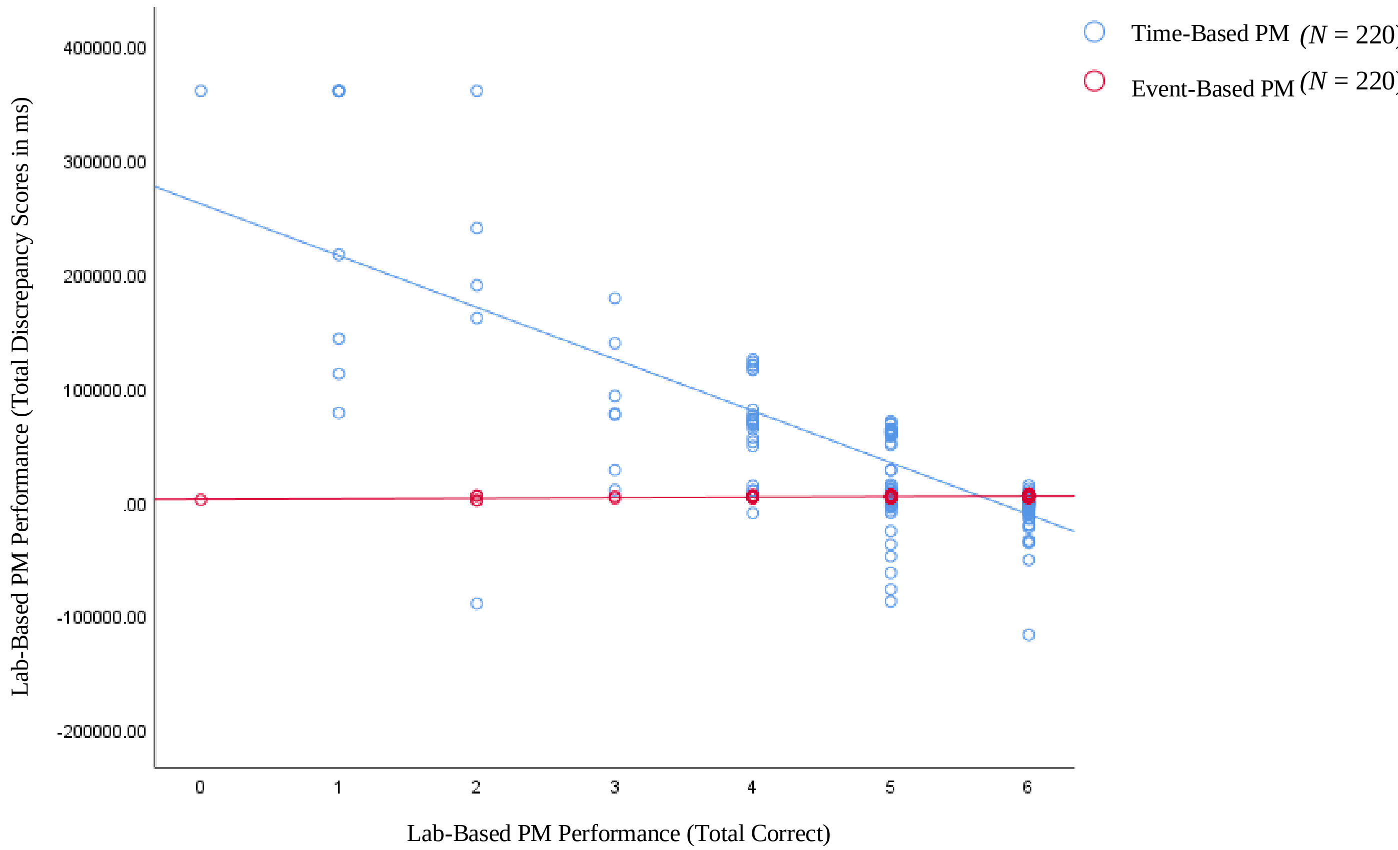


Figure 5. Comparison of correlations between lab-based event- and time-based prospective memory (PM) performance measures (total correct scores vs. total discrepancy scores).

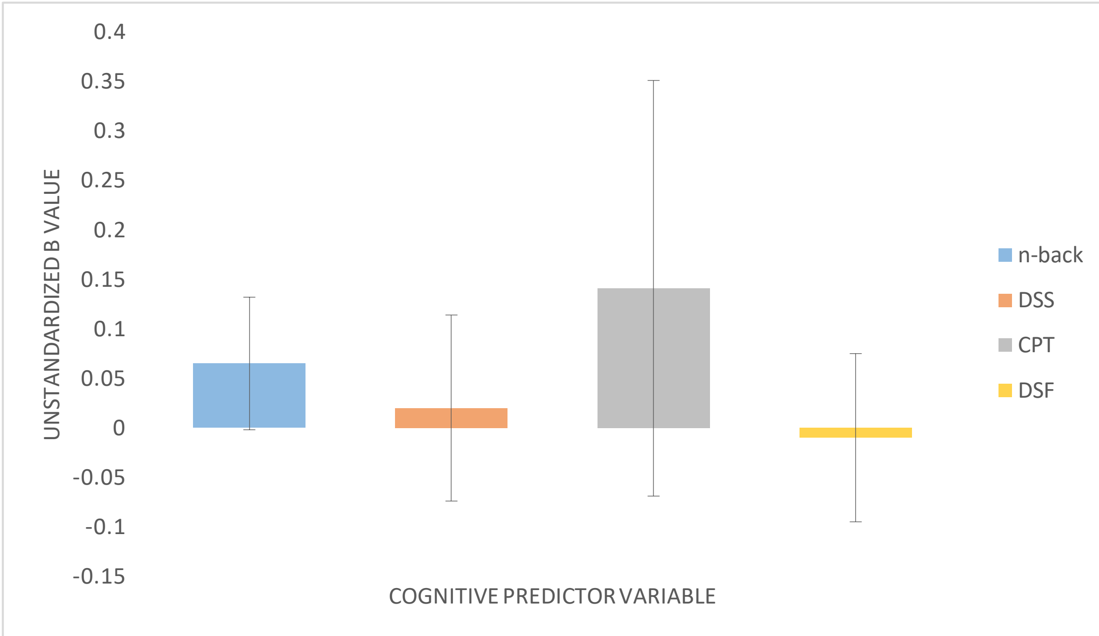
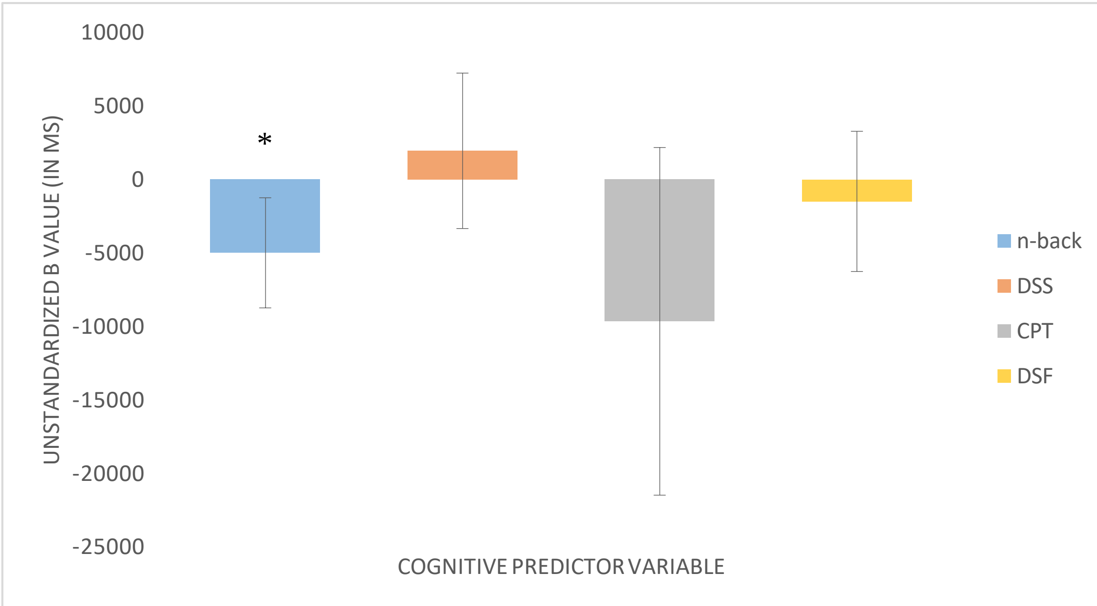


Figure 6. Lab-based time-based total score unstandardized B values for each working memory and attention measure entered simultaneously into a regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.



* statistically significant predictor at $p < .05$ ** at $p < .001$

Figure 7. Lab-based time-based prospective memory discrepancy score unstandardized B values for each working memory and attention measure entered simultaneously into a regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.

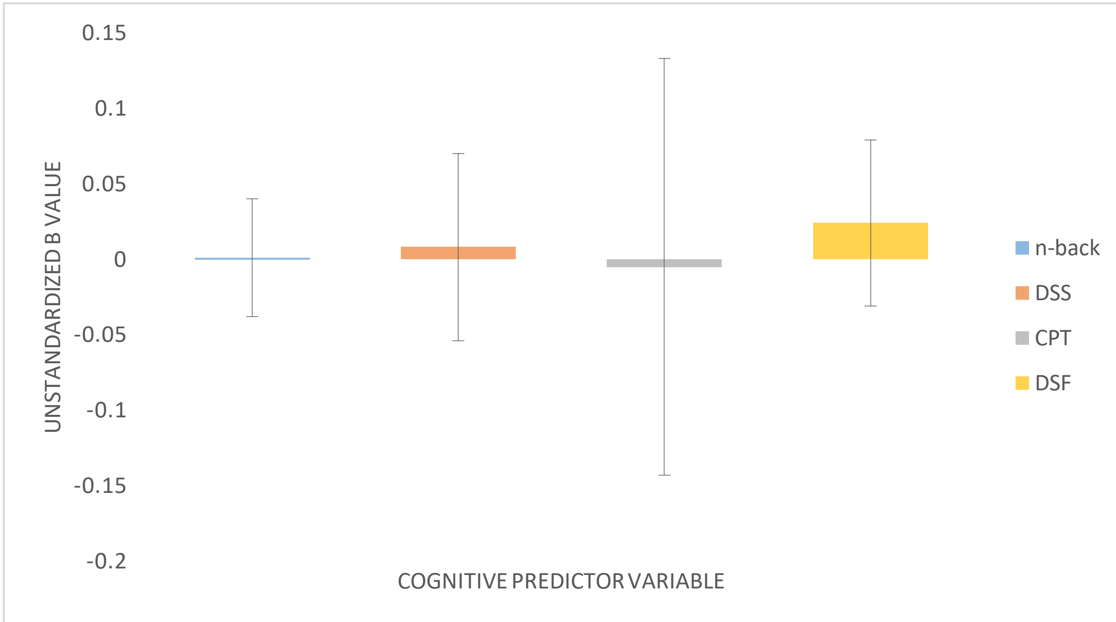


Figure 8. Lab-based event-based prospective memory total score unstandardized B values for each working memory and attention measure entered simultaneously into a regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.

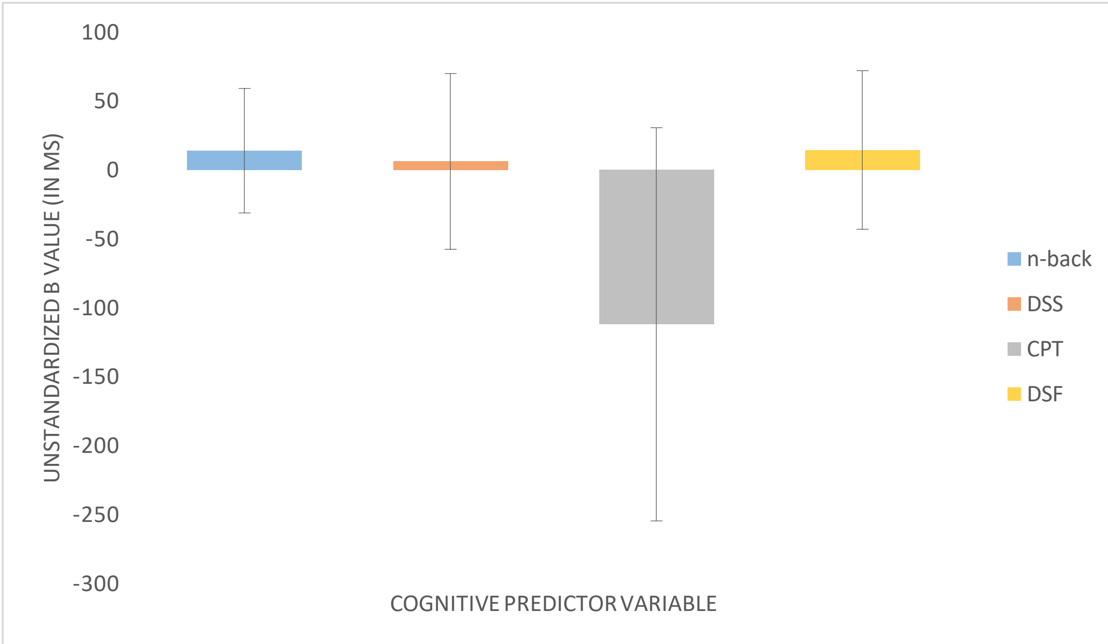


Figure 9. Lab-based event-based prospective memory discrepancy score unstandardized B values for each working memory and attention measure entered simultaneously into a regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.

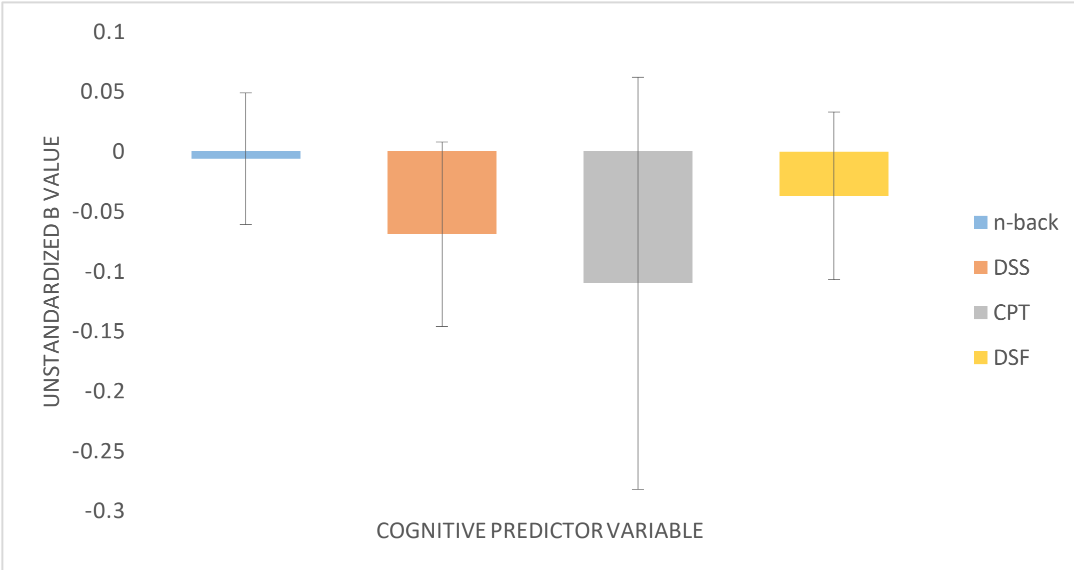
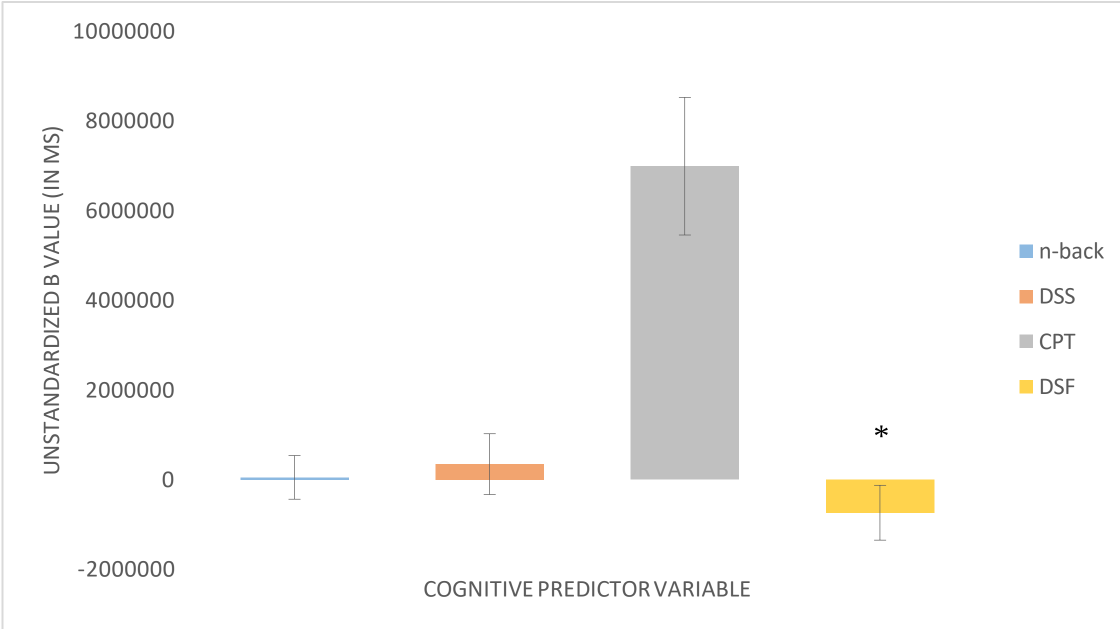


Figure 10. Figure 10. Naturalistic time-based prospective memory total score unstandardized B values for each working memory and attention measure entered simultaneously into a regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.



* statistically significant predictor at $p < .05$ ** at $p < .001$

Figure 11. Naturalistic time-based prospective memory total discrepancy score unstandardized B values for each working memory and attention measure entered simultaneously into the regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.

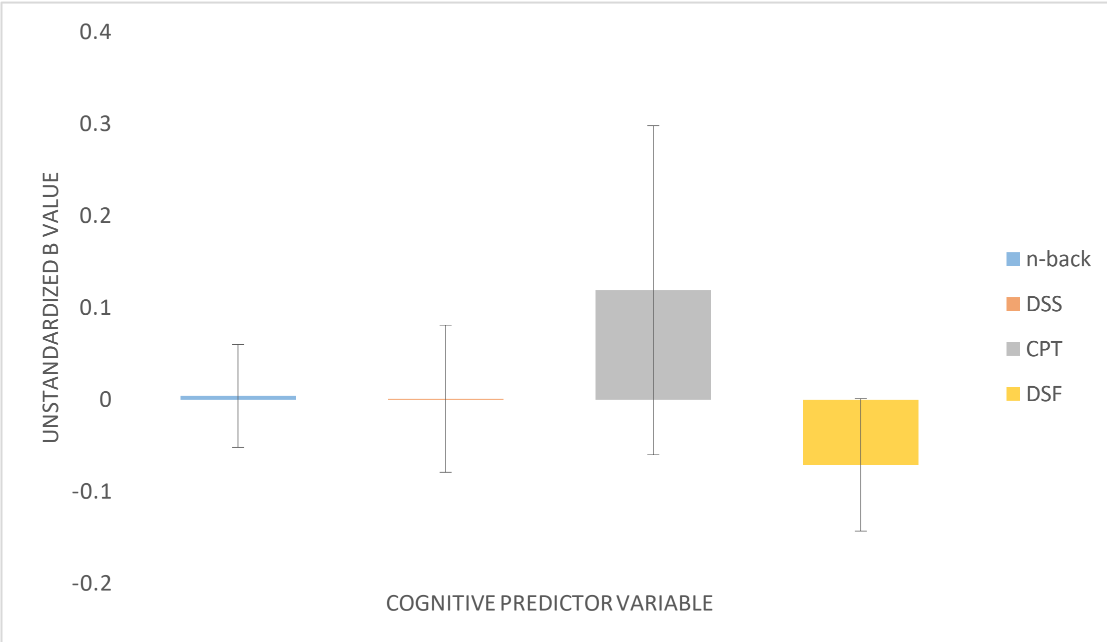


Figure 12. Naturalistic event-based prospective memory total score unstandardized B values for each working memory and attention measure entered simultaneously into the regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task.

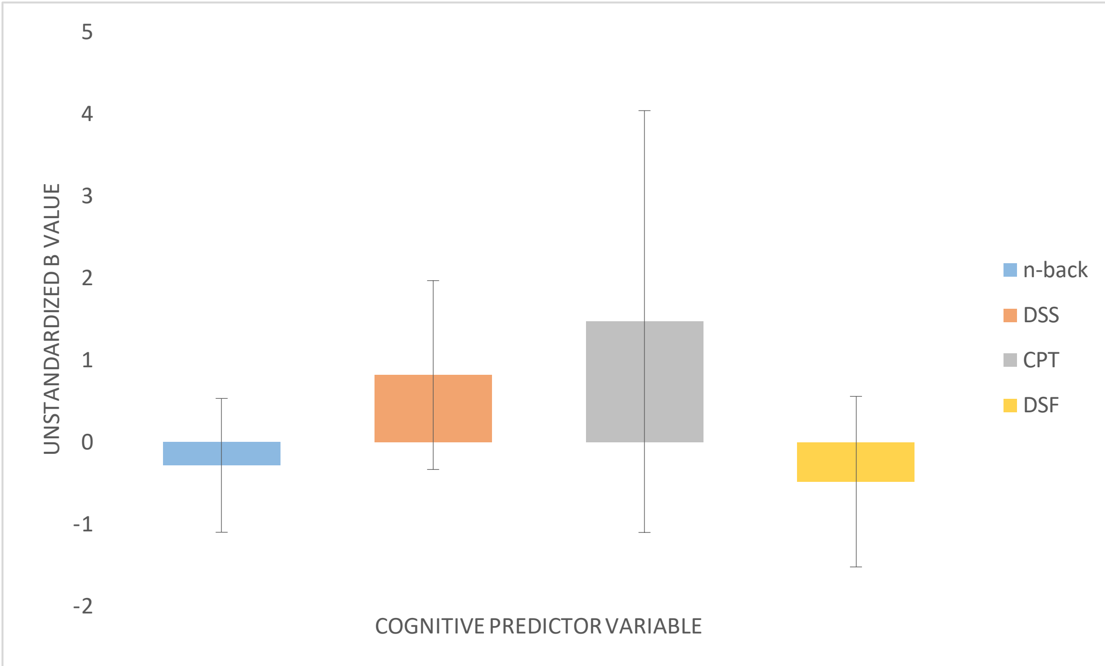


Figure 13. Self-Report CAPM error score unstandardized B values for each working memory and attention measure entered simultaneously into the regression model.

Note: n-back: visual working memory task; DSS: Digit Span Sequencing – verbal working memory task; CPT: Continuous Performance Test – visual sustained attention task; DSF: Digit Span Forward – brief verbal attention task; CAPM: Comprehensive Assessment of Prospective Memory – self-report prospective memory task.

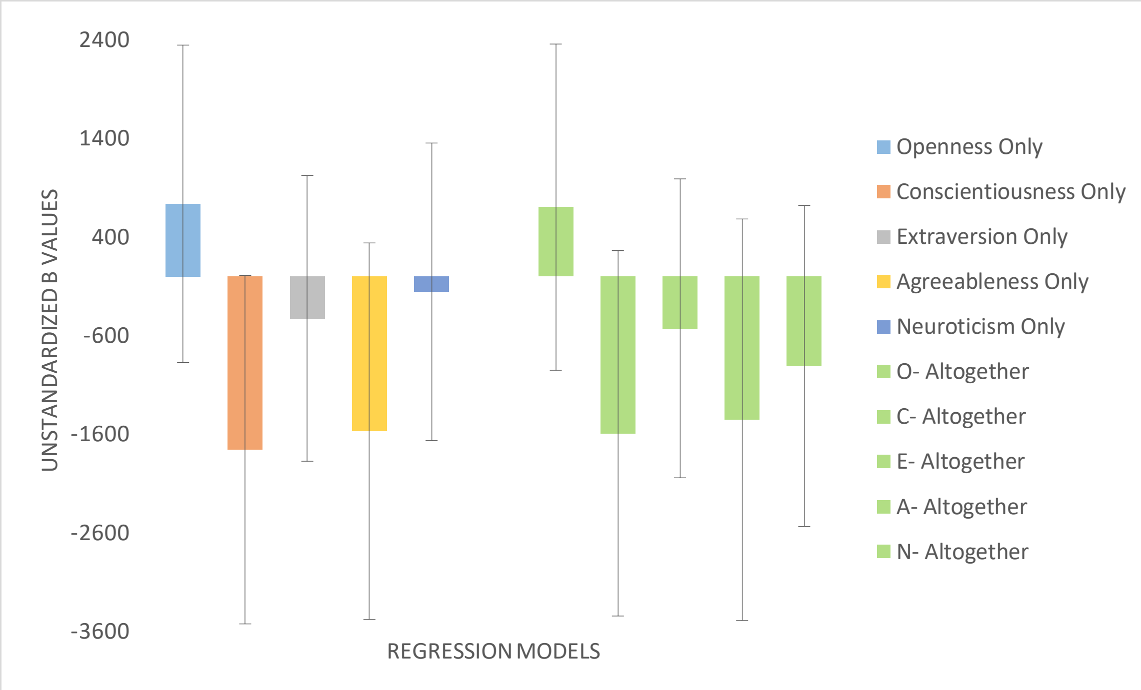


Figure 14. Lab-based time-based prospective memory total discrepancy scores unstandardized B values for each BFI personality trait entered individually and simultaneously into a series of regression models.

Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; BFI: Big Five Inventory – personality questionnaire.

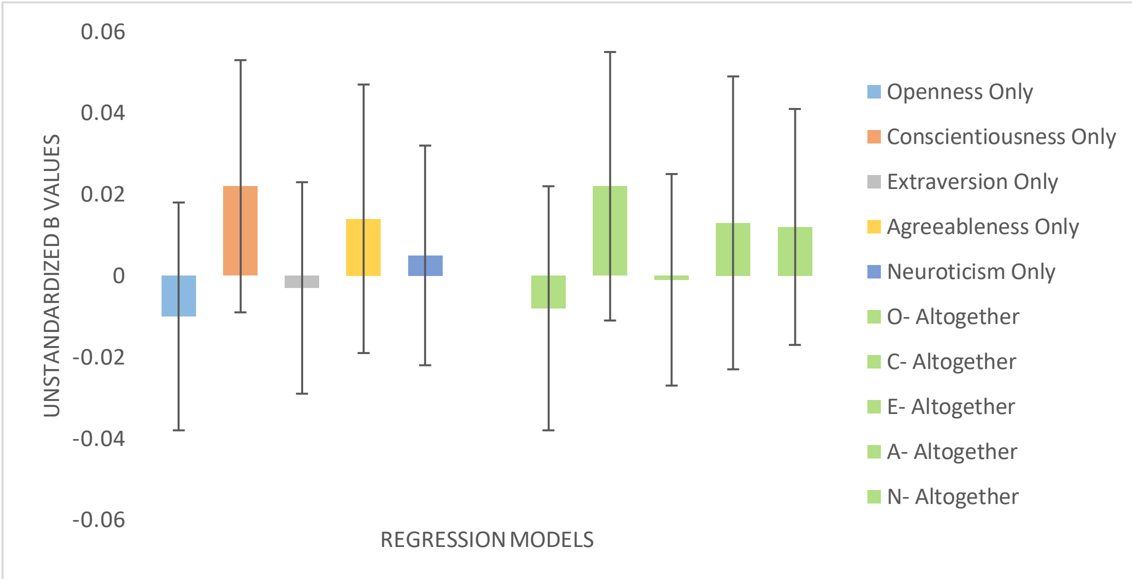


Figure 15. Lab-based time-based prospective memory total correct scores unstandardized B vales for each BFI personality trait entered individually and simultaneously into a series of regression models.

Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; BFI: Big Five Inventory – personality questionnaire.

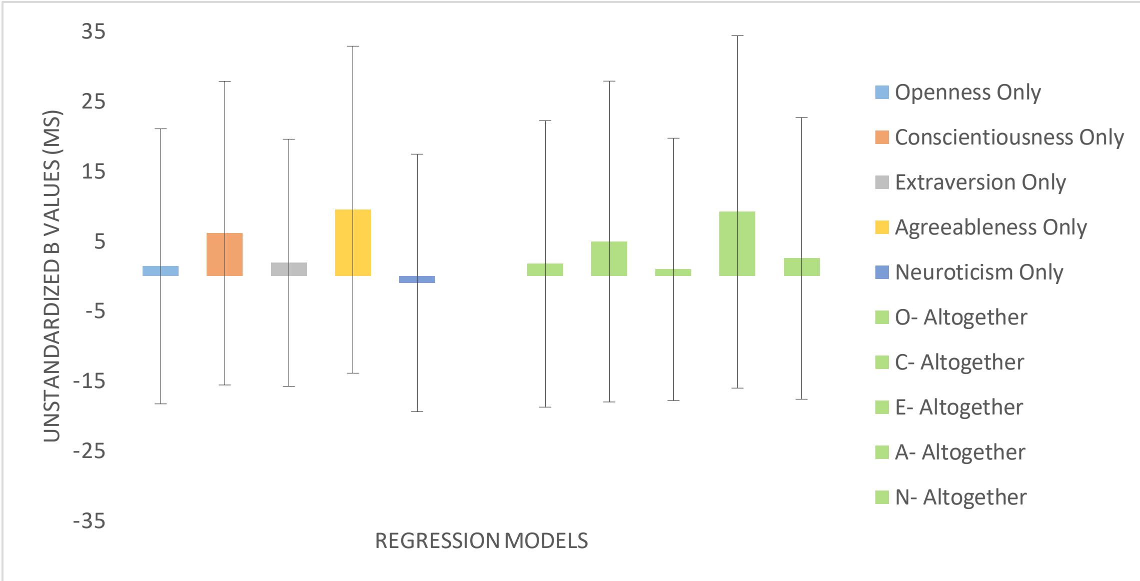
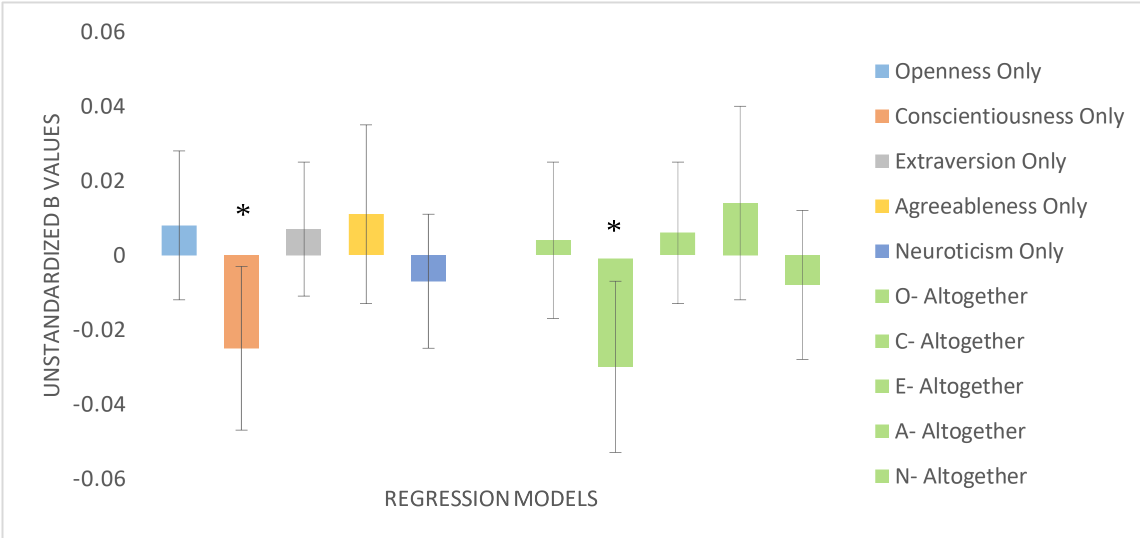


Figure 16. Lab-based event-based prospective memory total discrepancy score unstandardized B values for each BFI personality trait entered individually and simultaneously into a series of regression models.

Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; BFI: Big Five Inventory – personality questionnaire.



* statistically significant predictor at $p < .05$ ** at $p < .001$

Figure 17. Lab-based event-based prospective memory total correct score unstandardized B values for each BFI personality trait entered individually and simultaneously into a series of regression models.

Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; BFI: Big Five Inventory – personality questionnaire.

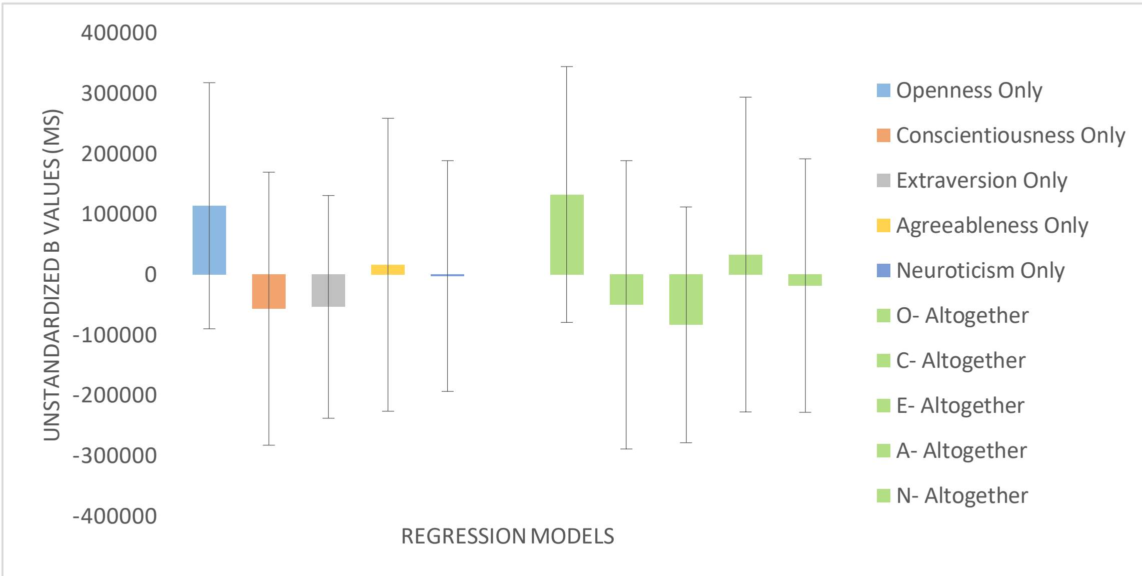
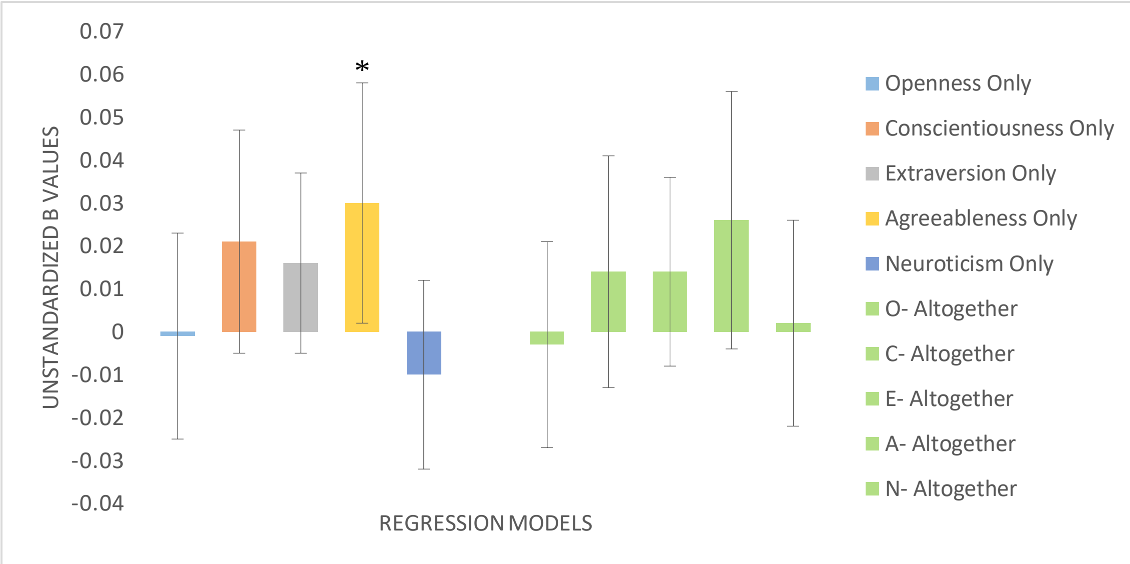


Figure 18. Naturalistic time-based prospective memory total discrepancy score unstandardized B values for each BFI personality trait entered individually and simultaneously into a series of regression models.

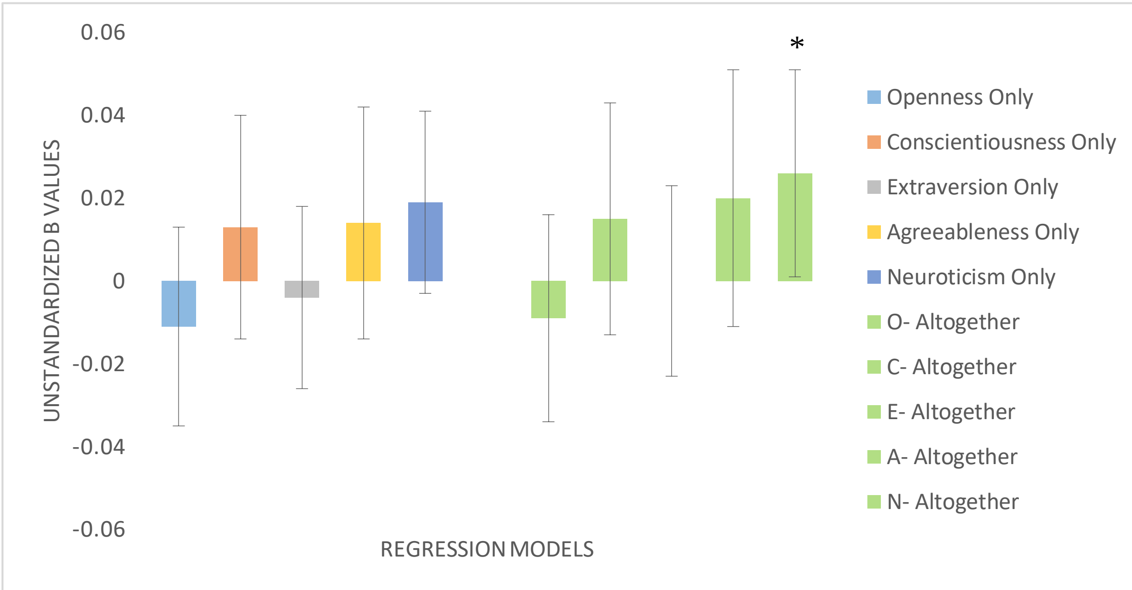
Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; BFI: Big Five Inventory – personality questionnaire.



* statistically significant predictor at $p < .05$ ** at $p < .001$

Figure 19. Naturalistic time-based prospective memory total correct score unstandardized B values for each BFI personality trait entered individually and simultaneously into a series of regression models.

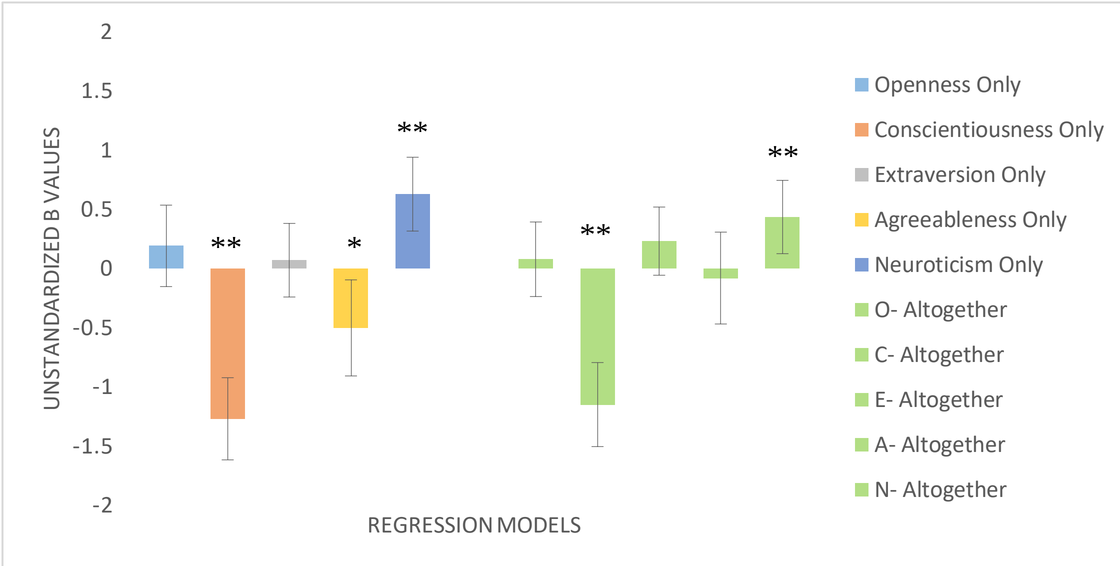
Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; BFI: Big Five Inventory – personality questionnaire.



* statistically significant predictor at $p < .05$ ** at $p < .001$

Figure 20. Naturalistic event-based prospective memory total correct score unstandardized B values for each BFI personality trait entered individually and simultaneously into a series of regression models.

Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; BFI: Big Five Inventory – personality questionnaire.



* statistically significant predictor at $p < .05$ ** at $p < .001$

Figure 21. Self-report CAPM error scores unstandardized B values for each BFI personality trait entered individually and simultaneously into a series of regression models.

Note: O: openness; C: conscientiousness; E: extraversion; A: agreeableness; N: neuroticism; CAPM: Comprehensive Assessment of Prospective Memory – self-report prospective memory questionnaire; BFI: Big Five Inventory – personality questionnaire.