Age differences in prospective memory: Laboratory versus naturalistic settings

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Declaration

This thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma.

No parts of this thesis have been submitted towards the award of any other degree or diploma in any other tertiary institution.

No other person's work has been used without due acknowledgment in the main text of the thesis.

All research procedures reported in the thesis received the approval of the relevant Ethics/Safety Committees.

Signed ____________________________

Date ____________________________

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Abstract

Prospective memory (PM) is the ability to remember and perform intended actions at the appropriate point in the future. PM is a cognitive ability that is vital to many aspects of daily functioning, and it is particularly important for older adults who wish to maintain functional independence. The overall aim of this thesis was to investigate factors that potentially contribute to the age-PM paradox. The age-PM paradox refers to the contrasting age effects on PM performance with age-related deficits observed on laboratory tasks, but no age differences or even age-related benefits observed on naturalistic tasks. Several proposed factors that possibly contribute to the age-PM paradox were examined in two tangential studies.

Firstly, a descriptive study of self-directed PM tasks in daily life was conducted. The study examined how the context of PM task completion in the real world might vary between young and older adults, as such differences may contribute to age differences in naturalistic PM performance. To improve upon previous naturalistic studies, the study employed an experience-sampling method to capture PM successes and failures throughout the day. Contrary to popular belief, the findings suggest that dissimilarities in the demands of everyday life and the usage of external reminders, such as diaries, cannot explain the improved naturalistic PM performance of older adults. However, older adults were found to regard their PM tasks as important more often than young adults. Older adults also rehearsed their PM intentions more frequently than young adults. Thus, it is possible that the age benefit observed in naturalistic settings is related to older adults' motivation and their ability to plan and rehearse their PM tasks within their own environment. Relatively few instances of PM failures were reported by both age groups. Further evidence suggests that participants retrieved their PM intentions through both spontaneous retrieval and strategic monitoring processes, which provides support for the multiprocess framework of PM.

The second study rigorously examined whether the comparison of inherently dissimilar tasks could be contributing to the age-PM paradox. Laboratory PM tasks are predominantly event-based tasks, while naturalistic PM tasks are typically time-based, occurring at a set time of day. To address the lack of task comparability across settings, novel naturalistic PM measures were developed to objectively assess PM performance on three types of tasks: event-based, scheduled time-based (typical of prior naturalistic studies), and time-check tasks (typical of prior laboratory studies). The study is the first investigation of age differences in laboratory and naturalistic settings on all three types of PM tasks using the same participant sample in both settings. Laboratory PM performance was assessed using a computerised version of Virtual Week, which simulates activities of daily life in a board game format. Naturalistic PM performance was assessed using smartphones and an application developed specifically for this thesis. In the laboratory, age-related deficits were observed on all three task types. However, in the naturalistic setting, older adults performed better than young adults on scheduled time-based tasks, performed just as well as the young adults on event-based tasks, and performed equally poorly on time-check tasks. The findings suggest that older adults demonstrate improved PM performance in everyday life when the PM tasks possess an event-like quality, which allows for further environmental support for successful task completion. Regardless of the setting, older adults consistently exhibited poor performance on time-check tasks. This finding suggests that older adults' PM performance suffers when the PM tasks are particularly demanding and rely heavily on effortful monitoring processes for intention retrieval.

Overall, the current research suggests that the age-PM paradox cannot be completely explained by contextual differences surrounding naturalistic PM performance or by the lack of task comparability across settings in the existing literature. However, given the substantial improvement in older adults' naturalistic performance on scheduled time-based tasks, but not on time-check tasks, this thesis highlights the importance of this relatively rare time-based task distinction when considering the age-PM paradox. Taken together, the studies indicate that older adults' naturalistic PM performance benefits from explicit cues, environmental support, and the ability to plan and rehearse PM intentions.

Chapter 1: General Introduction

'— but there's one great advantage in it, that one's memory works both ways.'

'I'm sure **mine** only works one way,' Alice remarked. 'I can't remember things before they happen.'

'It's a poor sort of memory that only works backwards,' the Queen remarked.

- Lewis Carroll, *Through the Looking Glass*

1.1 General Overview

Prospective memory (PM) refers to the ability to remember and perform an intended action at the appropriate point in the future, such as remembering to pick up a child after dance class (Brandimonte, Einstein, & McDaniel, 1996). This cognitive ability impacts multiple facets of daily life, including social relationships (e.g., remembering to buy an anniversary gift), financial capacity (e.g., remembering to pay bills on time), and health (e.g., remembering to take blood pressure medication). Given the high prevalence of PM tasks in everyday life, it is not surprising that individuals often put a number of safeguards in place to ensure they complete their intended actions, especially when the PM task is very important. For example, to prevent a PM failure, individuals may write to-do lists, use reminders on their calendars or mobile phones, or place their passport on top of their packed suitcase so they do not leave for the airport without it. Despite these efforts, an estimated 50-80% of everyday memory problems are failures of PM (Maylor, 1990; Terry, 1988). Many of these PM failures result in frustrating and inconvenient outcomes, such as missing the train on your morning commute or incurring late fees on a rented film. However, a single PM failure could potentially have disastrous or even life-threatening consequences. M. R. Nelson, Reid, Ryan, Willson, and Yelland (2006) found that when patients with high blood pressure forgot to take their medication on just one occasion, the likelihood of a heart attack or death increased. Thus it is clear that PM plays a critical role not only in the management of everyday activities, but also in preserving one's health and well-being.

PM is a vital skill in the lives of older adults. For the elderly population, impairments in PM can threaten their ability to maintain functional independence (Freeman & Ellis, 2003; McAlister & Schmitter-Edgecombe, 2013). Maintaining independence does not only benefit the individual in question, but also benefits the individual's family as well as society as a whole. In 2010, the world's elderly population (i.e., adults aged 65 years or more) reached 542 million, and it is projected to reach nearly 1.5 billion worldwide in 2050 (World Health Organization, 2011). There will be huge economic and social burdens associated with the growing number of older adults who are likely to require long-term care. Therefore, it is of the utmost importance to determine whether PM declines with age, like other cognitive abilities, and if so, how older adults might be able to compensate with memory aids or other strategies in order to maintain independence and a high quality of life.

The prevailing literature on PM and ageing shows conflicting age effects. Years of laboratory research investigating the influence of age on PM has led to the consensus that similar to many other cognitive abilities, PM declines with age (Henry, MacLeod, Phillips, & Crawford, 2004; Kliegel, Jäger, & Phillips, 2008). However, when PM is assessed in naturalistic settings (i.e., participants' daily lives), the findings contrast those of laboratory studies. Naturalistic studies often find that older adults perform just as well as (and sometimes better than) young adults on PM tasks (Henry et al., 2004; Rendell & Craik, 2000). This contrasting performance pattern across settings is referred to in the literature as the age-PM paradox (Rendell & Craik, 2000; Rendell & Thomson, 1999). While many factors have been considered in an effort to explain the age-PM paradox, thus far all of the proposed factors fall short (Phillips, Henry, & Martin, 2008). Currently, it is unclear what might explain this paradox and it remains an issue that needs to be addressed in further studies. The research presented in this thesis focuses on several factors that potentially contribute to the contrasting age differences, including differences in naturalistic PM behaviours and the lack of task comparability across laboratory and naturalistic settings.

Context of Prospective Memory in Everyday Life

One issue hampering our understanding of the age-PM paradox is the fact that little is known about how individuals manage to complete PM tasks in daily life, and which factors influence this real-world PM performance. It is possible that such factors are differentially affected by age; therefore it is necessary to investigate their role in the age-PM paradox. The current thesis investigated several factors that, despite being under-researched, have been presumed to differentially influence naturalistic PM performance, and as such these factors still prevail as possible explanations of the age-PM paradox. First, older adults are thought to have less demanding lifestyles compared to young adults, which could allow them to better focus their attention on PM tasks in naturalistic settings (Bailey, Henry, Rendell, Phillips, & Kliegel, 2010). Additionally, young adults and older adults are thought to differ in their level of motivation to complete PM tasks (Aberle, Rendell, Rose, McDaniel, & Kliegel, 2010; Niedźwieńska, Janik, & Jarczynska, 2013). The context of PM failures was also explored in the current thesis, as older adults have been found to be more susceptible to distractions (Knight, Nicholls, & Titov, 2008). Finally, the degree to which older adults use effortful strategies (e.g., external reminders or frequently thinking about their planned tasks) in everyday life in order to compensate for PM impairments was examined. In order to clarify the factors contributing to the age-PM paradox, a clearer picture of the ways in which young and older adults differ in the completion of PM tasks in everyday life must be obtained.

Lack of Task Comparability across Settings

Another possible explanation for the age-PM paradox is that the comparison between laboratory and naturalistic performances is flawed because the PM tasks used to assess performance in the laboratory are drastically different from the PM tasks used in naturalistic assessment. In the literature, PM tasks have long been categorised based upon the nature of the target cue that signals the moment the intended action should be performed (Einstein & McDaniel, 1990). PM tasks are classified as *event-based* when the target cue is a specific event (e.g., taking medication with dinner), or as *time-based* when the intended action must be performed at a specific time or after a period of time has elapsed (e.g., taking medication at 8 a.m.). This classification has been invaluable to PM research as it has considerably enhanced our understanding of the cognitive processes involved in PM (Kvavilashvili, Cockburn, & Kornbrot, 2013). Laboratory studies of PM and ageing have predominantly measured performance using event-based tasks, whereas the majority of naturalistic studies have used time-based tasks largely due to the difficulty associated with verification of event-based task completion in naturalistic settings. However, given that the cognitive processes involved in recognising the target cue and recollecting the intended action are thought to vary based upon the nature of the target cue, it is reasonable to predict that PM performance on event-based tasks and on time-based tasks could be differentially influenced by age (Kvavilashvili, Kornbrot, Mash, Cockburn, & Milne, 2009; Yang, Wang, Lin, Zheng, & Chan, 2013). Therefore, it is essential that age differences in PM performance be systematically compared across settings using the same type of PM task in each setting in order to investigate this empirically.

Before performance can be further assessed across settings however, a crucial distinction within time-based tasks must be made that is currently absent from most PM paradigms. Laboratory studies that have incorporated time-based tasks have done so primarily using only tasks that required participants to monitor the passing of time (e.g., remembering to press the space bar in 2 minutes). These time-based tasks, referred to as *time-check tasks* in this thesis, are cognitively demanding as they are believed to rely on conscious monitoring processes and working memory for task completion. While time-check tasks exist in everyday life (e.g., remembering to remove cookies from the oven in 10 minutes), they have not yet been thoroughly examined in naturalistic studies. Instead, thus far, participants in naturalistic studies have been required to complete tasks at scheduled times (e.g., call the researcher at 2 p.m.). Tasks that occur at a specific time of day, referred to as *scheduled time-based tasks* in this thesis, are afforded many contextual cues to support and facilitate prospective remembering when they are completed in everyday life. For example, participants could link the task of calling the researcher with other cues in their environment, such as lunchtime. In that case, participants would be able to use more automatic processes to complete their PM task, which potentially leads to improved PM performance. Thus, it is possible that the conflicting pattern of age differences across settings is a result of the comparison of PM performance on tasks that are too dissimilar. These two variants of time-based tasks merit distinction based upon their fundamental differences, and further investigation is essential to determine whether the age-PM paradox can be resolved once the PM tasks are better matched across settings.

The Role of Encoding in the Age-Prospective Memory Paradox

While the lack of task comparability across settings could contribute to the age-PM paradox, there is also the possibility that differences in the cognitive processes involved in PM could contribute to the age-PM paradox. For example, one phase where older adults struggle in the laboratory, and where young adults might struggle in naturalistic settings, is during the formation of a PM intention (Ellis & Kvavilashvili, 2000). During this phase, details of the intended action as well as the target cue are identified and encoded. However, research suggests that individuals tend to form general intentions and focus solely on the intended action as opposed to the target cue (Gollwitzer, 1999). As a result, individuals are dependent upon deliberate monitoring processes to recall their intention, which often leads to failures in PM (Einstein & McDaniel, 2014). In the laboratory, young adults perform well on

PM tasks despite the abstract nature of the target cues largely due to their working memory capacity and the brief period of assessment, but perhaps young adults rely too heavily on their monitoring skills in naturalistic settings which results in diminished PM performance. Furthermore, it is possible that older adults are better able to encode their PM intentions in naturalistic settings than in the laboratory because they are able to easily identify the target cues within their familiar environment or perhaps the structure of their daily life allows them to better predict where they will be and what they will be doing when they encounter the target cues. Thus, a strategy that targets the encoding phase could potentially improve the PM performance of older adults in the laboratory and/or the PM performance of young adults in everyday life, thereby eliminating the contrasting pattern of age differences. The implementation intentions encoding strategy is thought to strengthen the association between the intended action and the target cue by instructing individuals to encode their intention in a precise format while visualising task completion (Gollwitzer, 1999). This strategy has been found to improve PM performance in the laboratory (Burkard et al., 2014; Zimmermann & Meier, 2010), but our knowledge regarding its effectiveness as well as its limits in naturalistic settings remains inadequate (Brom et al., 2014). Further evaluation of the implementation intentions encoding strategy in both laboratory and naturalistic settings could clarify the role of encoding ability in the age-PM paradox.

1.2 The Current Research Project

The overall objective of this research project was to investigate factors that possibly contribute to the age-PM paradox. Two tangential studies were conducted. The first was a descriptive study of self-directed PM tasks in daily life, which aimed to enhance our understanding of the context in which individuals succeed and fail at their PM tasks in the real world. The study examined how the context of PM task completion in daily life might vary between young and older adults, and how these differences might help explain group differences in naturalistic PM performance. Naturalistic studies that have attempted such an investigation have often relied upon self-report in the form of diary studies, whereby participants must recall their PM successes and failures at the end of each day. This places the burden on participants to not only monitor these occurrences and the conditions under which they occur, but to also accurately remember the details at the end of each day. To improve upon previous naturalistic studies, the first study employed an experience-sampling method using personal digital assistants. The second study rigorously examined the methodological issues which could be contributing to the age-PM paradox, namely the use and comparison of disparate tasks across settings. Novel naturalistic PM measures were created to objectively assess PM performance on all three task types (i.e., event-based, scheduled time-based, and time-check tasks). The second study also explored the potential influence of enhanced encoding on laboratory and naturalistic PM performance. This research project is the first to investigate age differences in laboratory and naturalistic settings on all three types of PM tasks. Moreover, the same participant sample was used in both settings so that potential differences could not be attributed to differences between samples.

Research Objectives

The first study examined the context of PM in daily life. More specifically, the study investigated the circumstances of participants' PM successes and failures in their everyday lives. The study had the following objectives:

1. To explore differences in the daily lives of young adults and older adults that might provide potential explanations for the age differences in PM performance observed in previous naturalistic studies.

2. To examine whether there is any dissimilarity in the demands of everyday life, the level of motivation, or the use of external reminders that might potentially explain the age differences found in previous naturalistic investigations of PM.

3. To identify the circumstances that are associated with PM failures in daily life and whether those circumstances differ according to age group.

The second study examined whether the age-PM paradox might reflect the lack of parallel tasks in laboratory and naturalistic assessments of PM performance. The study had the following primary objectives:

1. To assess whether the age-PM paradox is evident when performance is compared using PM tasks that are matched by cue type across settings.

2. To systematically investigate age differences on three types of PM tasks (i.e., event-based, scheduled time-based, and time-check) in both laboratory and naturalistic settings.

3. To develop objective naturalistic measures of PM for the three types of PM tasks.

Additionally, Study 2 had a secondary objective to examine whether differences in encoding may contribute to the age-PM paradox.

1.3 Thesis Structure

Following the general introduction, this thesis presents a literature review on PM and ageing. This literature review (Chapter 2) includes an overview of PM and the current literature on age effects in PM across laboratory and naturalistic settings. The purpose of this literature review is to provide a rationale for investigating age differences in PM performance within both laboratory settings and everyday life. The first empirical study (Study 1) of age differences in PM is presented in Chapter 3. This study investigated the context of PM tasks in everyday life using an experience-sampling method. The fourth chapter provides a detailed description of the PM measures used to assess performance in both the laboratory and naturalistic settings used in the subsequent experimental study (Study 2). Chapter 4 also describes the development of original naturalistic measures designed specifically for this research. The second empirical study is presented in Chapter 5. It systematically examined age differences in PM performance across three types of PM tasks in both laboratory and naturalistic settings. The final chapter is a general discussion of the research conducted, including an overall summary and implications of the findings, strengths and limitations of the thesis, and directions for future research.

Chapter 2: Review of Prospective Memory Literature

2.1 Prospective Memory

Prospective memory (PM) is the ability to remember to perform an intended action at the appropriate moment in the future (Brandimonte et al., 1996). This cognitive ability is essential in daily life, from remembering to pay bills on time to remembering to wish a friend a happy birthday. There are three defining characteristics of PM tasks (Ellis & Kvavilashvili, 2000). Firstly, there must be a delay between the formation of a PM intention and its execution. Secondly, the retrieval of an intention must occur while the individual is engaged in a competing activity often referred to in the literature as an *ongoing task* (McDaniel & Einstein, 2000). Participation in the ongoing task must be interrupted in order to perform the intended action. Lastly, PM tasks are performed in the absence of direct instruction or an explicit reminder to do so (Ellis & Kvavilashvili, 2000). For example, if your spouse reminds you while at the supermarket of your previous intention to purchase ice cream, this is not considered to be a PM task. PM is comprised of both a retrospective component and a prospective component (Brandimonte et al., 1996). The retrospective component consists of the recollection of the content of a PM task (i.e., remembering *what* has to be done and *when* that intended action should be completed). The prospective component consists of the self-initiated retrieval of the PM intention (i.e., remembering *that* the action must be completed) at the appropriate moment (Ellis & Kvavilashvili, 2000; McDaniel & Einstein, 2007).

Failures in PM contribute to an estimated 50-80% of all everyday memory problems (Crovitz & Daniel, 1984; Maylor, 1990; Terry, 1988). Such failures often lead to frustrations and inconveniences, but failures in PM can have life-threatening consequences. For example, the World Health Organization (2003) identified poor medication adherence for chronic illnesses, such as diabetes and hypertension, as a worldwide dilemma. Within medication adherence research, patients reported forgetfulness as the most common barrier to proper adherence (Osterberg & Blaschke, 2005). Forgetting to take even a single dose could greatly impact health outcomes, such as a substantial worsening of symptoms, a costly hospital admission, or in some cases death (Osterberg & Blaschke, 2005). Furthermore, research has shown an association between cognitive functioning and medication adherence among older adults (Insel, Morrow, Brewer, & Figueredo, 2006). Another dire example of the potential severity of a lapsed intention, but sadly one that does occur each year, is forgetting a sleeping infant in the backseat of a car. From 1998 to 2015, 661 children in the United States died from heat stroke after being left unattended in a vehicle (Null, 2016). In approximately 54% of these cases, the caregiver tragically forgot that the child was in the car (Null, 2016). For a review of critical PM failures in workplace situations in the aviation and medical fields, see Dismukes (2012). Given the ubiquity of PM tasks in everyday life and the negative outcomes associated with PM errors, it is imperative to research the potential causes of deficits in PM as well as potential strategies to improve PM (Kliegel & Martin, 2003).

Phases of Prospective Memory

Research suggests that PM consists of four distinct, sequential phases: formation, retention, initiation, and execution (Ellis, 1996; Ellis & Freeman, 2008; Kliegel, Mackinlay, & Jäger, 2008; Kliegel, Martin, McDaniel, & Einstein, 2002). To better illustrate the phases, an example PM task will be used: remembering to purchase stamps on the way home from work.

The first phase of PM is the formation phase, which involves the encoding of a PM intention and the planning of the future task. The precise details of the intention (i.e., the denomination and number of stamps required) and the appropriate moment or situation when the action is to be performed (i.e., on the way home from work) is decided upon in this phase. Formation is followed by an extended period of time where an individual's intention must be retained while completing other tasks and ongoing activities; this is known as the retention phase. For example, after forming the intention prior to work, you must retain the intention of buying stamps until you walk home. The retention period can vary in duration from, for example, a few minutes to a few months depending on the PM task (McDaniel & Einstein, 2007). During the third phase, the initiation phase, an individual monitors the environment for an appropriate cue while also inhibiting any concurrent tasks. When the appropriate moment occurs, it should be followed by the interruption of the ongoing task and the self-initiated retrieval of the PM intention. For example, if you were talking on your phone while walking past the neighbourhood post office, you must remember your intention, switch attention from your conversation, and enter the post office to purchase stamps. Successful PM performance is strongly influenced by the ability to identify and process the target cue, whatever it may be, during the initiation phase (Kliegel, Martin, McDaniel, & Einstein, 2004; McDaniel & Einstein, 2007). The final phase of PM is execution, which occurs when the intended action is properly completed (e.g., you buy stamps on your way home from work). Ellis (1996) argues that some degree of evaluation occurs after execution to prevent repetition of the PM task or to trigger the fulfilment of failed intentions.

Theoretical Models of Prospective Memory

Several explanatory frameworks or theoretical models of PM have been developed over the past 25 years of PM research (Ellis, 1996; McDaniel & Einstein, 2000; R. E. Smith, 2003). The preparatory attentional processes and memory processes model (PAM) theory was developed by R. E. Smith (2003). The PAM theory proposes that intention retrieval utilises preparatory processes that draw upon limited cognitive resources (R. E. Smith, 2003; R. E. Smith & Bayen, 2004). According to PAM theory, the performance of PM tasks are dependent on these preparatory attentional processes, and the increased monitoring required will result in a cost to the ongoing activity (R. E. Smith & Bayen, 2004). The key distinction between PAM theory and other models of PM is that according to PAM theory, intention retrieval is always effortful and resource-demanding (R. E. Smith, 2003). However, there is a growing body of research which suggests that successful completion of PM tasks can also be achieved through an automatic intention retrieval process (Einstein et al., 2005; Scullin, McDaniel, Shelton, & Lee, 2010).

Arguably, the most influential and prominent model of PM within the literature is the multiprocess framework (McDaniel & Einstein, 2000). The multiprocess framework put forth by McDaniel and Einstein (2000) proposes that intention retrieval is achieved both through a strategic monitoring process and also through a more automatic or spontaneous retrieval process. The framework operates on the assumption that prospective remembering is critical to our functioning, therefore the development of a flexible system of intention retrieval, supported by multiple mechanisms, would be considered adaptive (Einstein & McDaniel, 2014). Strategic monitoring of the environment for the presence of a target cue is thought to be resource-demanding and it involves a number of cognitive skills that make up executive functioning (Kliegel, Mackinlay, et al., 2008; Martin, Kliegel, & McDaniel, 2003). Spontaneous retrieval processes, on the other hand, are less effortful and are often triggered by the target cue involuntarily capturing one’s attention. Spontaneous retrieval of an intention is introspectively experienced as the PM task “popping into mind” (Einstein & McDaniel, 1990; McDaniel & Einstein, 2000). The existing literature suggests that failures in PM are more likely to occur when target cues lack sufficient environmental support or when strategic monitoring is required (Craik, 1986; Einstein & McDaniel, 2014). PM errors can occur when relying on strategic monitoring processes due to the susceptibility to distractions and fatigue, as well as the demands on working memory resources, which have been shown to decline with age (Bisiacchi, Tarantino, & Ciccola, 2008). Although there is arguably a greater likelihood of PM failures when using strategic monitoring processes, it is not always possible to utilise spontaneous retrieval processes instead, and even then task completion is not guaranteed (Einstein et al., 2005). Intention retrieval will likely require strategic monitoring processes in the following conditions: the target cue is not distinctive, the PM task and the target cue are unrelated to the ongoing task, the association between the target cue and the intended action is weak, and the ongoing task is particularly engaging (Harrison & Einstein, 2010; Phillips et al., 2008). Given that spontaneous retrieval and strategic monitoring differ in cognitive demand and the attentional resources required, PM performance may be influenced by which retrieval process is used to complete a PM task (Gonneaud et al., 2011). Certain task features, such as cue type and task importance, have been proposed to determine which intention retrieval process is necessary for the completion of a given PM task (Einstein et al., 2005). For recent refinements of the multiprocess model, see Scullin, McDaniel, and Shelton (2013), which suggests that individuals dynamically employ both intention retrieval processes.

The type of PM cue as it pertains to the lack of task comparability across laboratory and naturalistic settings is a major focus of this thesis. Although the multiprocess model was developed in relation to event-based tasks, aspects of the theoretical framework may also apply to time-based PM tasks (McDaniel & Einstein, 2000). As such, the multiprocess model provided the theoretical framework underpinning the current research. In particular, Study 2 drew heavily on the principles of the multiprocess model to guide the predictions made regarding PM performance and the age differences in both settings. It is possible that the contrasting age differences previously reported when comparing laboratory and naturalistic PM performance could be related to differences in the intention retrieval processes across settings. For example, perhaps older adults perform better in naturalistic settings because the tasks are accompanied by environmental support, which could allow for spontaneous retrieval of their PM intentions. Thus, the findings of this thesis have some implications for the multiprocess model.

Task Characteristics

There are many dimensions of PM tasks that could serve as means by which to classify the tasks and examine PM performance. Categorisation of PM tasks allows for thorough investigation into the underlying mechanisms of PM and the potential differential effects of ageing. Cognitive demands required for successful PM performance are thought to vary depending on the type of PM task (Einstein & McDaniel, 2014; Hannon & Daneman, 2007). The primary distinguishing characteristic of PM tasks in the field thus far has been the nature of the target cue that signals the moment an intended action should be performed. This distinction has proven to be an important categorisation for the examination of ageing effects on PM performance (Jäger & Kliegel, 2008; Kvavilashvili et al., 2013; Yang et al., 2013), and is of particular importance to the current research. Another valuable distinction, particularly in the PM literature on ageing, is the setting in which the PM task occurs. As this thesis focuses on age differences in PM performance, the nature of the target cue and the setting of PM assessment are of great interest since differential age effects have been observed across these variables (Henry et al., 2004; Kvavilashvili et al., 2013). Additionally, the less common distinction of task regularity will be discussed as a secondary point as the regularity of the PM task has also been found to interact with age and influence PM performance (Aberle et al., 2010; Henry et al., 2004; Kvavilashvili et al., 2013; Rendell & Thomson, 1999).

Event-based and time-based tasks. Einstein and McDaniel (1990) proposed the distinction of PM tasks into two categories based upon the nature of the target cue. Event-based tasks are carried out in response to a specific, external event (e.g., posting a letter when seeing a post box). Successful execution of an event-based task requires an individual to remember and identify the anticipated environmental cue, which in turn reminds the individual to complete the intended action (Hicks, Marsh, & Cook, 2005). Time-based tasks are performed at a specific time or after a certain time interval without a cued reminder (e.g., taking medication at 3 p.m. or 30 minutes after eating). Due to the lack of a distinct cue in time-based tasks, intention retrieval for time-based tasks is thought to rely on strategic monitoring processes. Therefore, of the two task types, time-based tasks are widely considered to be more dependent on internal control mechanisms and are more cognitively demanding than event-based tasks (Brandimonte et al., 1996; d'Ydewalle, Bouckaert, & Brunfaut, 2001; Einstein & McDaniel, 2014; Henry et al., 2014). More recently, neuroimaging studies have incorporated the event- and time-based task distinction into their investigations of PM. The findings suggest that there are in fact different processing demands made upon the rostral prefrontal cortex, the brain region associated with completion of PM tasks, depending on the type of PM cue (Okuda et al., 2007).

Distinguishing between event- and time-based tasks has proven to be a fundamental step in understanding the nature of encoding and retrieval of PM intentions (Kvavilashvili & Fisher, 2007). However, PM research has not yet focused on the necessary distinction between two variants of time-based tasks.[1] For clarification purposes, two new terms are proposed for these two time-based task variants. In this thesis, PM tasks that are to be performed at a specific time will be referred to as *scheduled time-based tasks*. Scheduled time-based tasks are appointment-style tasks that occur frequently in daily life (e.g., remembering to attend a meeting at 10 a.m.). PM tasks that are to be performed after a certain period of time has elapsed will be referred to as *time-check tasks*. Examples of time-check tasks include remembering to take the cookies out of the oven in 10 minutes and remembering to move your car before the time limit expires on the parking meter. In the

[1] Another classification scheme for time-based tasks has been proposed by Ellis (1996). In the *pulse-step* proposal, time-based tasks can be distinguished by the specific temporal requirements of successful retrieval and execution. For example, a *pulse* is a time-based task with a specific point of retrieval (e.g., meeting a friend at 3 p.m.), whereas a *step* is a time-based task with a wider time period in which retrieval must occur (e.g., meeting a friend sometime this afternoon). This proposed classification of time-based tasks has been widely ignored in the literature and therefore it lacks thorough investigation. Nearly all investigations of PM performance on time-based tasks fail to make any further distinction of time-based tasks.

current PM literature, time-based tasks are customarily grouped together, with no distinction made between scheduled time-based tasks and time-check tasks (Cona, Arcara, Tarantino, & Bisiacchi, 2012; d'Ydewalle et al., 2001; Gonneaud et al., 2011; Henry et al., 2004; Hering, Cortez, Kliegel, & Altgassen, 2014; Jäger & Kliegel, 2008; Kvavilashvili & Fisher, 2007; Niedźwieńska & Barzykowski, 2012). Research conducted with the laboratory paradigm Virtual Week is the exception, as both types of time-based tasks are simulated within the assessment (Rendell & Craik, 2000). However, previous Virtual Week studies have typically compared the performance of time-check tasks with the performance of regular and irregular PM tasks (Mioni, Rendell, Stablum, Gamberini, & Bisiacchi, 2014; Rendell & Henry, 2009; Rendell et al., 2011; Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010) or have excluded time-check tasks when assessing clinical groups (Henry et al., 2014; Niedźwieńska, Rendell, Barzykowski, & Leszczyńska, 2014) or when examining other task features, such as cue focality (Foster, Rose, McDaniel, & Rendell, 2013). The general absence of the distinction between scheduled time-based tasks and time-check tasks can make it difficult to compare performances on time-based tasks across studies and thus creates a large gap in the literature. The division of time-based tasks into these two variants is critical for future studies of PM for reasons that become apparent when considering the comparison of PM performances across settings.

Laboratory and naturalistic settings. PM tasks can also be distinguished according to the setting in which they occur. As the name suggests, laboratory tasks take place in a laboratory setting, which is typical of research environments. Laboratory settings allow for a high-level of experimental control. In contrast, naturalistic tasks take place in the everyday environment of the participant (Phillips et al., 2008). Laboratory studies of PM generally utilise a dual-task design where participants are asked to complete a PM task that has been embedded into an ongoing task. For example, while rating words based on their familiarity (the ongoing task), participants are to press a designated key either when a specific word appears (event-based task) or after a specified period of time has elapsed (time-based task; Kliegel, Martin, McDaniel, & Einstein, 2001). Naturalistic studies of PM vary in their design, and can include tasks such as remembering to write the time and date on a questionnaire before mailing it back to the researcher (Kvavilashvili et al., 2013) or telephoning the researcher at a specified time (Maylor, 1990). The ongoing tasks in naturalistic studies are the everyday activities in which participants are engaged during the retention phase.

Presentation of event-based and time-based tasks across settings. Much of the theoretical understanding of PM and the factors proposed to influence PM performance result from laboratory investigations. Laboratory studies are far more prevalent than naturalistic studies within PM research. Event-based tasks have dominated laboratory studies of PM, but until recently they were rarely used in naturalistic studies (see Bailey et al., 2010; Cavuoto, Ong, Pike, Nicholas, & Kinsella, 2015; Kvavilashvili et al., 2013; Masumoto, Nishimura, Tabuchi, & Fujita, 2011; Niedźwieńska & Barzykowski, 2012). The scarcity of event-based tasks in naturalistic studies of PM may be partly due to difficulties in empirically assessing performance on such tasks in everyday life (Phillips et al., 2008). For example, verification of task completion can be challenging as it would be difficult to determine if a participant did indeed pass along a message to their colleague on the first instance of seeing the colleague or if the participant only realised on the third encounter with said colleague. Consequently, evaluations of PM performance across settings often disregard the PM cue type, and frequently compare performance on mismatched PM tasks. In the existing literature, the typical comparison of PM performance across settings concerns the performance on event-based tasks in the laboratory and the performance on time-based tasks in naturalistic settings. Despite the relative ease of measuring time-based task performance both in the laboratory and in everyday life, this has not resulted in a more suitable comparison of PM performance across settings. Comparison of performance on time-based tasks across laboratory and naturalistic settings has been marred by the failure to discern scheduled time-based tasks from time-check tasks. Laboratory studies that examine performance on time-based tasks almost exclusively use time-check tasks to assess performance (d'Ydewalle et al., 2001; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Schnitzspahn, Ihle, Henry, Rendell, & Kliegel, 2011; Vanneste, Baudouin, Bouazzaoui, & Taconnat, 2015), while naturalistic studies thus far have primarily used scheduled time-based tasks in their assessments (Kvavilashvili & Fisher, 2007; Maylor, 1990; Schnitzspahn et al., 2011). Only two naturalistic studies have investigated PM performance on time-check tasks (Rendell & Craik, 2000; see also "the call-back task" in Rose et al., 2015). Interpreting comparisons of PM performance on mismatched tasks is challenging given the fundamental differences between event-based, scheduled time-based, and time-check tasks, particularly when they are performed in naturalistic settings.

In everyday life, PM tasks that vary by cue type also vary by other features, including the salience of the target cue, the environmental support available for task completion, and the proposed intention retrieval processes involved in task completion. These features of naturalistic PM tasks are displayed in Table 2.1. In naturalistic settings, event-based tasks often have salient cues with many environmental supports. While there are a number of factors that influence which intention retrieval process is necessary when completing event-based tasks (for in depth reviews of such factors, including focality, see Einstein & McDaniel, 2014; Einstein et al., 2005; Kliegel, Jäger, et al., 2008; McDaniel & Einstein, 2000; Niedźwieńska & Barzykowski, 2012), it is thought that in naturalistic settings, intention retrieval for event-based tasks can occur through spontaneous or more reflexive processes. Scheduled time-based tasks that occur in everyday life do not have an explicit cue, but they are often accompanied by environmental support and conjunction cues, which allow participants to connect the PM task with their routine activities (Maylor, 1990; Rendell & Thomson, 1999). This contextual support can be viewed as providing scheduled time-based tasks with an event-like quality when they occur in naturalistic settings. Therefore, it is plausible that naturalistic scheduled time-based tasks can be completed through both spontaneous retrieval processes and strategic monitoring processes. Note, the few laboratory studies that include scheduled time-based tasks employ simulations of activities encountered in daily life, and use the “virtual time of day” rather than the actual time of day as the PM cue (Logie, Trawley, & Law, 2011; Mioni et al., 2014; Potvin, Rouleau, Audy, Charbonneau, & Giguère, 2011; Rendell & Henry, 2009). In opposition to the other PM tasks, time-check tasks lack both an explicit cue and environmental support. Regardless of the setting, time-check tasks are thought to rely on strategic monitoring of the environment in order to detect when the intended action should be performed, which makes them quite cognitively demanding (Kliegel, Mackinlay, et al., 2008; Martin et al., 2003). Thus, the fundamental differences associated with PM tasks of varying cue types could impact the performance of said tasks. Moreover, previous investigations of how PM performance might vary across settings have been hampered by the lack of consideration given to the PM cue types in each setting, and this remains an area that requires further attention.

Table 2.1

Features of Prospective Memory Tasks in Naturalistic Settings

PM Task	Explicit Cue	Environmental Support	Is Spontaneous Retrieval Possible?
Event-based	Yes	Yes	Yes
Scheduled time-based	No	Yes	Maybe
Time-check	No	No	No

Regular versus irregular tasks. While the event- and time-based distinction has featured prominently in PM literature, PM tasks can also be distinguished based on the regularity of the PM task. In everyday life, PM tasks vary in terms of their regularity, but this feature is relatively uncommon in the literature as it has not been included in many laboratory assessments of PM. The exceptions are laboratory studies that have used the Virtual Week paradigm (Rendell & Craik, 2000), which is the laboratory measure of PM used in Study 2 of this thesis. *Regular* tasks refer to PM tasks that are performed routinely and in response to the same cue (e.g., remembering to pick up your children from school at 4 p.m. each weekday). *Irregular* tasks refer to the once-off tasks that occur occasionally and often differ from day to day (e.g., remembering to bake a cake for tomorrow's bake sale). If regular tasks are repeated enough, such as locking the door when leaving the house every day, they can become habitual. However, regularity has a specific meaning in the context of Virtual Week that differs from that of everyday life. The repetition of the regular tasks assessed in Virtual Week does not meet the degree of repetition necessary for the tasks to be considered habitual (Foster et al., 2013). Instead the variations in regularity in Virtual Week have been argued to index low and high retrospective memory demand (Foster et al., 2013; Terrett et al., 2014). Task regularity has been examined to clarify whether PM failures reflected difficulties in the retrospective or the prospective component of PM (Foster et al., 2013). Task regularity is of particular interest when examining age effects in PM, as an increase in the retrospective demand should result in an age deficit (Rendell & Thomson, 1999). Regular tasks place fewer demands on retrospective memory than irregular tasks due to the enhanced encoding of regular tasks (Rendell & Henry, 2009; Rose et al., 2010). Consistent with this, laboratory studies have found superior performance on regular PM tasks compared to irregular PM tasks (Rendell & Craik, 2000).

The Impact of Enhanced Encoding on Prospective Memory Performance

As previously mentioned, the nature of the PM cue and the level of environmental support available influence the retrieval process of PM intentions, and as such these features could play a role in the age-PM paradox. Ellis and Kvavilashvili (2000) suggested that age differences not only in intention retrieval processes, but also in encoding abilities could influence PM performance. One possibility for why older adults demonstrate improved performance in naturalistic settings is that they are better able to encode their PM intentions outside of the laboratory (Craik & Rose, 2012). In naturalistic settings, the encoding of PM intentions can take place over a longer timeframe and in greater detail than in the laboratory (Dixon, Rust, Feltmate, & See, 2007). In order to examine the extent to which the contrasting age patterns across settings reflect differences in encoding abilities, the impact of a strategy thought to enhance encoding was investigated.

The encoding strategy known as *implementation intentions* was examined as a secondary objective of Study 2. This encoding strategy was developed by Gollwitzer (1999) and it is designed to connect the goal-directed behaviour to the target cue, thereby eliciting the proper response (Schnitzspahn & Kliegel, 2009). Implementation intentions involves the formation of the PM intention in a precise format, i.e., “When X occurs, I will do Y” (Gollwitzer, 1999). The idea is not only to specify the desired action when forming a future intention, but to also specify the situation in which the action must occur (McFarland & Glisky, 2011). For instance, instead of thinking, “I have to return my library book,” an individual would form the intention by saying, “When I walk past the library this afternoon, I will return my library book.” Customarily, the commitment statement would be repeated aloud three times. In more recent studies of this encoding strategy, a visualisation component is also added where the individual should imagine with great detail the specific context of task execution. For instance, an individual would imagine the street where the library is located, the sign on the building, taking the library book out of the bag, etc. By determining and visualising the context, the link between the target situation or cue and the intended action is strengthened. Gollwitzer (1999) proposed that many PM failures occur because the individual only focuses on the action to be performed, while spending less time identifying the situation in which the target cue might present itself and trigger intention retrieval. Moreover, the most common type of PM failure involves the failure to act when the target cue arises (Dismukes, 2010). It is argued that by strengthening the association between the intended action and the specific cues or situation, when the cue or situation is encountered it can trigger the spontaneous retrieval of PM intentions, thereby facilitating PM performance (Einstein & McDaniel, 2014; McDaniel, Howard, & Butler, 2008). Though the exact mechanism by which implementation intentions improves PM remains uncertain (Chen et al., 2015), this encoding strategy has been found to improve PM performance in laboratory studies, albeit to varying degrees depending on the type of PM cue and the age of participants (Chasteen, Park, & Schwarz, 2001; Gollwitzer & Sheeran, 2006; Lee, Shelton, Scullin, & McDaniel, 2015; McFarland & Glisky, 2011, 2012; Schnitzspahn & Kliegel, 2009; Zimmermann & Meier, 2010). However, its effectiveness has not been as thoroughly examined in naturalistic PM assessments, therefore it is unclear whether or not enhanced encoding plays a role in the contrasting age patterns observed in previous studies (Henry et al., 2004).

In the current PM literature, there are only two studies that have investigated the effect of implementation intentions on naturalistic PM performance within a healthy, older adult sample (Brom et al., 2014; Liu & Park, 2004), and no such study has been conducted with a young adult sample. The findings from both naturalistic studies indicated that the implementation intentions encoding strategy improves PM performance; however, similar to most naturalistic studies of PM, both studies only measured performance using scheduled time-based tasks (i.e., measuring blood pressure or blood glucose levels at set times each day). The current research addressed this gap in the literature, using a variety of PM tasks as well as a sample of both young and older adults, by examining the impact of enhanced encoding on PM performance and age differences in laboratory and naturalistic settings.

2.2 Prospective Memory and Ageing

PM is an essential part of daily living for all individuals, but this cognitive ability is of vital importance to older adults (Freeman & Ellis, 2003). Impairments in PM have been associated with difficulties in instrumental activities of daily living even in a healthy, elderly population (Woods, Weinborn, Velnoweth, Rooney, & Bucks, 2012). Troubles with PM tasks, such as medication adherence and management of finances, can drastically reduce one's ability to function independently (McDaniel, Einstein, & Rendell, 2008). Furthermore, PM is necessary not only for remembering to take medication correctly and paying bills on time, but it also helps to maintain social relationships (e.g., remembering to call a sick friend who is in the hospital), which is significant for older adults as they are vulnerable to becoming socially isolated (Altgassen, Kliegel, Brandimonte, & Filippello, 2009; Penningroth, Scott, & Freuen, 2011). Given the importance of PM tasks in the daily lives of older adults, it is not surprising that there is an abundance of studies that have examined the effect of ageing on PM, although the findings have not been consistent.

Age Effects in Prospective Memory

In healthy, elderly populations, cognitive decline with respect to retrospective memory has been well documented (Maylor, Smith, Della Sala, & Logie, 2002; Zacks, Hasher, & Li, 2000); however, the effect of ageing on PM remains unclear. In his theory of memory and ageing, Craik (1986) postulated that older adults would particularly struggle with PM given that PM tasks require self-initiated retrieval. As such, large age decrements are expected on PM tasks, especially when strategic monitoring processes are necessary (Einstein & McDaniel, 2014). However, early research efforts on PM and ageing suggested that PM was spared typical ageing effects as the studies showed no age-related deficit in PM performance (Einstein & McDaniel, 1990; Maylor, 1990; Moscovitch, 1982). Despite these initial findings, the prevailing literature examining age effects in the laboratory suggests that, similar to many other cognitive abilities, PM declines with age. A significant age-related deficit in the performance of laboratory PM tasks has been illustrated by the findings of several meta-analyses (Henry et al., 2004; Kliegel, Jäger, et al., 2008; Uttl, 2008). However, the magnitude of the deficit varies across studies, and it has been suggested that the age effect differs according to the intention retrieval process involved, and by extension, the type of cue (Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997).

Following from the multiprocess framework of PM, older adults are expected to perform especially poorly on PM tasks that lack external cues and require strategic monitoring processes, given how resource-demanding such processes are (McDaniel & Einstein, 2000; Park et al., 2002). PM tasks that rely on monitoring, such as time-check tasks, place demands on attentional and working memory resources (d'Ydewalle et al., 2001). Since working memory capacity and other executive functions are known to decline with age (McDaniel & Einstein, 2011), large age differences are expected on tasks that require monitoring processes (Einstein & McDaniel, 2014). In line with this prediction, existing laboratory research demonstrates consistent age-related deficits on time-check tasks (d'Ydewalle et al., 2001; Einstein et al., 1995; Park et al., 1997; Phillips et al., 2008; Rendell & Craik, 2000). The picture is more complex for event-based tasks, as the strategic demands of such tasks can be manipulated in the laboratory. However, when the event-based task has a salient external cue, or a cue that is focal to the ongoing activity, the PM task can be completed through more automatic processes (McDaniel & Einstein, 2000). Moreover, there is evidence that spontaneous retrieval processes are spared with normal ageing (Mullet et al., 2013). Therefore, PM tasks that can be performed through spontaneous processes, due to a salient and/or focal cue, exhibit minimal age differences (Henry et al., 2004). However, while the age-related deficit was reduced on event-based tasks with lower strategic demands, older adults still performed worse than young adults on these tasks in the laboratory (Henry et al., 2004; Kliegel, Jäger, et al., 2008). Thus, based on laboratory investigations of both event- and time-based tasks, there appears to be a negative effect of age on PM performance. However, this pattern changes drastically when the age effect is examined in naturalistic settings.

Age-Prospective Memory Paradox

The age deficit observed in laboratory studies of PM (Henry et al., 2004; Uttl, 2008) is in sharp contrast to the findings of naturalistic studies (Henry et al., 2004; Rendell & Craik, 2000; Rendell & Thomson, 1999). When PM is tested in naturalistic settings, older adults have been found to perform as well as, and sometimes even better than, young adults (Henry et al., 2004; Niedźwieńska & Barzykowski, 2012; Schnitzspahn et al., 2015). This startling pattern, of age deficits on laboratory PM assessments and age benefits on naturalistic assessments, is referred to in the literature as the age-PM paradox (Rendell & Craik, 2000; Rendell & Thomson, 1999). Although many factors have been proposed to contribute to the age-PM paradox, the underlying mechanisms that are potentially driving this phenomenon remain unclear (Azzopardi, Auffray, & Juhel, 2015).

In their recent meta-analysis, Kliegel and colleagues (2008) suggested that future studies consider several factors that may impact PM performance and influence the ageing effect on PM. As PM research has grown, more factors have been investigated but thus far none have been able to explain or resolve the age-PM paradox. The factors include: the perceived level of importance associated with task performance (Altgassen et al., 2009; Hering, Phillips, & Kliegel, 2013; Ihle, Schnitzspahn, Rendell, Luong, & Kliegel, 2012; Niedźwieńska et al., 2013; Penningroth et al., 2011), the degree of planning involved (Gillholm, Ettema, Selart, & Gärling, 1999; Hering, Cortez, et al., 2014; McAlister & Schmitter-Edgecombe, 2013; McDaniel & Einstein, 2007; Niedźwieńska et al., 2013), the demands of the ongoing task (Bailey et al., 2010; Garrett, Grady, & Hasher, 2010; R. E. Smith, Horn, & Bayen, 2012), cue distinctiveness (Foster et al., 2013; Rose et al., 2010;

Titov & Knight, 2001), and encoding ability (Hannon & Daneman, 2007; Rummel, Einstein, & Rampey, 2012; Schnitzspahn & Kliegel, 2009; Zimmermann & Meier, 2010). The aforementioned factors have been found to influence the effect of ageing on PM performance in laboratory studies. Clearly, the benefits of laboratory assessment of PM are the high level of experimental control and the ability to manipulate or test these variables. However, the existing literature does not adequately address which of these factors (e.g., motivation, planning, demanding daily activities) are at play in naturalistic settings and to what extent. Further research is needed to examine these factors in everyday life and to consider how they might influence not only PM performance, but also how they may contribute to the age-PM paradox.

Naturalistic investigations of the age-prospective memory paradox. The findings of the meta-analysis conducted by Henry et al. (2004) confirmed the age-PM paradox. Reflective of the PM literature at the time, the meta-analysis consisted of nearly twice as many laboratory studies as naturalistic studies. Following that investigation, there have been significant advancements in the naturalistic study of PM, with a number of naturalistic studies conducted since then that explicitly aimed to examine the age-PM paradox. This review will focus on recently conducted naturalistic studies that assessed PM performance using objective measures and/or compared naturalistic and laboratory PM performances using the same participant sample in both settings.

In an effort to explore the possible mechanisms of the age-PM paradox, Schnitzspahn et al. (2011) investigated how motivation, metacognitive awareness, absorption in ongoing activity, and control over the PM task potentially impacts both laboratory and naturalistic PM performance. Consistent with the prevailing literature, young adults showed superior PM performance in the laboratory, but were outperformed by older adults in naturalistic settings, confirming the age-PM paradox. The findings suggested that in naturalistic settings, older adults benefited from their higher level of motivation and metacognitive awareness compared to young adults. Everyday life appears to offer older adults the opportunity to use their experience, knowledge, and perhaps personal compensatory strategies to overcome difficulties in PM. Schnitzspahn et al. (2011) also found that older adults were less absorbed in their daily activities than young adults which could explain their improved PM performance. However, this was measured using levels of perceived stress over the naturalistic period. Thus, it is possible that older adults were quite engaged in their daily activities, but they did not find this to be particularly stressful. One of the strengths of the study by Schnitzspahn et al. (2011) is that PM performance was measured using the same young and older adult sample across both laboratory and naturalistic settings. Very few investigations of ageing and PM have been conducted using the same sample across both settings (Kvavilashvili et al., 2013; Niedźwieńska & Barzykowski, 2012; Rendell & Thomson, 1999; Schnitzspahn et al., 2011). For an additional study that compared the same sample of older adults, but a different sample of young adults across settings, see Rendell and Craik (2000). Each of these studies once again found no evidence of an age-related deficit on PM performance in naturalistic settings. However, the age differences in naturalistic performance varied according to the type of PM cue that was used in each assessment.

Currently, it is difficult to determine how PM performance and the ageing effect might be differentially influenced by PM cue type because not many naturalistic studies incorporate PM tasks of varying cue types. In fact, most of the existing evidence for older adults' improved naturalistic performance stems from assessments of scheduled time-based tasks alone (Henry et al., 2004; Kvavilashvili & Fisher, 2007; Rendell & Thomson, 1999; Schnitzspahn et al., 2011). There is a large gap in the literature regarding the naturalistic performance of older adults on event-based and time-check tasks. Although a few naturalistic studies have attempted to utilise event-based tasks in their assessment of PM performance (Bailey et al., 2010; Kvavilashvili et al., 2013; Masumoto et al., 2011; Schnitzspahn et al., 2015), only a handful of studies employ objective measures of naturalistic event-based task performance (Bailey et al., 2010; Cavuoto et al., 2015; Niedźwieńska & Barzykowski, 2012; Rendell & Craik, 2000). Furthermore, there is only one known study that has compared laboratory and naturalistic performance on event-based tasks within the same sample of both young and older adults (Niedźwieńska & Barzykowski, 2012). Despite the limited research on event-based tasks in everyday life, the findings suggest that older adults perform as well as young adults on event-based tasks in naturalistic settings, and perform even better than young adults when the event cues presumably trigger spontaneous intention retrieval processes (Niedźwieńska & Barzykowski, 2012). Kvavilashvili and Fisher (2007) found that when older adults completed scheduled time-based tasks in naturalistic settings, they frequently encountered external or contextual cues that acted as reminders of their PM intentions. This form of environmental support may potentially lead the PM intention to be readily retrieved through increased activation or perhaps allowed for a strong association to be created between the environment and the PM intention (Einstein & McDaniel, 2014). Taken together, this could indicate that for both event-based tasks and scheduled time-based tasks, older adults are somehow able to utilise the available environmental support and contextual cues to trigger spontaneous intention retrieval processes, thereby facilitating the completion of these tasks. Although this is an intriguing possibility, by only measuring PM tasks that can potentially be performed through spontaneous retrieval processes, existing naturalistic studies provide an incomplete picture of everyday PM and the effect of ageing on PM.

Naturalistic studies on time-check tasks are exceptionally rare in the field of PM research, thus the pattern of age differences on the performance of time-check tasks is undetermined. Craik (1986) suggested that when retrieval is largely self-initiated due to the absence of environmental supports, high demands are placed on processing resources which decline with age. According to Einstein and McDaniel (2014), age-related deficits in PM performance should be most prominent on tasks high in self-initiated retrieval as well as on tasks that require strategic monitoring processes. Therefore, time-check tasks should be the most challenging task to complete in naturalistic settings, and should be particularly difficult for older adults. Rendell and Craik (2000) conducted the only study which included a comparison of young and older adults' performances on time-check tasks across both laboratory and naturalistic settings. The study included two older adult samples: a young-old sample (average age of 68 years) and an old-old sample (average age of 79 years). In the laboratory, participants were asked to remember to alert the researcher when a provided stop-clock showed 2 minutes and 30 seconds and 4 minutes and 15 seconds. Consistent with prevailing laboratory findings, young adults outperformed older adults on time-check tasks. Additionally, there was no difference between both older adult groups. The surprising results of the naturalistic portion, however, did not reveal a constant age-related deficit. Rendell and Craik (2000) emphasised that young-old adults were found to outperform the young adults in the naturalistic setting, a reversal of the age difference observed in the laboratory. However, the key finding of the time-check task that was highlighted in a review by Kliegel, Rendell, and Altgassen (2008) was that young adults performed substantially worse in naturalistic settings than they had in the laboratory. Although both older adult groups demonstrated poor naturalistic performance, their level of performance was consistent across settings. As a possible explanation for these findings, Rendell and Craik (2000) suggested that young adults' naturalistic performance could potentially suffer from the many demands on their attention that exist in the real world. However, it is also important to note that different samples of young adults were assessed in the laboratory and in naturalistic settings, which could potentially indicate that the drastic difference in the performances across settings was due to individual differences between the samples.

There is one additional study which incorporated time-check tasks in its naturalistic assessment of PM. In an investigation of cognitive and neural plasticity in older adults following a training program, Rose et al. (2015) assessed older adults (average age of 67 years) on the performance of “the call-back task”. This novel task involved the participants remembering to call the researcher back after a specified time period had elapsed (e.g., call back in exactly 35 minutes), and performance was measured by the absolute time difference in minutes between the target time and the actual response time. As only older adults were assessed in this study, no age comparison is possible. Older adults appeared to have some difficulty with this time-check task, responding on average more than 17 minutes off the target time. The scarcity of naturalistic assessments of time-check tasks in the literature makes it difficult to determine older adults’ ability to successfully complete time-check tasks in naturalistic settings. However, thus far the findings conflict with the level of accurate performance widely reported in existing naturalistic studies of scheduled time-based tasks (Henry et al., 2014; Rendell & Thomson, 1999; Schnitzspahn et al., 2015). Thus, our knowledge of ageing effects on naturalistic PM remains limited. In order to further develop our understanding of naturalistic PM and to clarify the factors of the age-PM paradox, further investigations must incorporate time-check tasks.

Consideration has been given to many factors in attempts to disentangle the age-PM paradox, yet little attention has been paid to the methodological issues which could be driving the paradox. Comparisons of PM performance across settings ignore the fact that the task types used in the assessments of PM are glaringly different across settings (G. Smith, Della Sala, Logie, & Maylor, 2000). In other words, the age-PM paradox could result from the comparison of disparate or nonparallel tasks. As previously discussed, laboratory measures of PM performance typically use either event-based or time-check tasks. This contrasts with naturalistic measures of PM performance, which typically use scheduled time-based tasks. As these tasks vary in the amount of environmental support available and presumably the intention retrieval processes necessary for task completion, it is reasonable to expect differential effects of ageing on the performance of these three PM tasks. Until comparisons of laboratory and naturalistic PM performance address the use of dissimilar tasks, the pattern of age differences in PM cannot be determined with certainty and the age-PM paradox will remain unresolved.

Chapter 3: Examining the Context of Prospective Memory in Daily Life – Study 1

3.1 Introduction

Many factors have thus far been proposed to influence PM performance, but it remains unclear which factors are particularly relevant in naturalistic settings. The identification of such factors would greatly enhance our understanding of everyday PM, and could also provide clarification of the age-PM paradox. By exploring the naturalistic behaviours of both young and older adults, potential age differences could emerge that shed light on the contrasting age effects between laboratory and naturalistic PM performances. The first study aimed to enrich our understanding of the context in which individuals succeed and fail at PM tasks in the real world. This study explored differences in the daily lives of young adults and older adults that may potentially contribute to age differences in naturalistic PM performance. In other words, what differences exist between young and older adults in terms of how they go about actually completing PM tasks in everyday life?

To explore potential age differences in the context in which PM tasks occur in daily life, the current study considered several factors that have been suggested in the literature as possible explanations for the age benefit in naturalistic settings (for a review, see Azzopardi et al., 2015; Phillips et al., 2008). These factors include: the influence of a demanding lifestyle, the level of motivation associated with task completion, and the extent to which external reminders or other strategies are used. As these factors pertain not only to successful completion of PM tasks, but also to failures in PM, the frequency of, and circumstances surrounding PM failures were also examined in both age groups.

Proposed Contributing Factors of the Age-PM Paradox

Demands of everyday life. A common presumption, not only in the literature but also in the general population, is that young adults lead busier lives than older adults, and that this could be contributing to the age-PM paradox in a number of ways (Martin & Park, 2003; Wilson & Park, 2008). One might argue that perhaps the diminished performance of young adults is caused by them having a more demanding schedule, with multiple tasks and duties competing for their attention. There is some evidence to suggest this might be the case. In a study conducted on everyday memory problems, Vestergren and Nilsson (2011) found that while older adults attributed their errors to simply ageing, middle-aged adults attributed their errors to multitasking and stress. Similarly, Maylor (1998) found that young and middle-aged adults were more likely than older adults to blame their PM failures on an ongoing task or activity. However, Rendell and Thomson (1999) argued that older adults' improved naturalistic PM performance cannot be explained by their having a less busy lifestyle compared to young adults. Rendell and Thomson (1999) found an age-related benefit on a naturalistic PM task, and importantly, this benefit was consistent regardless of the occupation of the older adults. Older adults demonstrated superior naturalistic performance whether they were employed, home makers, or retired (Rendell & Thomson, 1999). Despite the self-professed detrimental link between young adults' ongoing activity and their PM performance, very little research has been conducted into the nature of these ongoing activities and PM tasks in the real world.

This raises the question: are young adults, in fact, engaged in ongoing activities that are more engrossing than the ongoing activities of older adults? In a study investigating rehearsals of PM intentions in naturalistic settings, Kvavilashvili and Fisher (2007) discovered that older adults were generally engaged in familiar and habitual activities, such as household chores. This is in line with another study by Schnitzspahn et al. (2015) which found that older adults reported a greater number of housekeeping and organisational PM tasks compared to young adults. Young adults, on the other hand, reported a greater number of work-related PM tasks. At first glance, the ongoing activities of older adults appear to be less demanding than those of young adults. However, there is a wide range of household and organisational tasks, from vacuuming to preparing for a large dinner party or even organising a massive fundraiser for the local church. These organisational activities likely vary in how demanding (and also how important) older adults consider them to be. Thus, it is necessary to consider not only what types of ongoing activity participants were engaged in prior to PM task completion, but also how busy participants felt while they were engaged in those activities. To explore the potential role that age differences in the demands of everyday life has on naturalistic PM performance, this study considered the frequency of PM task executions, the ongoing activities that participants were engaged in at the time of task completion, as well as participants' self-reported busyness.

Motivation. Both laboratory (Hering et al., 2013; Jeong & Cranney, 2009; Kliegel et al., 2001; Marsh, Hicks, & Landau, 1998) and naturalistic studies (Aberle et al., 2010; Ihle et al., 2012; Moscovitch, 1982; Niedźwieńska et al., 2013) have found an influential effect of motivation and task importance on PM performance. PM tasks that participants considered to be very important were more likely to be successfully completed than the less important tasks (Ihle et al., 2012; Marsh et al., 1998; Niedźwieńska et al., 2013). It stands to reason that tasks of higher importance increase an individual's motivation to ensure that those tasks are correctly executed. Besides influencing PM performance overall, motivation is thought to play a key role in the age-PM paradox. Older adults are thought to be more motivated to complete PM tasks in everyday life, and have been shown to attribute a higher level of importance to their PM intentions compared to young adults (Niedźwieńska et al., 2013). Older adults' naturalistic performance is likely boosted by their strong motivation, while the lack of motivation in young adults contributes to their diminished performance in everyday life. In a naturalistic study conducted by Aberle and colleagues (2010), participants were provided with monetary incentive to increase their motivation for completing the PM task. The monetary incentive sufficiently improved young adults' performance to eliminate the age benefit, though it did not have an impact on older adults' performance. Given that older adults have been found to already have high levels of motivation for PM task completion in daily life, it is not surprising that their performance was unaffected by the additional reward. Thus, the naturalistic performance of young and older adults is comparable when the PM task is considered to be very important, or when both age groups are highly motivated to complete the task (Ihle et al., 2012; Niedźwieńska et al., 2013). However, this finding still contradicts the age pattern widely observed in the laboratory (Henry et al., 2004). If motivation was the sole explanation for the age-PM paradox, then young adults would be expected to outperform older adults in naturalistic settings once experimenters controlled for motivation. Hence, it appears that motivation only provides a partial explanation, and the findings also suggest that young adults might not be performing to the best of their abilities in naturalistic settings (Ihle et al., 2012). To explore the possibility that motivation might be one of the factors in the age-PM paradox, it is necessary to establish whether young adults and older adults do in fact differ in their level of motivation to complete tasks in everyday life.

The reasons why older adults might attribute more importance to naturalistic PM intentions and why they may have a stronger motivation for task completion than young adults remain unclear. However, one possibility is that these tasks provide older adults with a social motive. Several studies have found the addition of a social motive (e.g., telling participants that a task's completion is particularly important to the researcher) to improve PM performance, especially the performance of older adults (Altgassen et al., 2009; Brandimonte, Ferrante, Bianco, & Villani, 2010; Walter & Meier, 2014). In a recent investigation of participants' own PM intentions, Schnitzspahn et al. (2015) found that social intentions were rated as more important by older adults compared to young adults. Social intentions in everyday life, such as remembering to pick a friend up from the airport, often involve an element of social obligation. Individuals can be motivated to complete a social PM task in order to somehow benefit an acquaintance or loved one, or additionally their motivation can derive from wanting to avoid unwanted social ramifications. Maintaining social relationships is of increasing importance as we age and as our social networks shrink. Therefore it would be quite adaptive of older adults to prioritise social intentions, which they have been found to do (Carstensen, Mikels, & Mather, 2006). However, a study by Penningroth et al. (2011) found that young adults also viewed social tasks to be more important than nonsocial tasks, and their performance rate was higher for social tasks compared to nonsocial tasks. If both age groups perform well on social tasks, perhaps the strong naturalistic PM performance displayed by older adults is a by-product of them having more social intentions in real life than the young adults. There is very little evidence on the matter, though Schnitzspahn et al. (2015) found the number of social intentions did not vary between the age groups. Therefore, the conclusion that older adults complete more social PM tasks in everyday life than young adults, and consider them to be more important as well, cannot yet be made. The current study aimed to explore the potential role of motivation in the age-PM paradox by considering whether older adults do indeed view their everyday PM tasks as more important compared to young adults, and whether they complete social tasks more often than the young adults.

Forgetfulness. There are various reasons why an individual may fail to complete a PM task. According to Dismukes (2010), non-completion of PM tasks are usually failures in remembering to act in response to a target cue (e.g., walking past the grocery store and not remembering your earlier intention of wanting to buy milk on the way home), rather than failures in remembering what it is you need to perform (i.e., the retrospective content) in response to the target cue (e.g., going into the grocery store but forgetting that the item you intended to purchase was milk). In a study conducted by Maylor (1990), middle-aged and older adults reported many different explanations for non-completion of PM tasks, with the three main ones being that they were absorbed in an ongoing task, they were distracted, or they simply forgot. Knight and colleagues (2008) examined the effect that distraction has on PM performance in both young and older adults. The study used a simulated naturalistic task, where participants had to complete various PM tasks while navigating a virtual shopping centre. The performance of older adults declined significantly more than that of younger adults when both groups were in a noisy environment. Although this study suggests that older adults are more sensitive to distraction in everyday life, the older participants in this study were not screened for mild cognitive impairment. Therefore, their cognition could have been compromised and caution should be taken when generalising the findings to the healthy elderly population.

In a more recent study investigating real-life PM intentions, Schnitzspahn et al. (2015) found that the reasons for non-completions were actually fairly similar between young and older adults. In both age groups, the primary reason for non-completions was simply forgetting, and the secondary reason was a lack of time. Although "simply forgetting" is a fairly common reason given by participants when a lapsed intention occurs, it is a somewhat circular explanation that suggests that while individuals acknowledge the occurrence of a PM failure, they are possibly unaware of *why* it occurred. In everyday life, non-completions of PM tasks seem to be infrequent for both young and older adults (Schnitzspahn et al., 2015; G. Smith et al., 2000). However, given that a single PM failure can have disastrous consequences, it is necessary to learn more about non-completions and the associated circumstances that might make PM task completion more challenging. The current study set out to explore the conditions in which individuals forget to complete their PM intentions in the hope of identifying potential areas of vulnerability either for both age groups or for one age group in particular.

Nature of intention retrieval and compensatory strategies. The final factors examined in the current study were the nature of intention retrieval and the use of compensatory strategies in naturalistic settings. Laboratory studies have found that the magnitude of the age deficit depends upon the nature of task retrieval (Einstein, McDaniel, & Scullin, 2012; Einstein et al., 2005). According to the multiprocess model of PM, task completion can be achieved through either spontaneous retrieval processes or through strategic monitoring processes (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000). Age differences are typically reduced when the PM task can be executed through more spontaneous processes as opposed to processes that require strategic monitoring of the environment (Eusop-Roussel & Ergis, 2008), as the latter is thought to rely on working memory capacity which is known to decline with age (Park et al., 2002). McDaniel and Einstein (2000) argue that several elements determine which retrieval process is necessary or more likely to be implemented in order to successfully complete a given PM task. For example, spontaneous retrieval is more likely to occur when the target cue is salient or focal, when the PM task is unimportant, and when the ongoing activity is less absorbing or demanding. The combination of these elements in everyday life could potentially influence PM performance, however little is known about the nature of retrieval in naturalistic settings. Do older adults retrieve their PM intentions through spontaneous processes in everyday life, and has this been a contributing factor of the age-PM paradox? Alternatively, do older adults employ strategies to complement their monitoring of their environment for a target cue? This study explored the nature of intention retrieval in naturalistic settings by considering whether participants reported automatically remembering to complete their PM task.

A common argument put forth to explain older adults' improved performance in naturalistic studies is that older adults are able to use compensatory strategies in everyday life, such as external aids (Phillips et al., 2008) and repeated rehearsals of PM intentions (Maylor et al., 2002). The use of external reminders is often recommend by researchers as it is thought to facilitate intention retrieval through spontaneous processes, rather than relying on capacity-consuming monitoring processes (Einstein & McDaniel, 2014). As previously noted, the age differences on PM performance are greater when strategic monitoring processes are required for task execution (Eusop-Roussel & Ergis, 2008). Hence, older adults' use of reminders has frequently been proposed to explain age benefits observed in naturalistic studies (Moscovitch, 1982). However, what little empirical evidence exists on the matter is mixed. Some studies have found that older adults make more use of external reminders compared to young adults (Jackson, Bogers, & Kerstholt, 1988), while other studies found the opposite (Rendell & Thomson, 1993, 1999). Rendell and Craik (2000) instructed participants not to use external aids during the naturalistic assessment, and both age groups reported low use of reminders. Despite the low usage of external aids, an age benefit was still found on the naturalistic PM task (Rendell & Craik, 2000). A study by Ihle et al. (2012) focusing on everyday PM intentions found that more frequent use of reminders was associated with greater PM performance. However, both age groups benefited equally from the use of reminders. To further explore the role that the use of reminders potentially plays in the age-PM paradox, the current study examined whether young and older adults do indeed differ in their use of external reminders in everyday life.

Another compensatory strategy proposed to contribute to the age benefit observed in naturalistic settings is the repeated rehearsal of PM intentions (Dixon et al., 2007). Do older adults spend more time planning and thinking about their upcoming PM intentions in everyday life compared to young adults? This proposed factor relates to the notion discussed earlier that older adults lead less demanding lives, and are therefore able to spend more time rehearsing their planned intentions. The act of planning how to execute future intentions has been found to be beneficial for the performance of PM tasks (Chasteen et al., 2001; Niedźwieńska et al., 2013). In a recent study, performance was also improved when participants engaged in visualising the completion of their upcoming task (Altgassen et al., 2014). However, once again, there is conflicting evidence regarding whether or not older adults do, in fact, rehearse upcoming PM tasks more frequently than young adults in everyday life. Kvavilashvili and Fisher (2007) asked participants to record their PM rehearsals throughout the day using a pocket-sized diary. The study found that the frequency of rehearsals was similar in both young and older adults. These findings conflict with those of a recent study conducted by Gardner and Ascoli (2015). Using an experience-sampling method, participants were prompted at random intervals throughout their day to reflect on whether they were rehearsing a PM task at the time of the prompt. Gardner and Ascoli (2015) found that older adults were engaged in PM rehearsals twice as often as young adults. Thus, before it can be determined if rehearsals of PM tasks has influenced the age benefit in naturalistic settings, further examination of potential age differences in the frequency of rehearsals is necessary. The current study explored the frequency of PM rehearsals in the everyday lives of both young and older adults.

The Current Research

Throughout the literature, contextual differences between young and older adults have been proposed to contribute to the paradoxical findings of age deficits in the laboratory, but age benefits in naturalistic settings. In order to gain a better understanding of the context in which PM tasks occur in everyday life, the present study examined several factors thought to influence naturalistic PM performance. Specifically, the study focused on potential age differences in the demands of everyday life, the level of motivation to complete PM tasks, the frequency and circumstances of PM failures, the nature of intention retrieval, and finally, the use of compensatory strategies. This descriptive study of self-directed PM tasks used an innovative method to observe PM behaviour in everyday life. The experience-sampling method monitored PM behaviour as it occurred throughout the day, which is a significant improvement on existing diary-based studies of naturalistic PM. The experience-sampling method reduced the burden placed upon participants to recall their PM behaviours, and also provided a rich depiction of everyday PM through the large number of observations available.

3.2 Method

Participants

Forty-three young adults (aged 18-24 years) and 44 older adults (aged 64-84 years) participated in the study. The study was conducted in collaboration with the University of New South Wales, and was approved by the Human Research Ethics Committees from both institutions. Participants were recruited through both universities and the local community via a newspaper advertisement. Young adults were undergraduate students who volunteered in exchange for partial course credit, while older adults received monetary reimbursement of up to $20 for their participation. To be eligible for the study, older adults had to fulfil the following inclusion criteria: at least 64 years of age, living independently, no known neurological conditions, and achieve an adequate score on the revised Addenbrooke's Cognitive Examination (details provided below). Two older adults were excluded based on their performance on the global cognition measure. Three young participants were excluded from data analyses due to their failure to complete a minimum of five out of a possible 15 timepoints during the five-day study period. The final sample consisted of 40 young adults (age: M = 18.79 years, SD = 1.32 years; 55.3% female) and 42 older adults (age: M = 71.52 years, SD = 4.67 years; 57.1% female). For two young adult participants, the data on gender, exact age, and education were missing. Estimated intelligence was unable to be obtained for four young adults and three older adults. The age groups did not differ by years of education completed (young adults: *M* = 13.82 years, *SD* = 1.47 years; older adults: *M* = 13.10 years, *SD* = 2.90 years; $t(61.96) = 1.42$, $p = .161$). Older adults had a higher estimated IQ (*M* = 112.76, *SD* = 8.24) compared to young adults (*M* = 105.52, *SD* = 10.42; $t(73) = 3.35$, $p = .001$).

Materials

Information letter and consent form. Before the commencement of the testing session, participants were given an information letter that explained the nature of the study (see Appendix A.1). Informed consent was obtained and the consent forms were signed by both the participant and the researcher (see Appendix A.2). One copy of the form was kept by the researcher while the other copy was given to the participant.

Background questionnaire. To characterise the sample, a background questionnaire was administered to collect participants' demographic information (see Appendix B.1). The background questionnaire included questions regarding participants' age, gender, education, and known neurological conditions.

Estimated Intelligence. The National Adult Reading Test (NART; H. E. Nelson, 1982) is a measure of estimated verbal intelligence (see Appendix B.4). It is a word-recognition test that requires participants to read aloud 50 irregular English words that do not follow typical phonetic rules (e.g., 'thyme'). The high correlation between reading ability and verbal intelligence allows for a Wechsler Adult Intelligence Scale-Revised Full-Scale IQ to be reliably estimated on the basis of total number of correct word pronunciations (Bright, Jaldow, & Kopelman, 2002). Internal reliability for this widely-used measure has been estimated to be between .90 and .93 (Crawford, Parker, Stewart, Besson, & De Lacey, 1989).

Global Cognition. The Addenbrooke's Cognitive Examination – Revised (ACE-R; Mathuranath, Nestor, Berrios, Rakowicz, & Hodges, 2000) is a sensitive cognitive screening test that measures five sub-domains: attention/orientation, memory, verbal fluency, language and visuospatial abilities (see Appendix B.6). Lower scores suggest poorer cognitive performance. This measure has been established as a valid dementia screening test, and is sensitive to early cognitive dysfunction as well (Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006). This widely-used measure has a strong reliability of .80 (Mioshi et al., 2006) and validity of .62 (Mathuranath et al., 2000). The Australian version of the ACE-R was used to identify and exclude potential older participants who demonstrated cognitive impairment (a score below 84 out of a possible 100).

Prospective memory electronic questionnaire. Personal Data Assistant (PDA) devices were used to record participants' responses to a multiple-choice questionnaire (see Appendix C.1) which was completed at several points throughout each study day. The questionnaire was designed to capture participants' rehearsals and executions of their own PM tasks as well as instances of PM failures in everyday life. Eleven core questions were asked at each timepoint; however, the total number of questions presented varied depending upon the participants' responses. For example, a participant who answered "no" to the question "In the last few hours, did you execute any planned tasks?" was not presented with subsequent questions, such as "How many planned tasks did you execute?" A complete list of the question branches is provided in Appendix C.1. Participants selected their responses from the provided options. The questions covered a range of topics that are frequently proposed throughout PM research to have an impact on performance, and have been proposed as possible explanations for the age-PM paradox. The topics addressed in this thesis included: variability in the demands of everyday life between the age groups (frequency of PM tasks and perceived busyness); the motivation driving PM task completion (perceived importance of task completion and whether the task was for another person or for themselves); the potential automatic nature of intention retrieval; and the compensation available to older adults in a naturalistic setting (the use of external mnemonic aids and the frequency of task rehearsals).

Procedure

Initial testing session. The nature of the study was explained to participants prior to the provision of an information letter that detailed the process of the testing session as well as the second stage of the experiment. After reading the information letter, participants read and signed two copies of the informed consent form. The researcher retained one copy and the other copy was given to the participants. Participants independently completed the background questionnaire. Older adults were then screened for possible cognitive impairment using the ACE-R. Afterwards, the NART was administered to all participants, and their responses were audio recorded to ensure proper scoring. The participants were then given instructions on how to use the PDA devices. Participants completed a practice run, using the PDA with the researcher in the room in case further assistance was necessary. Once participants were familiar with the device and the PM questionnaire, participants were given written guidelines to take home with them (see Appendix C.2). The guidelines included clarifications of PM terms, how to reset the device if necessary, and the contact information of the researcher. Each participant was tested individually for approximately 1 hour.

Second stage – take home task. The PDA device prompted participants to complete the electronic questionnaire three times daily for a five-day period, yielding a total of 15 possible timepoints per participant. The experience-sampling method provided a greater level of insight into everyday PM while also reducing the burden typically placed on participants in self-report, naturalistic studies. The electronic questionnaire took approximately 3 minutes to complete at each timepoint. The device was programmed to activate between 9 a.m. and 6 p.m. on weekdays, and between 10 a.m. and 6 p.m. on weekends. The questionnaire was programmed to occur once in the morning, once around midday, and once in the afternoon; however, the precise timing was randomised within each time block, and participants were unaware of the timing. In addition to the illumination of the device's screen when the program was activated, an alarm would alert the participants. If the participant did not respond to the alarm, it would sound again every 10 minutes until either the questionnaire was completed or 3 hours had passed. Participants were instructed to charge the device each night with the provided wall charger. Upon study completion, participants returned the devices and charger via post using a pre-paid envelope that was provided in the initial testing session.

3.3 Results

The aim of this study was to explore the context in which participants complete their own PM tasks in everyday life, and to consider any contextual age differences that could possibly explain the discrepancies in PM performance across settings. The nature of the data collected was best suited to descriptive analyses. Inferential statistical analyses were not appropriate because of a range of features of the design and the scoring procedure of this study.

The data is essentially frequency data and reflects the number of responses to specific questions that participants answered when completing the electronic questionnaire. Participants were prompted to complete the questionnaire at 15 timepoints over a five-day period. The same questionnaire was repeated at each timepoint. However, participants often did not respond to all 15 timepoints. We therefore set a minimum response of 5 timepoints for participants to be included in the study.

The core questions asked at each timepoint required a response, and three core questions are reported in the results of this thesis. For example, one of the core questions was, “In the last few hours, did you execute a planned task?” An individual proportion score was calculated for the responses to these core questions for each participant. In relation to the example given, the individual proportion score was the number of timepoints where the participant indicated that they had executed a planned task (i.e, the number of ‘yes’ responses) divided by the number of timepoints the participants completed overall (i.e., the total number of possible ‘yes’ responses). For these core questions, the total number of timepoints completed had to be at least five in order to provide a sufficient number to calculate proportion. In this situation, a mean and standard deviation of these individual proportions could be calculated for each age group, and a t-test could be conducted to compare group mean scores.

However, for the 10 subsequent questions, the minimum number of possible responses for calculating an individual proportion score was less than five and possibly as low as one. The reason that the possible number of total responses was as low as one was because of the branching design of the electronic questionnaire. Most questions were only presented upon affirmation of task completion. For example, if a participant did not report recently completing a planned task, then the follow-up question, “What were you doing just before completing the task?” was not asked. Therefore, participants who reported completing a planned task on just one occasion were only presented with the subsequent questions at that given timepoint, regardless of how many overall timepoints they completed. Thus, the subsequent questions were only answered a single time by these participants.

For the 10 subsequent questions reported in this thesis, calculating individual proportion scores was not appropriate, and thus it was not possible to calculate mean group proportions, nor to conduct comparisons of means using t-tests or analysis of variance. In these situations, the proportions of responses for each answer category were reported, and the proportions were determined by collapsing across the entire group. The proportions were not the average of individual proportions.

The next seemingly possible inferential statistic, that is commonly used to analyse frequency data, is Chi-square analysis. This analysis was not possible to conduct because for all questions, including the core questions, the participants provided multiple responses, and therefore violated the principle of independence required of a Chi-square analysis (Cohen, 1988).

Demands of Everyday Life

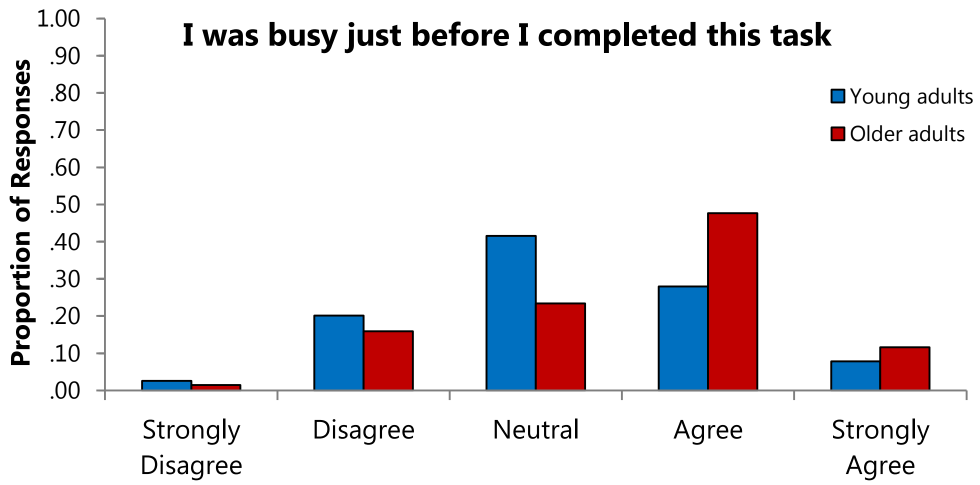
In order to assess how often PM tasks are completed in everyday life, participants were asked at each timepoint if they had executed any planned tasks in the last few hours. This was one of the exceptional situations where proportions of responses could be calculated for each individual, and independent t-tests could be used to investigate differences in the mean proportions for each age group. Effect sizes are represented as Cohen's *d*. Cohen (1988) defines effect sizes as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$). Older adults were significantly more likely to report completing a planned task ($M = .67$, $SD = .25$) compared to young adults ($M = .40$, $SD = .24$; $t(80) = 4.97$, $p < .001$, $d = 1.10$). Participants who reported the execution of a planned task were asked additional questions regarding the context of PM task completion. Two participants (one young and one older adult) never reported the execution of a planned task.

To explore whether the presumed busier lifestyle of young adults contributes to their poorer performance in naturalistic settings, participants were asked how many planned tasks they completed, if they were busy prior to task completion, and what they were doing just prior to completion of their planned task. The descriptive results are presented in Figure 3.1. If participants reported completing more than one PM task in the last few hours, they were instructed to respond to the subsequent questions only in regard to the most recently completed PM task. Figure 3.1a shows that most participants completed one to two tasks in the past few hours. Self-reports of busyness, as shown in Figure 3.1b, indicate that older adults were busy just prior to task completion about 59% of the time compared to 36% of the time for young adults. Figure 3.1c shows that the ongoing activities the participants were engaged in prior to task completion varied between the age groups. Young adults were engaged in “work/study” most often, followed by “resting”; older adults’ ongoing activities were more evenly spread out, but “housework/chores” was reported most often by a small margin.

(a)

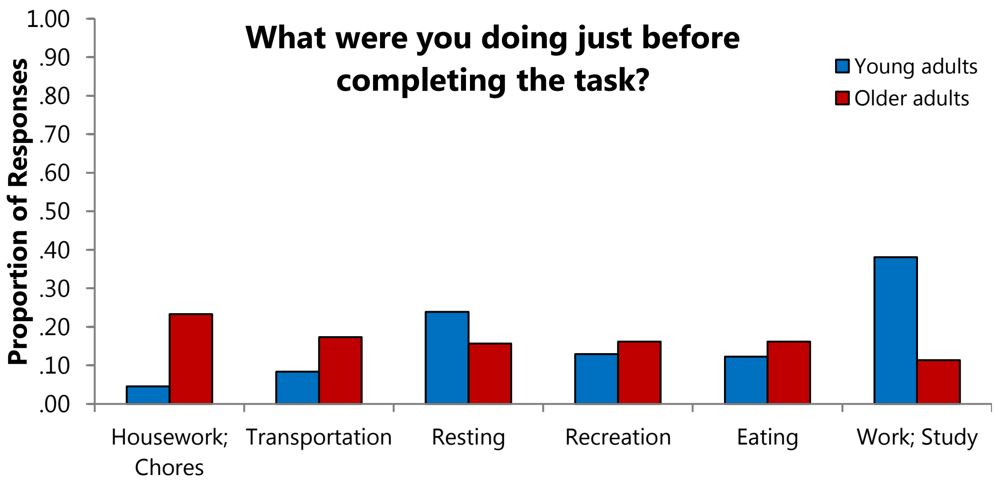
Total number of responses: 165 responses for Young adults; 353 responses for Older adults

(b)



Total number of responses: 154 responses for Young adults; 346 responses for Older adults

(c)



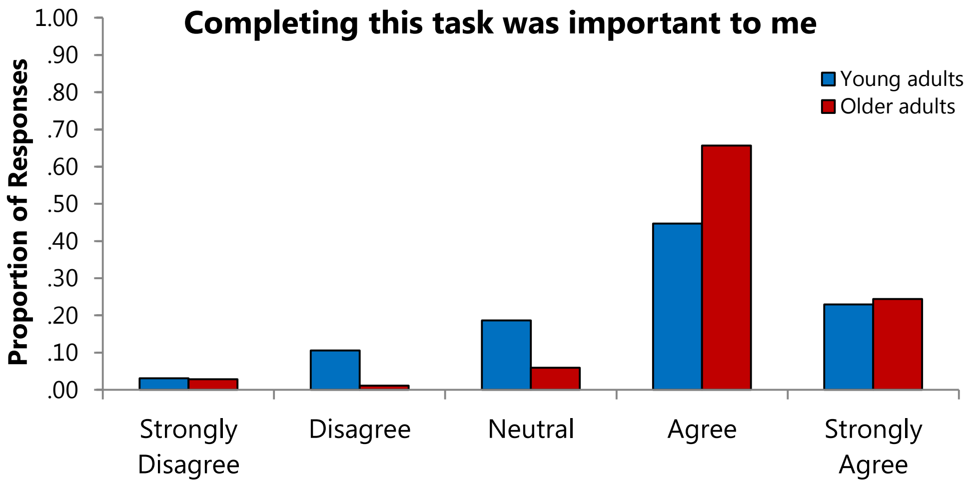
Total number of responses: 155 responses for Young adults; 352 responses for Older adults

Figure 3.1. Age differences on the demands of everyday life. Proportions of responses were determined by collapsing the frequency of responses across all participants in each age group. (a) Proportion of responses indicating the amount of planned tasks completed. (b) Proportion of responses indicating perceived busyness. (c) Proportion of responses indicating ongoing activity at time of task completion.

Motivation

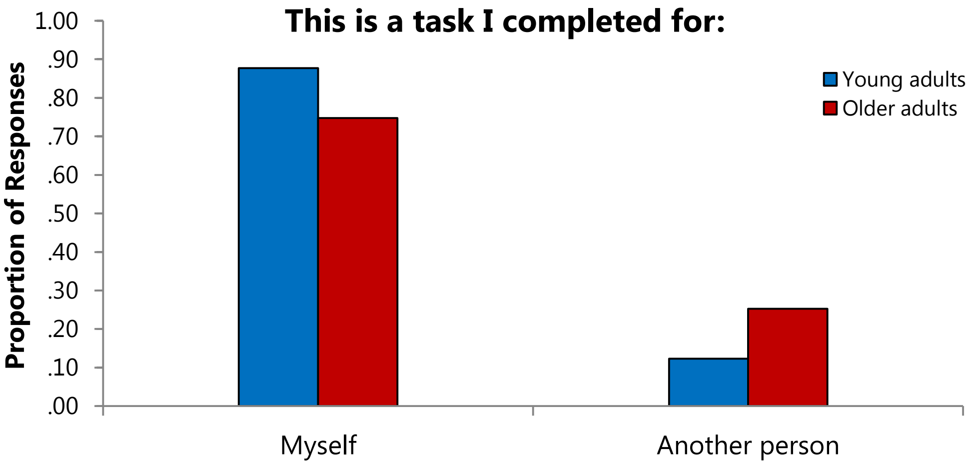
Motivation and importance was next considered as a contributing factor to the variability of age differences in PM performance. Participants who reported completing planned tasks were asked about the importance of said tasks and also whether the tasks were completed for themselves or for another person. These results are displayed in Figure 3.2. Young adults rated their completed PM tasks as important less often than the older adults (68% of young adults' responses compared to 90% of older adults' responses). In regards to social motivation, the majority of responses in both age groups indicated that the planned tasks were completed for the participants themselves (see Figure 3.2b).

(a)



Total number of responses: 161 responses for Young adults; 352 responses for Older adults

(b)



Total number of responses: 163 responses for Young adults; 352 responses for Older adults

Figure 3.2. Age differences in motivation. Proportions of responses were determined by collapsing the frequency of responses across all participants in each age group. (a) Proportion of responses indicating perceived level of task importance. (b) Proportion of responses indicating whether the task was completed for the participant or for someone else.

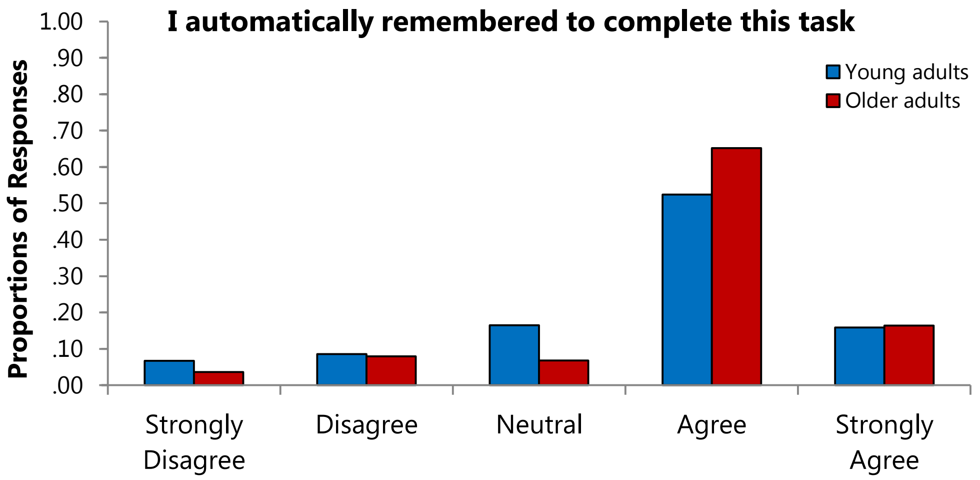
Forgetfulness

All participants were asked if they forgot to complete a planned task in the last few hours. This is another exceptional situation where it was possible to calculate individual proportions and conduct an independent samples t-test to compare the mean proportion of responses between the age groups that indicated instances of forgetfulness. Participants reported forgetting to perform a planned task only a small proportion of the time, but there was a nonsignificant trend that approached significance for young adults (M = .11, SD = .12) to forget planned tasks more often than older adults (M = .06, SD = .09; $t(69.93) = 1.97$, p = .053, d = 0.44). As so few instances of forgetfulness were reported, further investigation into the circumstances surrounding forgetfulness (such as the perceived importance of the forgotten planned task or how busy the participant was at the time) was not possible.

Nature of Intention Retrieval

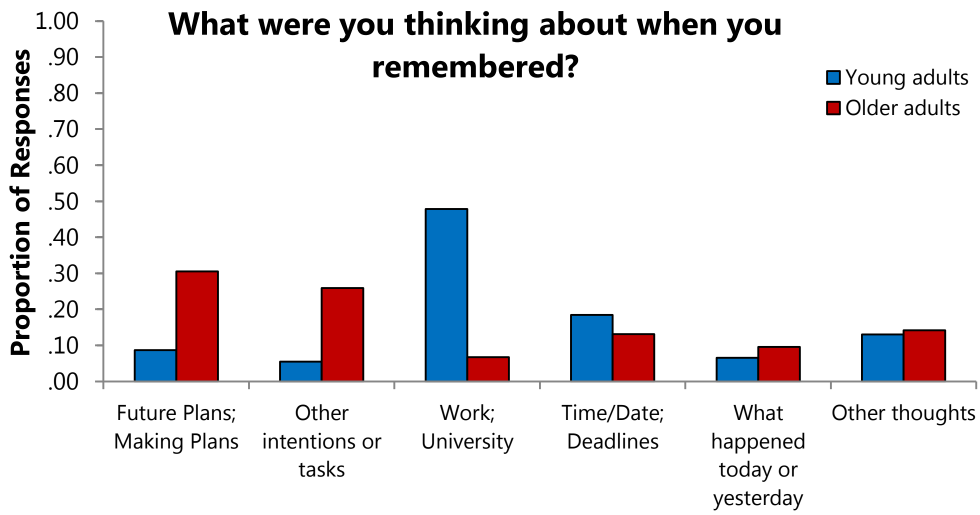
The possibility that older adults retrieve PM intentions in everyday life through more spontaneous processes was explored through several questions on the usage of internal cues and external cues. Participants were asked to what degree they automatically remembered to complete the reported task and what they were thinking about when they remembered to complete the task. The descriptive results are presented in Figure 3.3. For both age groups, the majority of those who completed a task reported automatically remembering to do so (see Figure 3.3a). Figure 3.3b shows that amongst those who reported using an internal cue (young adults, n = 33; older adults, n = 40), the thoughts that triggered execution of the PM task differed between the age groups. Young adults most often reported thinking about “work/university” when the task popped into mind, followed by “time/date or deadlines”. Older adults identified their internal cue as thoughts about “future plans” or “other intentions/tasks” most often. Some participants selected multiple internal cues despite the instruction to select only one. These were classified as response errors and were not included in the results shown in Figure 3.3. In total, there were 16 response errors for young adults and five response errors for older adults.

(a)



Total number of responses: 164 responses for Young adults; 353 responses for Older adults

(b)

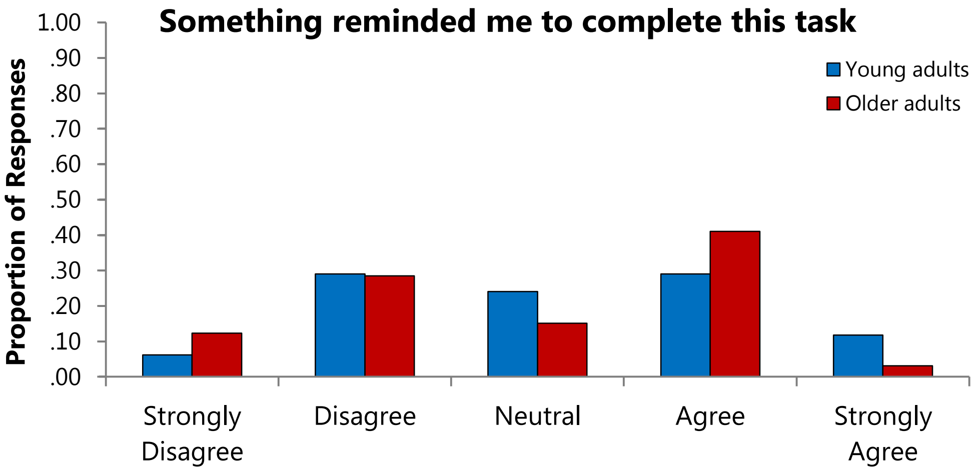


Total number of responses: 92 responses for Young adults; 282 responses for Older adults

Figure 3.3. Age differences in the prevalence of internal cue usage and the type of internal cue that triggered the completion of the planned task. Proportions of responses were determined by collapsing the frequency of responses across all participants in each age group. (a) Proportion of responses indicating automatically remembering to complete the planned task. (b) Proportion of responses for each internal cue category.

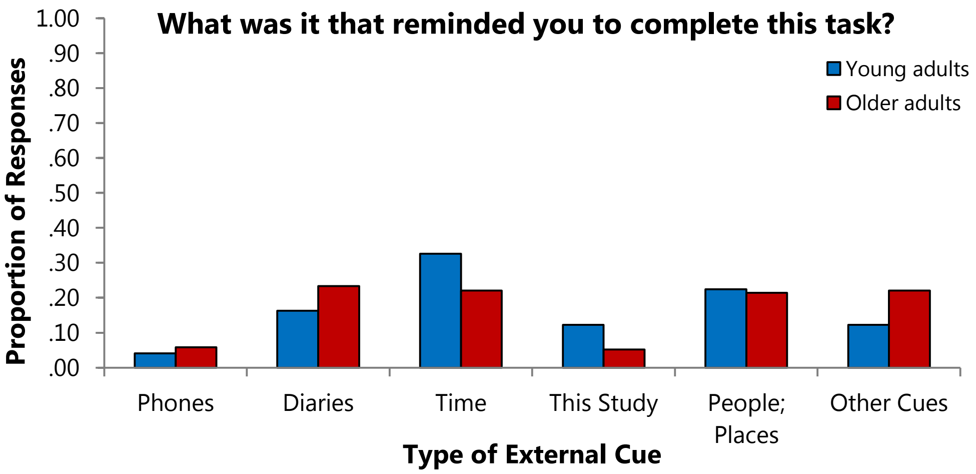
Participants were also asked to what degree something external in their environment reminded to complete the reported task, and to specify what type of external cue was used. Figure 3.4 illustrates that the role of environmental cues or external aids was split for both age groups. The proportion of responses indicative of external cue usage was nearly identical to the proportion of responses indicative of its absence (see Figure 3.4a). Older adults did not appear to be more reliant on external cues compared to the young adults.

(a)



Total number of responses: 162 responses for Young adults; 358 responses for Older adults

(b)

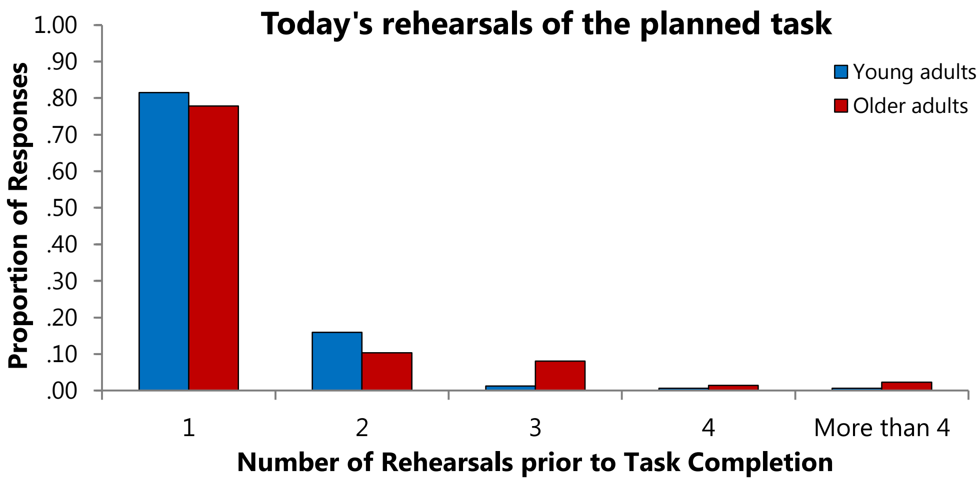


Total number of responses: 49 responses for Young adults; 154 responses for Older adults

Figure 3.4. Age differences in the prevalence of external cue usage and the type of external cue that triggered the completion of the planned task. Proportions of responses were determined by collapsing the frequency of responses across all participants in each age group. (a) Proportion of responses indicating an external cue triggered completion of the planned task. (b) Proportion of responses for each external cue category.

Compensation strategies afforded by naturalistic setting. While the descriptive results previously reported suggest no age differences in the overall use of external cues to trigger the execution of planned tasks, participants who did report being reminded of their planned task by something in their environment (young adults, n = 18; older adults, n = 35) were asked what the external trigger was. Figure 3.4b shows the variation in the types of external cues used by each age group. Some participants selected multiple external cues despite the instruction to select only one. These were classified as response errors and were not included in the results shown in Figure 3.4. In total, there were 13 response errors for young adults and four response errors for older adults. Both young and older adults used a wide range of external cues. When an external cue triggered the completion of a PM task, older adults most commonly identified the trigger as “diaries” (about 23% of the time), and young adults most commonly identified “time” as the trigger (about 33% of the time). However, within these two categories of external cues, there did not appear to be a considerable age difference.

Older adults are presumed to have fewer demands in daily life compared to their younger counterparts, which could allow older adults more time to rehearse their planned tasks. Although the findings previously addressed did not substantiate this notion (i.e., the demands on young adults were not greater than those on older adults according to self-reported busyness and the amount of planned tasks completed), the possibility that older adults’ improved PM performance in naturalistic settings is due to frequently rehearsing planned tasks was explored. All participants were asked if they had rehearsed a planned task in the last few hours. Individual proportions were able to be calculated in this instance and were averaged to provide a proportion of responses for each age group. An independent samples t-test was conducted to examine any age difference in how often rehearsals of PM tasks occur in everyday life. Older adults reported rehearsing PM tasks significantly more often than young adults (M = .52, SD = .30 and M = .36, SD = .26 respectively; $t(80) = 2.69$, $p = .009$, $d = 0.60$). However, as depicted in Figure 3.5, when participants were asked how many times they had rehearsed their completed task that same day, there was no age difference.



Total number of responses: 157 responses for Young adults; 348 responses for Older adults

Figure 3.5. Age differences on the rehearsal frequency during the day of task completion: Proportion of responses indicating the number of rehearsals of the planned task that occurred during the same day of task completion. Proportions of responses were determined by collapsing the frequency of responses across all participants in each age group.

3.4 Discussion

The present study examined potential age differences in PM behaviour in everyday life with a focus on differences in the context of PM successes and failures. This exploration of contextual age differences in everyday life was performed to elucidate the potential factors that are proposed to impact naturalistic PM performance in order to clarify contributing factors of the age-PM paradox.

Age differences in the demands of everyday life were observed, but the results often contradicted the direction suggested by previous research (Martin & Park, 2003; Wilson & Park, 2008). Older adults completed PM tasks much more frequently than young adults. However, this finding is in line with the recent study conducted by Schnitzspahn et al. (2015) that found older adults not only better remembered their PM intentions, but they also completed PM tasks more often than young adults. When participants completed a PM task, the majority of both age groups reported completing one or two PM tasks in the timespan of a few hours. This indicates that young adults complete less PM tasks overall in daily life compared to older adults, given that older adults reported task completion more frequently. There is a widespread view, although limited evidence that suggests, that environmental demands decrease with age (Martin & Park, 2003). However, this was not reflected in the current study. In fact, older adults reported being busy just prior to task completion considerably more often than young adults. In an effort to understand why participants might report being busy prior to task completion, the possible influence of the ongoing activity was explored. The ongoing activities differed between the age groups. Older adults appeared to be engaged in a wider variety of activities, with household maintenance being the most common by only a small margin. In contrast, young adults were overwhelmingly engaged in one of two activities prior to task completion: work/study or resting. It remains unclear how the nature of the ongoing activity (e.g., how absorbing or how cognitively demanding participants found the activity) might have influenced PM performance, especially since the pattern of ongoing activities associated with forgotten PM tasks could not be examined due to the paucity of PM failures. Further research on the ongoing activities preceding naturalistic PM tasks is necessary, however, there is evidence to suggest that young adults' reduced PM performance in naturalistic settings is not merely the result of having more challenging activities in everyday life. This is indicated by the young adults reporting that they were resting a significant proportion of the time. According to self-reported busyness and the amount of planned tasks completed, the demands on young adults do not appear to be greater than those on older adults. Therefore, based on the findings of the current study, age differences in the demands of everyday life do not seem to contribute to the diminished performance of young adults in naturalistic settings. However, it is important to acknowledge that the older participants were volunteers who live independently in the community, and the findings may be limited to this subset of the elderly population.

One factor that has been consistently found to influence PM performance, both in the laboratory and in naturalistic settings, is the level of motivation associated with task completion (Aberle et al., 2010; Hering et al., 2013; Ihle et al., 2012; Jeong & Cranney, 2009; Kliegel et al., 2001; Marsh et al., 1998; Moscovitch, 1982; Niedźwieńska et al., 2013). Older adults are thought to have greater motivation to complete PM tasks due to the high level of importance they attribute to their PM tasks (Ihle et al., 2012; Marsh et al., 1998; Niedźwieńska et al., 2013). Consistent with previous research, the current study found that older adults were more likely to rate their PM tasks as important compared to young adults. However, older adults did not report exactly why completing the PM task was important to them, which could have allowed for further clarification. For example, perhaps the task was important because of the potentially serious consequences of a non-completion or because the completion of the task would benefit a close friend or partner. For both age groups, task importance did not appear to be linked with the social motive of the PM task. The role of social motivation in naturalistic PM performance appeared to be limited, as the majority of both young and older adults' responses indicated that the planned task was completed for the participants themselves and not for another person. There was not a large age difference in the proportion of completed PM tasks that were considered to be social intentions. This finding adds to the work of Schnitzspahn et al. (2015), who found that the number of social intentions did not vary between the age groups. Based on these findings, the improved performance of older adults in naturalistic settings could be influenced by their level of motivation and the degree of importance associated with task completion. Thus, motivation remains a potential contributing factor to the age-PM paradox.

In addition to the examination of the contextual factors that could contribute to PM successes in everyday life, the present study also examined how these factors might contribute to failures in PM. Though not statistically significant, there was a trend for young adults to forget to complete their planned intentions more frequently than older adults. One aim of the study was to explore the circumstances of these PM failures (e.g., busyness, level of motivation, and use of external aids) in the hope of identifying how the context might differ from successful completion of PM tasks, as well as identifying any contextual age differences. However, as so few instances of PM failures were reported by both young and older adults, a closer investigation into the possible reasons why participants failed to complete a planned intention was not possible. Failures in PM appear to be rare in everyday life, especially for the older population. While this rarity seemingly contradicts earlier claims in the literature regarding the frequency of errors in PM (Crovitz & Daniel, 1984; Terry, 1988), one possibility is that when participants in those previous studies were asked to recall memory errors, they perhaps recalled the errors that were of most concern to them. Given the potential severity of the consequences associated with failures in PM, as opposed to failures in retrospective memory, it is possible that PM failures are both relatively infrequent and yet are still of great concern.

There is no reason to suggest the paucity of PM failures in the current study is due to an underreporting of PM failures. Contrary to traditional diary studies, participants in the current study were not required to recollect their PM performance after a prolonged period of time due to the experience-sampling method employed. Furthermore, a memory lapse can be quite noticeable in daily life, which suggests that participants would be likely to recall instances of forgetfulness more readily than task completions. There are several possibilities for why the current study found failures in PM to be quite scarce in naturalistic settings. One possibility is that participants were able to spread out or stagger their PM tasks, and were not always required to complete their PM tasks while engaged in resource-demanding activities. Although most laboratory studies report a higher frequency of PM failures compared to that of this study, laboratory assessments typically challenge participants to complete multiple PM trials while engaged in a demanding ongoing task. In everyday life, however, PM tasks occur over a longer timeframe and the ongoing tasks could be less cognitively-demanding. Another possibility is that participants are better able to use strategies in everyday life to safeguard their performance of PM tasks. Gilbert (2015) found that individuals utilised external reminders strategically, and established reminders when there was a high memory load or when the ongoing task was particularly distracting. This finding suggests that metacognitive awareness plays a role in PM performance, and perhaps this is especially important in naturalistic settings. A further possibility, is that the experience-sampling method of the current naturalistic study only observed performance over a relatively small proportion of waking hours per week (i.e., approximately 9 hours each day for a five-day period). Despite the innovative use of an experience-sampling method to observe naturalistic PM behaviour more closely than ever before, the context of real-life PM failures and any age differences therein, remain elusive and should be the subject of future investigations.

The most surprising findings from the current study pertain to the nature of task retrieval and the use of compensatory strategies. The vast majority of PM executions were the result of individuals automatically remembering to complete their PM intentions. Remarkably, this was true for both young and older adults. This finding suggests that spontaneous retrieval of planned intentions is not only possible, but it is prevalent in everyday life. Moreover, this finding lends further support to the multiprocess model of PM (McDaniel & Einstein, 2000). A closer look at the content of the thoughts which appeared to trigger the retrieval and subsequent completion of the PM tasks revealed age differences, but also some parallels. Prior to intention retrieval, older adults frequently had thoughts of future plans as well as thoughts of other PM tasks. Although young adults most often had thoughts of work/university, this can conceptually be interpreted as similar to thoughts of other PM tasks or intentions. Upon consideration of these internal cues, however, there appears to be evidence of both spontaneous retrieval of PM intentions that were triggered by incidental cues, as well as more deliberate, self-initiated retrieval of PM intentions. Older adults' thoughts of future plans could reflect strategic PM behaviour (Kvavilashvili & Fisher, 2007). For example, older adults could be deliberately thinking of their plans in order to assess which of their PM tasks have been completed already and which still remain, as if using a mental “to-do” list. This strategic behaviour is not always present, as indicated by older adults’ reports of incidental internal cues as well. One possibility is that older adults engage in strategic monitoring behaviour when the PM task lacks a salient cue, such as time-based tasks (McDaniel & Einstein, 2000), or when the task is considered to be of great importance (Kliegel et al., 2004). However, it remains unclear which task characteristic is most relevant in its influence on the retrieval process utilised by older adults in naturalistic settings. Nevertheless, the decision and the opportunity to engage in strategic behaviour in everyday life could potentially have a positive impact on older adults’ PM performance, and could very well be a contributing factor to the age-PM paradox.

The widespread belief that older adults achieve improved PM performance through the use of external cues or aids in naturalistic settings was not supported by the results of the present study. The older adults in this study were not more reliant on external cues compared to young adults. In fact, the use of external cues in everyday life was low for both age groups. The proportion of responses that indicated the use of an external cue was equivalent to the proportion of responses that denied doing so. Therefore, the use of external cues cannot explain older adults’ strong PM performance in naturalistic settings. Although a study conducted by Maylor (1990) is often cited as evidence that older adults perform well in naturalistic settings due to their greater use of external aids compared to young adults, this is a misinterpretation of her findings (Phillips et al., 2008). Maylor (1990) in fact suggested that older adults are more *efficient* in their use of external cues. In the current study, when the use of external cues was reported, older adults were found to use a wider variety than the young adults. Older adults’ use of external cues was spread evenly across four categories: diaries, time, people/places, and other cues. In contrast, young adults predominantly relied on time or people/places as their external cues. Perhaps the variety of external cues used by older adults suggests that when they encode their PM intention, they select the target cue that would be the most beneficial for a given task. In other words, perhaps older adults use their many years of experience to match the PM intention with the most suitable trigger cue (Phillips et al., 2008). While the strong PM performance of older adults in naturalistic settings cannot be attributed to the frequency of their use of external cues, it is yet to be determined whether older adults are indeed more efficient than young adults in the use of external aids.

The final compensatory strategy considered as a contributing factor of the age benefit observed in naturalistic settings was the rehearsal of PM intentions. Consistent with the findings of Gardner and Ascoli (2015), a stark age difference was observed in the overall frequency of PM rehearsals, with older adults reporting rehearsal of their planned intentions more often than young adults. This is in line with the discovery discussed earlier that older adults reported thinking about their future plans more often than young adults. Deliberate planning and rehearsing of a PM intention may encourage older adults to carefully consider the context in which they are likely to encounter the target cue, thereby facilitating the future retrieval of their intention at the appropriate time (Gollwitzer, 1999; Niedźwieńska et al., 2013; Szarras & Niedźwieńska, 2011). Thus, it is plausible that older adults' frequent rehearsals of PM intentions contribute to their improved performance in naturalistic settings. One curious observation regarding this compensatory strategy is that older adults' greater overall frequency of PM rehearsals did not translate into a greater number of rehearsals on the day the PM task was completed. The majority of the time, both young and older adults reported rehearsing that particular PM task only once in the lead up to task completion. This suggests that when older adults rehearse their intentions, they are planning for PM tasks they hope to complete beyond just that given day. At this point, it is unclear whether some aspect of older adults' daily lives makes such rehearsals possible or more beneficial for older adults compared to their younger counterparts. That is to say, why do young adults not engage in more rehearsals of their PM intentions in everyday life? Though only speculation, one possibility is that older adults are able to rehearse future intentions more effectively because their daily or weekly routine is more predictable than that of younger adults (Rendell & Thomson, 1999). The structure of their everyday lives likely permits older adults to more accurately predict the conditions in which target cues will be encountered, which in turn facilitates intention retrieval and task completion. Therefore, if young adults' everyday lives are less routine or their PM intentions are more prone to re-prioritisation, then the use of rehearsals as a strategy would be less fruitful for young adults. Although the structure and routine nature of everyday life was not directly explored in the current study, such contextual differences between the age groups could significantly impact PM performance in naturalistic settings. Thus, the rehearsal of PM intentions as a compensatory strategy warrants further investigation as it could help clarify the age-PM paradox.

Strengths and Limitations

The current study has several strengths and a few limitations that stem from the use of an experience-sampling methodology. The experience-sampling method better captured the details of participants' everyday PM performance than previous research by gathering information in real time. This significantly improved upon existing naturalistic studies of PM by minimising the burden placed upon the participants to accurately recall their behaviours and earlier instances of forgetfulness. This procedure reduced the likelihood that errors in retrospective memory biased the reporting of PM performance (Schnitzspahn et al., 2015). It also allowed for a large number of observations, which provided a rich, descriptive picture of PM in everyday life. Despite these benefits, there were some limitations that should be addressed. The repeated presentation of the PM electronic questionnaire, and particularly the branching nature of the questions, may have discouraged some participants from answering honestly in an attempt to finish the questionnaire quickly. Additionally, the branching of questions meant that participants were not equally represented in the data for each question, which restricted the use of inferential statistics as discussed earlier. However, the study design produced a rich data set that provides clear directions for future, targeted research.

Future Directions

Until recently, naturalistic studies have primarily focused on investigating PM through participants' performance on experimenter-given tasks in their daily lives. For example, participants have had to remember to call the experimenter at a certain time of day (Maylor, 1990), remember to log times on a personal organiser (Rendell & Thomson, 1999), or remember to write their initials on the top of a questionnaire before mailing it to the experimenter (Kvavilashvili et al., 2013). This allows for greater experimental control and the manipulation of variables that could impact PM performance. However, it is also important to investigate the contributing factors to participants' performance on their own PM intentions. Such investigation could identify which variables matter most in real-life PM performance for both young and older adults. The current research adds to the handful of naturalistic studies to have examined participants' own naturally occurring intentions (Ihle et al., 2012; Niedźwieńska et al., 2013; Schnitzspahn et al., 2015). These studies have highlighted PM task type (Schnitzspahn et al., 2015) and planning capabilities (Niedźwieńska et al., 2013) as possible contributing factors to the age-PM paradox that warrant further investigation. The current examination of everyday PM behaviour adds the rehearsal of PM intentions as another worthy avenue of further research. Future naturalistic studies could examine the interplay between these three variables, as well as any potential age differences in their influence on PM performance.

The current study, although descriptive in nature, has implications for an issue at the forefront of PM research. Namely, how PM intentions are retrieved in everyday life. The descriptive data appear to fit the multiprocess framework of PM, whereby PM intentions are able to be retrieved through either spontaneous or effortful processes. As the magnitude of the age effects on PM performance is thought to be mediated by the retrieval process necessary for task execution (Eusop-Roussel & Ergis, 2008), the nature of intention retrieval is a prime target for investigations of the age-PM paradox. The findings of the present study suggest that older adults use both spontaneous and effortful retrieval processes. However, the factors that influence which retrieval process is required have yet to be clarified in naturalistic settings. The current study highlights the need for future research to focus on determining the contexts or tasks characteristics, such as salience of the target cue, that predicate the nature of task retrieval for a given PM intention.

Conclusion

The present study examined potential age differences in the context in which PM tasks occur in the daily lives of young and older adults. A novel experience-sampling method was employed to capture PM successes and failures as they occurred throughout the day, which is a significant advancement in the study of real-world PM. Several factors thought to influence naturalistic PM performance were explored in hopes of clarifying the age-PM paradox. Of the many factors considered, two factors in particular stand out as probable contributing factors to the age benefit typically observed in naturalistic studies of PM. Young and older adults were found to especially differ in their level of motivation and the nature of their intention retrieval. Older adults more often regarded their PM tasks as important, even in the absence of a specific social motive. Older adults also engaged in frequent rehearsals of their PM intentions, spending more time than the young adults thinking of their future plans. Detailed and precise planning of PM intentions improves PM performance (Gillholm et al., 1999; McDaniel & Einstein, 2007; Niedźwieńska et al., 2013; Szarras & Niedźwieńska, 2011). Therefore, it is possible that older adults' improved PM performance in naturalistic settings compared to their performance in the laboratory is related to their ability to better plan and rehearse their PM intentions when in their own environment. Another key finding is the evidence of both spontaneous retrieval and strategic monitoring, which lends support to the multiprocess model of PM. Inherent differences in the demands of everyday life or the use of external memory aids do not appear to be able to explain the age benefit observed in naturalistic settings, and therefore are less likely to be contributing factors of the age-PM paradox. Future research is needed to explore how young and older adults may differ in their planning of PM intentions, and particular attention should also be paid to factors that might affect the efficacy of their planning, such as the flexibility of their schedules and the types of PM cue.

Chapter 4: Development of Measures of Prospective Memory to Address Methodological Issues

A main focus of this thesis is to rigorously investigate the methodological issues which could be underlying the age-paradox. One of these issues is the difficulty in verifying task completion in naturalistic settings. Existing comparisons of performance on event-based tasks across settings have been limited by the inability to objectively verify performance in everyday life and the subsequent reliance on self-report methods. A novel and more objective measure of naturalistic event-based task performance was developed for the current study (Study 2). This measure advances the field of PM research considerably, and also allows for clarification of the potential impact this has had on the age-PM paradox. A second issue, and arguably of greater methodological concern, is the absence of analogous tasks between both settings. This is particularly problematic for time-based tasks, as the nature of time-based tasks in laboratory studies differs substantively from time-based tasks in naturalistic studies. Laboratory time-based tasks most often consist of time-check tasks, while naturalistic studies predominantly use appointment-style tasks as measures of time-based task performance. These two variants of time-based tasks differ in their cognitive demands, the presence of social or contextual cues, as well as the processes involved in task retrieval. Despite both of these time-based task variants existing in daily life, thus far only two naturalistic studies have examined time-check tasks (Rendell & Craik, 2000; Rose et al., 2015). Therefore, in the current study a systematic matching of tasks across settings was completed for each of the time-based tasks as well as for event-based tasks. Using analogous tasks across settings will address this methodological issue and the potentially confounding effect that comparison of disparate tasks has had on the age-PM paradox.

4.1 Laboratory Measure of Prospective Memory

Virtual Week

In response to the contradictory age differences on PM performance across settings, Rendell and Craik (2000) developed "Virtual Week," a laboratory measure in which tasks were designed to closely resemble everyday PM tasks. Often laboratory paradigms focus on capturing PM performance while participants are engaged in an ongoing task, believing this to be the crucial aspect of PM in real-life. Such paradigms include instructing participants to press a designated key on the keyboard in response to a specific target word that appears during the course of their ongoing lexical decision task (Einstein & McDaniel, 1990). However, this paradigm is somewhat removed from everyday PM tasks in that these laboratory tasks are abstract and lack the social or contextual cues that can occur in naturalistic settings. Virtual Week is regarded to be the first laboratory measure of PM to attempt to equate many elements on which commonly used laboratory tasks and real-life PM tasks differ (Ellis & Kvavilashvili, 2000). It simulates PM tasks that often occur in everyday life, embeds them in an ongoing task, and incorporates more contextual cues for its PM tasks. As in naturalistic studies, Virtual Week provides only one chance to complete each PM task, but it also provides a number of different PM tasks which leads to a more reliable assessment of PM performance. Additionally, Virtual Week facilitates the exploration of other task characteristics, such as cue type and task regularity, in a controlled setting.

In the one measure, Virtual Week systematically examines the PM tasks of interest in this research project which vary by cue type (i.e., event-based, scheduled time-based, and time-check tasks). This study used a computerised, brief version of the Virtual Week board game (Rendell & Craik, 2000) to assess PM performance in the laboratory (see Figure 4.1). This version of the measure simulates two days of everyday activities plus an additional trial day at the start where participants learn and practice the specific features of the game. Virtual Week has been widely-used within PM research and has demonstrated sensitivity to the effects of normal ageing (Aberle et al., 2010) as well as a split-half reliability for older adults ranging between .86 and .93 (Rose et al., 2010).

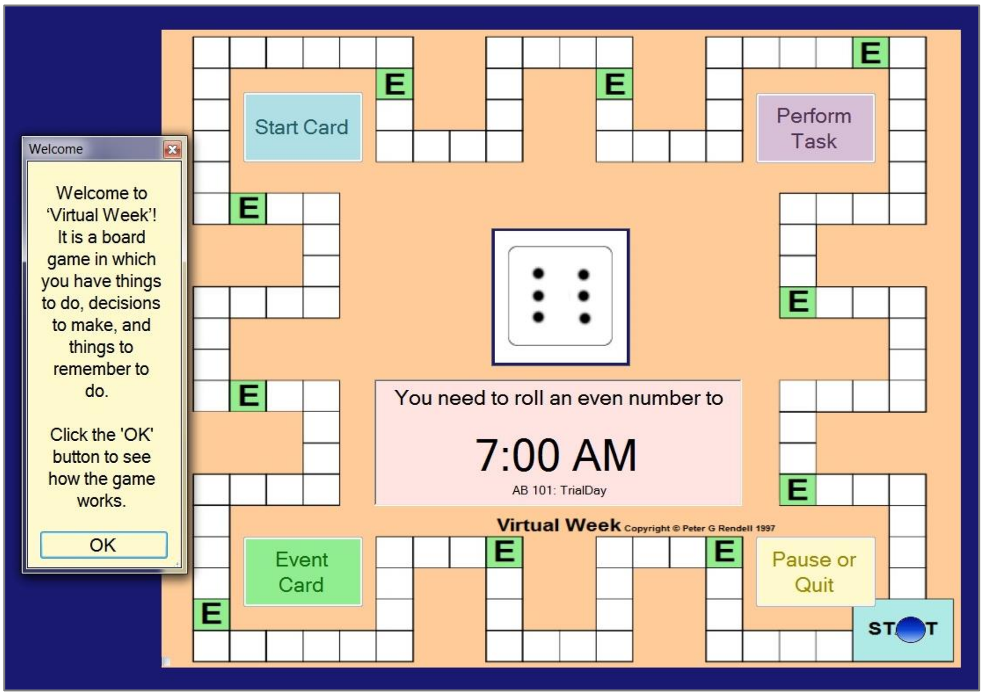
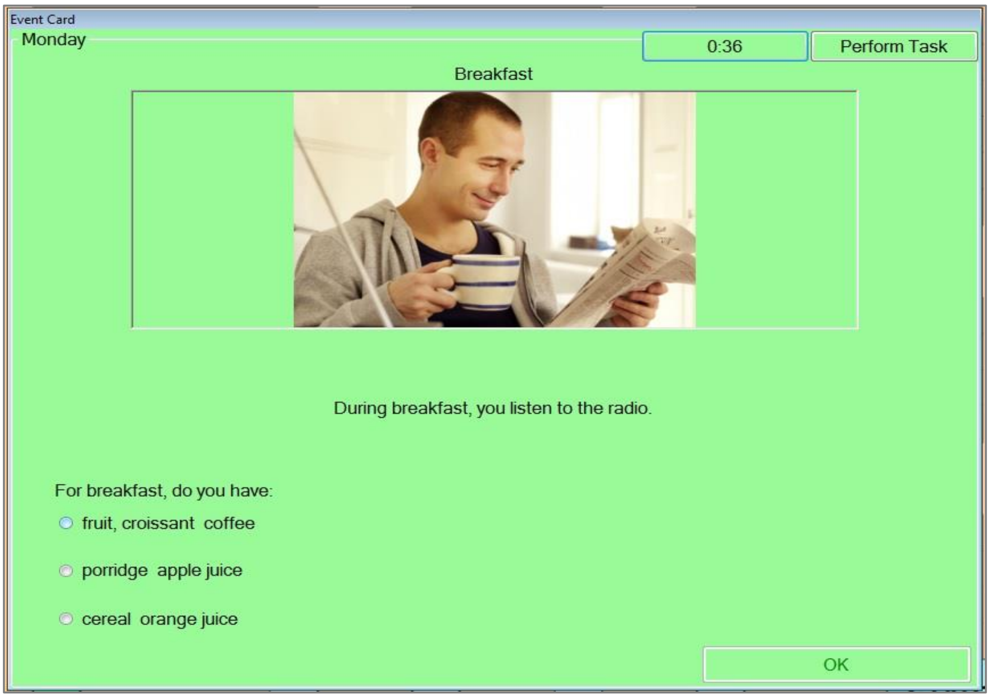


Figure 4.1. Screen display of the computerised Virtual Week.

During the game, participants move a token around the board with an electronic roll of a die. One circuit of the board represents one virtual day, and the central clock displays the virtual time of day. As participants move around the board, the virtual clock reflects the passing of time with every two squares indicating that 15 minutes have passed. As the virtual day progresses, participants are presented with "event cards" whenever they pass an "event" square (represented by an "E" on a green square), and these cards describe various events or activities. Participants read each event card aloud and then make a choice related to that event (e.g., select which food to eat for breakfast). The option selected dictates which number the participants must roll before they are next permitted to move their token. A crucial component of PM is the presence of an ongoing task. In Virtual Week, participants engage in the ongoing task of playing the game; this consists of rolling the die, moving the token the precise spaces indicated, reading event cards aloud, and deciding which action to take on each event card. Embedded within each virtual day are PM tasks that participants must perform in conjunction with certain events. For example, participants are informed at one point in the game that each day at breakfast and dinner (event cues), they must take medication (PM task). When participants are presented with a “breakfast” event card, they must complete their PM task in addition to selecting which food to eat for breakfast (see Figure 4.2). To complete a PM task, participants click on the ‘perform task’ button and then select the appropriate PM task from a list. During the practice day, participants are prompted to complete a PM task if they have not done so within two die rolls after a task is due. No such reminder or prompt is given during the two test days.

(a)



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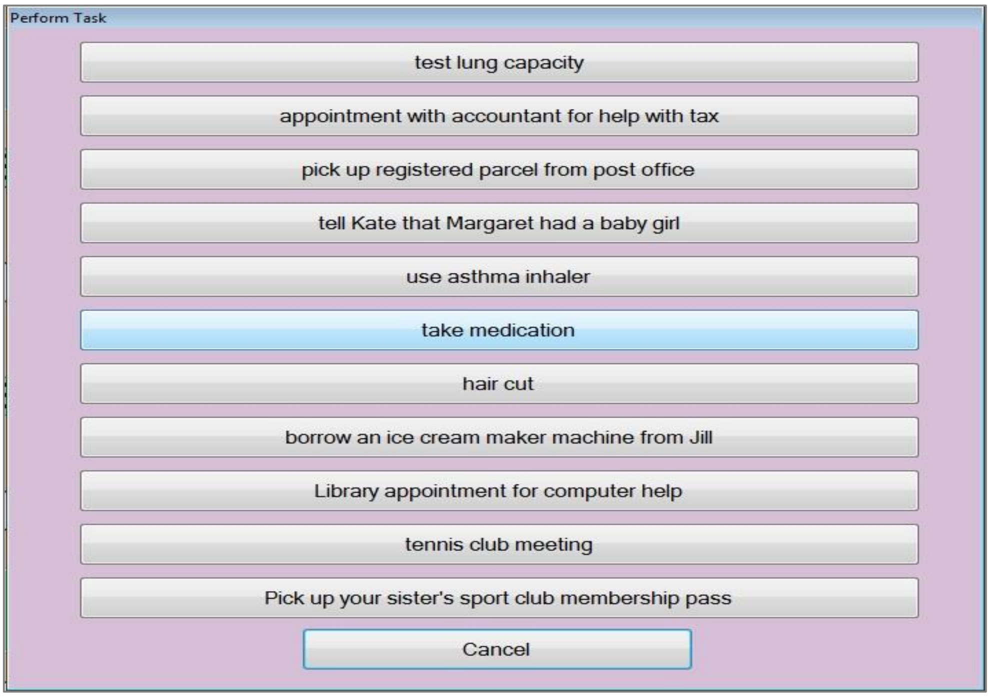

Figure 4.2. An event-based task in Virtual Week. (a) Breakfast event card is the cue for an event-based PM task. (b) Task is completed by selecting the appropriate PM task from a list of possible PM tasks.

Virtual Week also incorporates time-based tasks. Embedded within each virtual day are PM tasks that participants are to perform at set times (i.e., scheduled time-based tasks) or after a specified period of time has elapsed (i.e., time-check tasks). For example, participants must remember to put the casserole in the oven at 5 p.m. Participants need to monitor the virtual clock, but contextual cues are also provided through the presentation of various activities that are relevant to the virtual time of day. To complete the task, participants must click on the ‘perform task’ button at the appropriate time and select the correct PM task from the provided list. In addition to the virtual clock, there is a stop-clock (displayed in minutes and seconds). As shown in Figure 4.3, the stop-clock features above the central die and it indicates how long the participants have been playing the game that virtual day. In order to

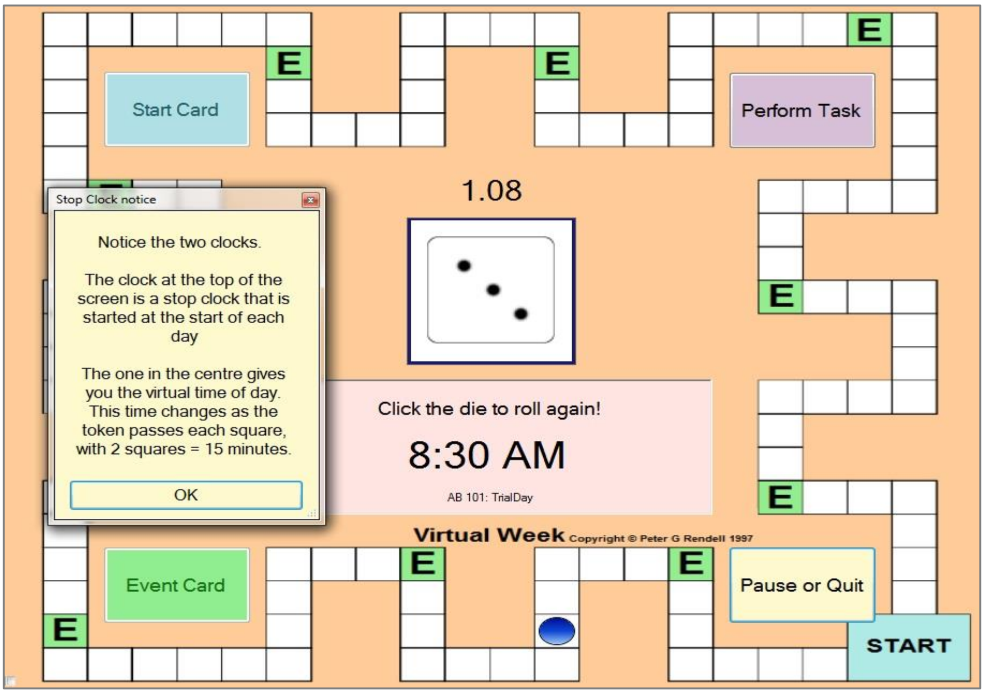

Figure 4.3. The screen displays a virtual clock below and a stop-clock above the die.

correctly perform the time-check tasks, participants must monitor the passage of real-time on this stop-clock and perform a PM task after a certain period of time has elapsed. For example, participants have to remember to “check their lung capacity” at 5 minutes and 7 minutes on the stop-clock each virtual day. The PM task is completed in the same manner as the event-based and scheduled time-based tasks, by first clicking on the ‘perform task’ button and then selecting the appropriate PM task from the list. The stop-clock is accessible at all times throughout the game, also appearing in the top right corner of every event card (see Figure 4.4).

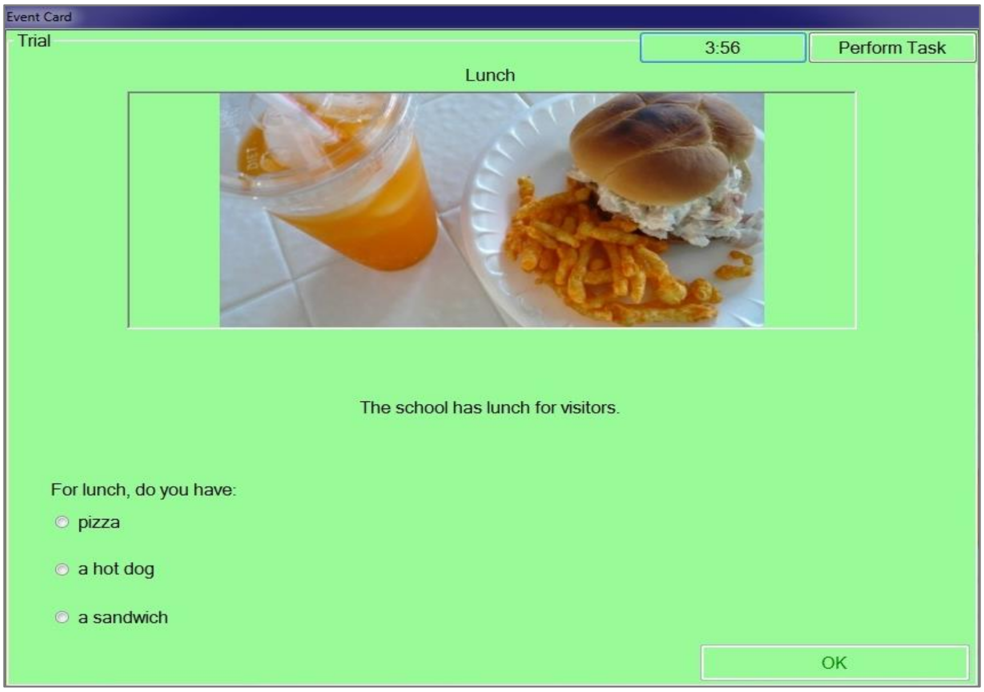

Figure 4.4. Screen display of event card with the stop-clock feature.

In addition to measuring performance on tasks of varying cue types, Virtual Week also examines the impact that task regularity has on PM performance. Task regularity refers to how frequently the PM task is required to be completed. In Virtual Week, *regular* tasks occur repeatedly both within and across each virtual day, and always with the same cue, be it an event or specific time. For example, upon commencing Virtual Week participants are instructed to take medication each day when they encounter breakfast and dinner event cards; these are the regular event-based tasks in the game. For the regular scheduled time-based tasks, participants must remember to use their asthma inhaler each day at 11 a.m. and 9 p.m. Both of the time-check tasks in Virtual Week are regular tasks (i.e., checking their lung capacity at 5 minutes and 7 minutes on the stop-clock each day). Regular tasks are introduced and practiced at the beginning of the game, which enhances intention encoding (Foster et al., 2013). Before beginning the first test day, the game reminds participants of their regular tasks and then instructs participants to verbally recall these tasks without looking at the computer screen. At the start of the second test day, participants are prompted by the researcher to verbally recall their regular tasks.

In contrast, *irregular* tasks occur once throughout the game, and they change both in terms of the task and the associated cue. For example, on one virtual day participants were instructed to remember to put the casserole in the oven at 5 p.m., and on another day they were instructed to get a haircut at 1 p.m. Since each irregular task has a unique cue, there are also a greater number of cue-task associations to remember compared to those pertaining to regular tasks. As a result, the regular tasks are less difficult to encode than the irregular tasks (Foster et al., 2013). Half of the irregular tasks (such as “return a book to the library” when presented with the “Library” event card) are introduced on the “start card” presented at the very beginning of each virtual day. The other half of the irregular tasks are introduced as the virtual day elapses, simulating tasks that participants may encounter as the day progresses. For example, participants receive news that their friend had a baby girl and are given the irregular event-based task of sharing the news when they next encounter a mutual friend. In this laboratory measure, there are 10 PM tasks to complete each virtual day: four event-based (two regular; two irregular), four scheduled time-based (two regular; two irregular), and two time-check (both regular) tasks.

The instructions for each PM task varied according to the encoding condition assigned to an individual participant. In the *control* condition, participants read the instructions aloud without any further direction regarding their encoding of the intention. In the *implementation intentions* condition, participants receive the additional instruction to form their intention using a specific sentence structure (i.e., “When *X,* I will *Y*), to repeat that statement aloud three times, and to visualise themselves completing the task. Figure 4.5 shows an example of the instructions provided to those in the implementation intentions condition. The instructions for those in the implementation intentions group remain on the computer screen for 45 seconds. Participants in the control condition close the instruction screen after reading the PM task aloud and are then able to continue playing the game. The PM tasks in Virtual Week are the same for both age groups and across encoding conditions.

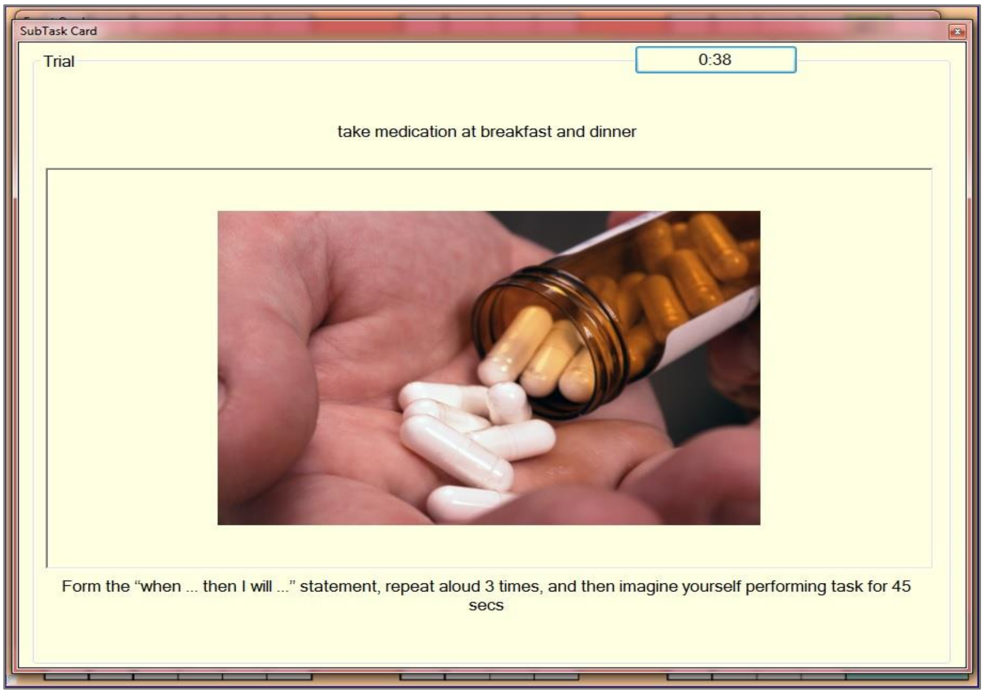

Figure 4.5. Regular event-based task instructions given to participants in the implementation intentions encoding condition.

Scoring Task Performance

In the current study, the proportion of correct responses for each of the five PM task types (regular/irregular event-based tasks, regular/irregular scheduled time-based tasks, and time-check tasks) were used as indicators of PM performance. A correct score indicates that the participant completed the appropriate PM task in response to the relevant cue. Correct responses were those performed when the token arrived at (or just passed) the target position on the board, and before the next die roll. In regards to time-check tasks, a correct response indicates the task was completed within 10 seconds of the target time. The proportion of missed responses was additionally used as an indicator of PM performance for time-check tasks. Missed responses reflect the absence of task completion at any point that virtual day.

4.2 Naturalistic Measure for Event-based Tasks

The aim throughout the development of the naturalistic measure was to create a means of objectively assessing PM performance on event-based tasks in everyday life. Previous PM research in naturalistic settings has relied heavily on self-report methods which can lead to inaccurate accounts or systematically biased results. Self-report methods also place the burden upon participants to monitor their performance and recall instances of forgetfulness over long periods of time. Many event-based tasks in everyday life are associated with a specific location (e.g., remembering to pick up your clothes from the dry cleaners or remembering to post a letter when you pass the post box). The use of global positioning system (GPS) was considered for use in this study given its ability to verify participants' locations. GPS could potentially be used to monitor PM failures (e.g., the participant walked past the bakery and forgot to buy bread) as well as successes. Location-based reminders have become widespread in the general population due to GPS-enabled smartphones. Smartphone users can set a reminder for a task (e.g., check for passport) and will be alerted when they arrive at or leave a particular destination (e.g., leaving the house on the way to the airport). Despite its proven usefulness as a PM aid, GPS has several limitations in terms of its effectiveness as a PM assessment tool in naturalistic settings.

GPS was not included in the assessment of naturalistic PM performance due to notable shortcomings in terms of its capacity to verify accurately PM task completion (or failure). This is due to a number of features. Firstly, adequate cellular service is required to monitor location in real-time; therefore data collection would rely on participants remaining in areas with reliable cellular reception for the duration of the study. Although several mobile device applications that collect GPS data will cache data onto the device while it is out of network coverage areas, the cached data do not provide real-time observations and often have a large margin of error in regard to geolocation. Secondly, GPS would only be applicable for event-based tasks that are location-specific, in other words for event-based tasks where the cue is a specific and pre-identifiable location. More importantly, GPS verifies the *location* but not the *completion* of event-based tasks. For instance, a person can shop within the supermarket, but still forget to complete the PM task of purchasing milk. Lastly, many everyday PM tasks are completed within the same environment (e.g., passing along a message to a classmate and returning a university library book), and verification in these cases would be limited.

Given the shortcomings of GPS in its ability to verify the completion of naturalistic event-based tasks, an alternative approach was adopted in the current study. This involved requiring participants to take a photo documenting, in real-time, their completion of activities or events. Participants were to complete four event-based tasks each day of the three-day naturalistic study period. The PM task was to take a photograph of an event using the camera function on a provided smartphone. The photograph, or lack thereof, also provided verification of task completion. The specific event cues were determined by each participant using a list of common activities and events (see Appendix C.3) that was created for this study. During the testing session, participants were asked to select activities or events that were highly likely to occur in their own lives during the three-day study period. Afterwards, the participants did not have access to the nominated activity list. Instead, at the start of each day, participants received notifications on a provided smartphone that indicated the day’s tasks; these notifications could only be viewed once. The appearance of a notification on the screen was accompanied by an audio alert. When participants received an alert, they were to encode their prospective intentions, close the message, and then remember to take the photos only when they were engaged in the events that were mentioned. This unique combination of nominated event cues, which were part of the participants’ lives, and the artificial task of taking photos allowed for greater experimental control and is one of the most objective verifications of naturalistic event-based tasks to date within the PM field (see also Bailey et al., 2010; Cavuoto et al., 2015; Niedźwieńska & Barzykowski, 2012).

Manipulation of task regularity was also embedded within the naturalistic measure of event-based PM to mimic the types of event-based tasks assessed in the laboratory. Similar to the laboratory event-based tasks, participants completed two regular tasks and two irregular tasks each study day. For regular tasks, participants photographed the same activity each day. The first regular task was to photograph their lunch each day (N.B. an alternative meal was chosen for one participant who did not eat lunch regularly). Three cue options were given for the second regular task; participants chose either brushing their teeth, taking medication, or passing a specific landmark as the cue for their event-based tasks. The provided smartphones were programmed to send an alert at 9 a.m. each day, informing participants of the regular tasks that they were to perform later on that day (e.g., take photos of your lunch and brushing your teeth). The cues for the irregular tasks varied for each participant, but were chosen from the nominated activity list. An example of an irregular task was to photograph the halftime score of a specific sporting event. Participants were asked when selecting the events to provide details, such as specifying the teams and approximate time of the sporting event, for verification purposes. The smartphones would alert participants at 9:30 a.m., informing participants of the irregular tasks that they were supposed to perform later that day (e.g., take photos of bowling club and grocery shopping). Separate alerts were sent due to a limited number of characters permitted in each alert. The timing of the alerts was altered for four participants (one young adult and three older adults) to better suit their schedules. Irregular tasks were not repeated, even if a cue occurred more than once over the study period. For instance, the irregular task of photographing the act of feeding a pet was completed only once, despite the participant (hopefully) feeding the pet each day.

Just as in the laboratory assessment of PM, a manipulation of encoding condition was also included in the naturalistic measure of event-based PM tasks. Participants in the implementation intentions encoding condition received an additional instruction in their alerts (e.g., take photos of your lunch and brushing your teeth. Say your ‘When…I will’ statement aloud 3 times). Participants were familiar with the “When *X*, I will *Y*” formation by this point, having repeatedly practiced the encoding strategy during the laboratory measure. The resulting measure of naturalistic event-based tasks was not only verifiable but its tasks also paralleled the laboratory event-based tasks to a greater extent than previous naturalistic measures.

Scoring Task Performance

Initially, the event-based tasks were scored according to three categories: *correct*, *missed*, and *remembered forgetfulness*. Participants were told that if they failed to take a photo while they were engaged in a nominated activity, but remembered their forgetfulness later on in the day, they should do one of two things: they should either draw a “sad-face” on a piece of paper noting which task they failed to complete and take a photo of this piece of paper, or if pen/paper were not available at that moment then they should take a photo of their hand making a “thumbs-down” signal. Upon viewing the photos taken by the first few participants and the accompanying timestamps of each photo, the scoring categories were updated to include three additional categories: *reminded by another task*, *contrived*, and *unable to take photo*. Photos were scored as *reminded by another task* if they were taken within one minute of another task’s photo. For instance, if the participant took a photo of taking medication at 6:30 p.m. and less than a minute later the participant took a photo of watering the garden, the first photo was scored as *correct* while the second photo was scored as *reminded by another task* since it is likely that the completion of the first task prompted the participant to complete the other task. If, however, the second photo did not indicate task completion (e.g., a photo of watering the garden) but rather a remembrance of forgetfulness (e.g., a photo of a piece of paper with a sad-face and “watering the garden” written on it), then the second photo was scored as *remembered forgetfulness*. Only a small proportion of responses (less than 5%) were in the *reminded by another task* category. Photos were scored as *contrived* if the photos were made to look as if they were correctly completed, but the timestamp or other features indicated otherwise. An example of a contrived photo is a photograph of dinner at 8 p.m. trying to be passed off as the daily lunch photo. This category was also relatively infrequent with about 5% of responses categorised as contrived. The final category, *unable to take photo*, included photos that indicated either that the activity/cue did not occur that day (e.g., the photo was of a note saying their doctor appointment had been re-scheduled by the doctor) or that the participant engaged in the activity but was unable to take a photo at the time (e.g., one participant took a photo of a note saying she did attend church but was unable to take a photo while she was there). This final category consisted of approximately 1% of the total responses.

4.3 Naturalistic Measure for Time-based Tasks

In relation to laboratory studies, results more consistently show age-related deficits on time-based tasks than on event-based tasks (Henry et al., 2004). One explanation for this finding is that event-based tasks have explicit cues that trigger intention retrieval. Without such cues, intention retrieval pertaining to time-based tasks relies on active monitoring which is more cognitively demanding (Einstein & McDaniel, 2014), and hence are more susceptible to age-related cognitive decline. This is certainly true for laboratory paradigms where participants are commonly expected to press a designated button after a certain time period had elapsed (i.e., time-check tasks). However, time-based tasks in everyday life differ dramatically in that they are accompanied by contextual and social cues, and are more often scheduled time-based tasks (i.e., tasks that occur at a specific time, such as attending a doctor's appointment at 3 p.m.). The presence of conjunction cues for scheduled time-based tasks allows for intention retrieval through spontaneous processes while still having a time-monitoring component. To date, naturalistic studies have almost exclusively assessed time-based task performance using scheduled time-based tasks, whereas laboratory studies have predominately used time-check tasks to measure performance. These variants fundamentally differ from each other on levels of cognitive demand, the presence of social and contextual cues, as well as the intention retrieval processes involved. Therefore, it is highly plausible that the existing discrepancies on time-based task performance across settings reported in the current literature are due to the inappropriate comparison of these two variants. The naturalistic measure of time-based PM tasks developed for the current study therefore aimed to address the widespread flaw within PM research of comparing disparate tasks across settings. The measure assesses both scheduled time-based tasks and time-check tasks to better match those tasks measured in the laboratory, which will allow for more suitable comparisons of performance.

Scheduled Time-based Tasks

A smartphone application was created specifically for this research project to measure both types of time-based tasks in naturalistic settings. The application (referred to as "Quiz app") was developed to capture PM performance in real-time. To measure scheduled time-based task performance, participants were asked to complete a very brief quiz at two specific timepoints each day over a three-day study period. This three-day study period was counterbalanced with the three-day naturalistic study period of event-based tasks. Participants received an alert (i.e., a written notification accompanied by an auditory alert) on the provided smartphone at 9 a.m. each morning that instructed them to, "Schedule today's quizzes." Once this notification was received, participants opened the Quiz app and chose one morning and one afternoon time when they would be available to complete the quiz. Participants were given two times in the morning (10 a.m. or 11 a.m.) and two times in the afternoon (3:30 p.m. or 4:30 p.m.) from which to choose. Once chosen, the selections were confirmed and participants closed the Quiz app. Participants in the implementation intentions encoding condition, received an additional instruction when confirming the selected times for their scheduled time-based tasks. These participants were instructed to verbalise their intention in the specific format (e.g., When it is 10 a.m., I will complete a quiz), repeat the statement aloud three times, and visualise task completion. The time options provided for each task, and also for each day, allowed a degree of flexibility. This flexibility was designed for the purpose of reducing the likelihood that incomplete quizzes would be falsely attributed to PM failures. Participants did not receive any reminders for the times chosen and they were unable to refer back to the scheduled times in any way. When the actual time of day reached one of the scheduled times, participants had to remember their intention, open the Quiz app, and complete the scheduled quiz. Task completion was verified by the accompanying timestamp.

The same questionnaire was used for both scheduled time-based tasks and time-check tasks, and it consisted of the same three questions for each PM task. The quiz questions were: 1) What type of quiz is this?; 2) Where are you right now?; and 3) What are you doing? The first question addressed whether a participant's response was the completion of a scheduled time-based task or a time-check task. Participants answered 'Scheduled' if they were completing a scheduled time-based task and 'Pop' if they were completing a time-check task. This question provided clarification when scoring participants' responses, especially for incorrect responses. The remaining questions focused on the location of participants and their ongoing activity to address the proposed influence of structured, daily life and level of busyness on PM performance in naturalistic settings (Kvavilashvili & Fisher, 2007; Martin & Park, 2003; Vestergren & Nilsson, 2011).

Scoring task performance. For each scheduled time-based task, performance was assessed based on the time deviation between the expected response time and the participant's actual response time. This time deviation was used to classify each response into one of six completion timeframes: *early* (>15 min); *little early* (5-15 min); *correct* (± 5 min); *little late* (5-15 min); *late* (15-60 min); and *missed* (>60 min or no response). Using this categorisation of each response, response proportions were calculated for each participant as well as for each age group (young adults, older adults) overall. A score reflecting absolute time deviation was also calculated for each age group.

Time-Check Tasks

The Quiz app also captured time-check task performance. This involved two unscheduled occasions where participants received a notification instructing them to complete a quiz after a specified period of time had passed. The specified time-elapsed period varied between 10, 15, and 20 minutes to minimise the likelihood of practice effects. Once this notification was received, participants were to enter the Quiz app to initiate the stop-clock feature. Participants encoded the intention and started the clock by selecting the time-elapsed period that was specified in the alert.[2] No clock or timer was presented on the screen or within the Quiz app. Whenever participants believed the time-elapsed period had concluded, they were to return to the Quiz app and complete the quiz. No alert of any kind signified when the time-elapsed period had expired. The inclusion of the stop-clock feature provided participants with the ability to postpone task completion temporarily. This was useful in instances where participants received the notification at an inopportune moment (e.g., while the participant was driving) or if they did not hear the accompanying auditory alert due to noisy surroundings. For example, if participants were driving when they received an alert at 12:30 p.m. instructing them to complete a quiz in 15 minutes, they could ignore the alert until they arrived at their destination. Upon arriving at their destination at 1 p.m., they could then start the stop-clock, thereby making the target response time 1:15 p.m. rather than 12:45 p.m. based on the initial alert. Participants explicitly expressed their intention to complete the time-check task by starting the stop-clock. While the timing of the notifications varied each day, it was not randomised so as to avoid potential clashes with the scheduled

[2] Upon reviewing the responses of the initial participants, the researchers took note of a few instances where the participants completed a quiz without initiating the stop-clock. To clarify this step in the performance of a time-check task, the alert for all time-check tasks was updated to read, “Start the clock now, then complete quiz in *x* minutes.”

time-based tasks. All time-based tasks occurred over the same three-day study period, and each day participants were required to complete four tasks: two scheduled time-based tasks and two time-check tasks.

Scoring task performance. Primarily, performance was assessed based on the time deviation between the expected response time and the participant's actual response time. The expected response time was derived from the timepoint at which the participant started the stop-clock and the period of time the participant was instructed to wait until completing the task. The time deviation was used to classify each response into one of seven completion timeframes: *early* (> 2 min); *correct* (± 2 min); *little late* (2-5 min); *late* (5-10 min); *very late* (>10 min); *forgotten* (participant started the stop-clock, but never completed the quiz); and *missed* (participant did not engage with the task, i.e., did not start the stop-clock or complete the quiz). Using this categorisation of each response, response proportions were calculated for each participant as well as for each age group overall.

Various procedural errors were apparent including several instances where participants chose a time-elapsed period that differed to the period specified in the alert (e.g., the participant was instructed to complete a quiz in 15 minutes, but s/he selected 10 minutes when starting the stop-clock). It is unclear why this occurred, as it could be due to a number of possibilities. Perhaps the participants did not take enough care when selecting the option on the touchscreen, or they may have chosen a shorter time period because they did not want to wait as long as instructed, or perhaps it reflects poor or inaccurate encoding of the task. For scoring purposes, the instructed time-elapsed period which featured in the alert was used to determine the expected response time, regardless of which time-elapsed period the participant selected. For instance, if at 2 p.m. a participant selected "10 minutes" when starting the stop-clock instead of "15 minutes" as instructed, and then completed a quiz at 2:19 p.m., this response would be scored as 4 minutes late rather than 9 minutes late.

Another procedural error apparent while scoring involved cases where participants failed to start the stop-clock before completing a quiz. This was addressed when scoring through a process whereby, where possible, task performance in these instances was determined by using the alert timing and the participant's response time. For example, if a participant was sent an alert at 6 p.m. with instructions to "Start the clock now, then complete a quiz in 15 minutes," and the participant did not start the stop-clock, but did complete a quiz at 6:14 p.m., this was scored as a *correct* response. Even without the stop-clock timestamp, it is not possible for this response to be late given that the alert was sent less than 15 minutes prior to task completion. However, it could be argued that perhaps the participant did not see the alert until 6:10 p.m.; the response would be quite early in this case, rather than correct. To ensure that the scoring of such responses would not inflate the overall proportions of correct responses, PM performance was additionally assessed using strict criteria, whereby only the responses that completely complied with task instructions (i.e., the stop-clock was started and the instructed time-elapsed period was selected) were included in data analyses.

Development Considerations

Much effort was taken to make the Quiz app as user-friendly as possible. The font and response buttons were enlarged to facilitate the participants' navigation of the Quiz app. This was especially important for those older adults who had little or no experience with smartphones. All participants were given detailed guidelines, with minimal jargon, and these were accompanied by photos that outlined how to operate the smartphone to complete tasks (see Appendix C.4). These guidelines were designed to minimise any errors that could occur due to inexperience with smartphones and also unfamiliarity with the Quiz app. The quizzes were kept brief so that completing them would not be laborious. These quizzes provided an opportunity to investigate how location and ongoing tasks might relate to PM performance on time-based tasks, and also how these patterns might differ across age groups.

Chapter 5: Age-related Differences in Prospective Memory Performance across Task Types in both Laboratory and Naturalistic Settings – Study 2

5.1 Introduction

Initial investigations of age effects in PM utilised a number of assessment methods, conducted both in laboratory (Einstein & McDaniel, 1990) and naturalistic settings (Maylor, 1990). In the decades that followed, contrasting age differences in PM performance across settings have become well-established, with older adults exhibiting inferior performance in the laboratory, but equivalent or superior performance compared to young adults in naturalistic settings (Aberle et al., 2010; Henry et al., 2004; Kvavilashvili et al., 2013; Rendell & Craik, 2000; Rendell & Thomson, 1999; Schnitzspahn et al., 2011; Uttl, 2008). Many possible explanations for these paradoxical findings have been explored; however, adequate consideration has not yet been given to a potentially critical flaw in the existing comparisons of laboratory and naturalistic PM performances. In particular, PM performance across settings has been assessed on PM tasks that are quite dissimilar in terms of the type of PM cue and by extension the degree of environmental and contextual support available. The current study investigated the possibility that the comparison of PM performance on disparate tasks has contributed to the discrepancy between age differences in the laboratory and those in naturalistic settings, known in the literature as the age-PM paradox.

Within PM research, PM tasks are most commonly categorised by the nature of the target cue that signifies when the intended action is meant to be performed. Einstein and McDaniel (1990) proposed that PM tasks either require a response to a specific external event (i.e., event-based tasks) or require a response at a specific time or after a certain period of time has elapsed (i.e., time-based tasks). Event-based tasks have dominated PM research and are particularly abundant in laboratory studies. Although the vast majority of laboratory studies on PM and ageing have used event-based PM tasks to measure performance, nearly all of the naturalistic studies have measured performance using time-based PM tasks (Henry et al., 2004; Uttl, 2008). Specifically, scheduled time-based tasks (e.g., remembering to call the experimenter at 12 p.m.) have dominated naturalistic studies of PM. Thus, typical comparisons between laboratory and naturalistic PM performance have not matched PM tasks according to cue type. This is somewhat surprising given that event- and time-based PM tasks can vary in the level of cognitive demand placed upon individuals as well as the degree of environmental support available. Moreover, these tasks often require different intention retrieval processes for successful PM task completion. Therefore, it is reasonable to predict that the performance of event- and time-based PM tasks could be differentially influenced by age (Gonneaud et al., 2011; Kvavilashvili et al., 2009; Yang et al., 2013).

In his theory of memory and ageing, Craik (1986) proposed that memory performance is determined both by the environmental support available and the type of processing necessary to execute the task (Maylor et al., 2002). McDaniel and Einstein (2000) argued that event-based tasks rely less on self-initiated retrieval than time-based tasks since the target cue or event can automatically trigger intention retrieval. There is evidence to suggest that this spontaneous intention retrieval process is preserved in normal ageing (McDaniel & Einstein, 2011; Mullet et al., 2013). As such, age-related deficits are thought to be minimal on event-based PM tasks with salient, external cues (Einstein & McDaniel, 1990). Laboratory findings have shown that young adults outperform older adults on event-based tasks, but there are inconsistencies as to the magnitude of the age deficit (see Kliegel, Jäger, et al., 2008, for a meta-analysis on the moderating effect of cue focality). The prevailing literature suggests that age deficits on event-based laboratory tasks are minimised when intention retrieval can be achieved through spontaneous processes (Henry et al., 2004; Kliegel, Jäger, et al., 2008; Uttl, 2008). Proper comparison of PM performance across settings has not been possible for event-based tasks, however, because so few naturalistic studies have incorporated event-based tasks in its PM assessment (Bailey et al., 2010;

Cavuoto et al., 2015; Kvavilashvili et al., 2013; Kvavilashvili & Fisher, 2007; Masumoto et al., 2011; Niedźwieńska & Barzykowski, 2012; Rendell & Craik, 2000), and even fewer have done so using objective measures (Bailey et al., 2010; Cavuoto et al., 2015; Kvavilashvili & Fisher, 2007; Niedźwieńska & Barzykowski, 2012).

Thus far, only two studies have examined age differences in PM performance on event-based tasks using the same sample of young and older adults in both laboratory and naturalistic settings (Kvavilashvili et al., 2013; Niedźwieńska & Barzykowski, 2012). Kvavilashvili et al. (2013) found that young adults performed better than older adults on event-based tasks in the laboratory, but there was no difference in their performance on the naturalistic event-based task, where participants were asked to write the date and time on the upper-left corner of a questionnaire when completing it at home. Naturalistic performance in this case was determined by a single PM task. The findings of Niedźwieńska and Barzykowski (2012) are also in line with the age-PM paradox: age-related deficits were found in the laboratory, but not in the naturalistic setting. Niedźwieńska and Barzykowski (2012) additionally found that the magnitude of the age-related differences varied based on cue focality. For the naturalistic tasks, participants were asked to call the experimenter as soon as the weather map of Poland was displayed on the evening news (focal cue) and at the first mention of a Polish politician on the evening news (nonfocal cue). Each event-based PM task was to be completed a total of four times in the naturalistic portion of the study. The most demanding event-based tasks, those with nonfocal cues, produced the largest age deficit in laboratory performance, and yet produced no age difference in naturalistic performance. Moreover, older adults outperformed young adults on the naturalistic tasks with focal cues. Cue focality appeared to impact older adults' performance, but it did not significantly impact young adults' naturalistic performance. Niedźwieńska and Barzykowski (2012) proposed that while older adults' performance was influenced by factors that relate to the cognitive demand of the PM task, perhaps young adults' performance was influenced more by an unexamined aspect of naturalistic settings, such as the presence of real-life activities that potentially competed for their attention during the ongoing activity. Thus, the very limited naturalistic research suggests that there is no age deficit on event-based task performance in everyday life.

Following from Craik's cognitive ageing theory (1986) and the multiprocess framework of cue monitoring (McDaniel & Einstein, 2000), PM tasks that lack external cues or have low levels of environmental support are thought to be particularly challenging because they rely upon strategic monitoring processes for intention retrieval (Einstein & McDaniel, 2014). Such effortful monitoring draws upon attentional and working memory resources which have been found to decline with age (d'Ydewalle et al., 2001; McDaniel & Einstein, 2011; Park et al., 2002; Phillips et al., 2008; Shelton et al., 2011). Thus, age deficits in PM are thought to be quite pronounced when the PM task lacks an explicit cue or has low environmental support. Laboratory findings support this claim as age deficits have been more consistently demonstrated on time-based tasks than on event-based tasks (d'Ydewalle et al., 2001; Einstein et al., 1995; Henry et al., 2004; Park et al., 1997; Phillips et al., 2008; Rendell & Craik, 2000). However, no such age deficit has been found on time-based tasks in naturalistic settings (Henry et al., 2004; Kvavilashvili & Fisher, 2007; Niedźwieńska & Barzykowski, 2012; Rendell & Thomson, 1999; Schnitzspahn et al., 2011). If time-based tasks require the use of cognitive resources known to decline with age and are considered to be more cognitively demanding than event-based tasks, then why are older adults not performing worse than young adults on time-based tasks in naturalistic settings? As highlighted earlier, one possibility is that the time-based tasks customarily used in laboratory assessments are fundamentally different to the scheduled time-based tasks used in naturalistic assessments of PM. Once again, the performance comparison of disparate tasks could be contributing to the discrepancy in age effects on time-based tasks.

In the laboratory, the performance of time-based PM tasks is primarily measured using time-check tasks (e.g., remembering to press the space bar in 3 minutes). Time-check tasks lack both an external cue and environmental support. As such, time-check tasks are thought to rely on effortful monitoring processes for intention retrieval (d'Ydewalle et al., 2001; Martin et al., 2003). In contrast, when scheduled time-based tasks are performed in naturalistic settings, they are less abstract and are often accompanied by considerable environmental and contextual support (Uttl, 2008). For example, the PM task occurs within the context of participants' everyday lives, and participants also have the opportunity to connect the PM task to their daily routine by performing the scheduled time-based task in conjunction with another activity (Maylor, 1990; Rendell & Thomson, 1999). Maylor (1990) found that older adults' naturalistic PM performance of scheduled time-based tasks improved when they used conjunction cues. Additionally, Kvavilashvili and Fisher (2007) found that the intention retrieval of scheduled time-based tasks in naturalistic settings were mediated more by automatic processes than by effortful monitoring processes, and also reported no age difference in the performance of these tasks. Thus, it is argued that scheduled time-based tasks possess an event-like quality, especially in naturalistic settings, due to the available environmental support and the potential to associate the task with external cues. This raises the possibility that scheduled time-based tasks could be completed through both spontaneous intention retrieval processes and strategic monitoring processes. This event-like quality could enhance the encoding and retrieval of the PM intention, and subsequently facilitate the execution of scheduled time-based tasks in everyday life. As the distinction between time-check tasks and scheduled time-based tasks proposed in this thesis has not yet been established in the PM literature, existing studies can only provide limited insight as to how the PM performance on these two variants might also be differentially influenced by age. Therefore, it is crucial to investigate age differences on both variants of time-based tasks across settings in an attempt to resolve the age-PM paradox.

The laboratory measure used in the current study, Virtual Week (Rendell & Craik, 2000), incorporates all three PM tasks of interest which vary by cue type (i.e., event-based, scheduled time-based, and time-check tasks). Virtual Week also evaluates PM performance using simulations of daily activities (e.g., taking medication at mealtime and attending appointments at set times). Contextual cues are provided as well in an effort to make the PM tasks less abstract. As noted in the previous chapter, this version of Virtual Week does not have a manipulation of cue focality, but it does include PM tasks that vary in regularity. Varying the regularity of the embedded PM tasks can clarify whether poor PM performance is related to difficulties in the encoding of the intention or difficulties in intention retrieval (Foster et al., 2013). Extensive laboratory research has shown worse performance on irregular tasks compared to regular tasks (Rendell & Craik, 2000; Rendell & Henry, 2009). The regularity distinction in Virtual Week is argued to reflect demands on retrospective memory because regular tasks are learned to criterion, practised during the trial day, and involve fewer cue-action pairings to learn compared to irregular tasks (Foster et al., 2013). Irregular tasks are thought to place more demands on the retrospective memory component of PM task completion, which causes a high monitoring load (Aberle et al., 2010; Rendell & Henry, 2009). Thus, irregular tasks require more effortful retrieval given that the PM intentions are not as strongly encoded compared to those of regular tasks (Rose et al., 2010). Irregular tasks also have the potential to elicit age-related deficits. To create event-based tasks that were comparable to those in Virtual Week, task regularity was incorporated into the naturalistic event-based tasks. However, task regularity was not included as a variable within the naturalistic measure of scheduled time-based tasks due to constraints in the timing of both naturalistic time-based tasks. The current study is the first to examine the effects of task regularity in a naturalistic setting.

The main focus of the present study is to investigate whether the lack of task comparability across settings could contribute to the age-PM paradox. However, there is also the possibility that age differences in the cognitive processes involved in PM could be a factor in the dissociation of PM performance across settings. Age differences in encoding abilities and retrieval processes have been suggested to influence PM performance (Ellis & Kvavilashvili, 2000). Craik and Rose (2012) suggested that the reduced processing capabilities of older adults result in less detailed and less intricate formation of PM intentions. However, the encoding of PM intentions is potentially influenced by the setting in which it occurs, be it laboratory or naturalistic. Environmental and contextual cues can support not only the retrieval of PM intentions, but also the encoding of them (Craik & Rose, 2012). This is especially relevant for event-based and scheduled time-based tasks in naturalistic settings, where the target cues are often supplemented by the rich, environmental support readily available in everyday life. The external cues available are typically familiar as is the context in which they are likely to occur. For example, the PM task of remembering to take medication with breakfast or at 7 a.m. is accompanied by other contextual cues, such as a glass of orange juice or the newspaper one reads while eating breakfast at the kitchen table. Thus, the environmental and contextual support in naturalistic settings could allow older adults to encode PM intentions in greater detail and accuracy than is possible in the laboratory. Furthermore, it is possible that older adults' improved naturalistic performance pertains to having the opportunity to engage in deliberate planning of their PM intentions over the longer timeframe allotted in most naturalistic measures of PM (Dixon et al., 2007). The encoding benefits of the environmental support available in everyday life should facilitate PM performance for both age groups. However, there is some evidence to suggest that young adults may lack the metacognitive awareness to realise the need for more detailed encoding of PM intentions in naturalistic settings (Schnitzspahn et al., 2011).

A secondary aim of the current study was to investigate the impact of an encoding strategy, known as implementation intentions, on PM performance in order to assess the extent to which the perplexing pattern of age differences across settings reflects encoding difficulties. The implementation intentions encoding strategy, as outlined earlier, is thought to strengthen the association between the cue and the intended action (Chasteen et al., 2001; Gollwitzer, 1999; McFarland & Glisky, 2011, 2012). The strategy is relatively straightforward to implement, and it involves encoding the PM intention in a specific format while visualising task completion (Gollwitzer, 1999). For example, participants would say, “When it is breakfast, I will take my medication,” and would then visualise the execution of this intention in great detail. While the exact mechanism of action underlying implementation intentions has not yet been determined (see Chen et al., 2015), one proposal is that this strategy promotes PM performance through automatic detection of target cues and spontaneous intention retrieval processes (McFarland & Glisky, 2012; Zimmermann & Meier, 2010). Implementation intentions has been found to improve PM performance on a variety of laboratory tasks in both young and older adults (Chasteen et al., 2001; Gollwitzer & Sheeran, 2006; Lee et al., 2015; McFarland & Glisky, 2011, 2012; Schnitzspahn & Kliegel, 2009; Zimmermann & Meier, 2010). Although use of implementation intentions has demonstrated benefits in real-life health contexts (Liu & Park, 2004; Orbell, Hodgkins, & Sheeran, 1997), its effectiveness on everyday PM performance, as well as its impact on age differences across settings, has yet to be determined. The current study is the first to examine the impact of implementation intentions on PM performance in both the laboratory and naturalistic settings.

A further difficulty in clarifying the contrasting age effects across settings is that most studies of PM and ageing not only fail to match PM tasks, but they also use different participant samples in each setting (Phillips et al., 2008; Will et al., 2009). Hence, the disparity between the age differences could potentially be attributed to differences between the samples. Thus far, only four PM studies have investigated age differences using the same sample of young and older adults in both the laboratory and naturalistic settings

(Kvavilashvili et al., 2013; Niedźwieńska & Barzykowski, 2012; Rendell & Thomson, 1999; Schnitzspahn et al., 2011). Each of these studies found an age deficit in the laboratory, and either no age effect or an age benefit in naturalistic settings. However, the studies that compared time-based PM performance across settings, did so using time-check tasks in the laboratory while using scheduled time-based tasks in everyday life as is customary in the literature (Niedźwieńska & Barzykowski, 2012; Rendell & Thomson, 1999; Schnitzspahn et al., 2011). The current study is the first to systematically investigate age differences on all three types of PM tasks using the same participant sample in laboratory and naturalistic settings.

The primary aim of the current study was to determine whether the use and comparison of disparate PM tasks across settings has contributed to the age-PM paradox. In other words, will the age differences in laboratory PM performance resemble the age differences in naturalistic PM performance when the PM cue type is taken into consideration? For the purpose of this investigation, objective naturalistic measures of PM were developed for the three types of PM tasks considered. Based upon the existing literature, it was predicted that young adults would outperform older adults in the laboratory on all PM tasks (Henry et al., 2004). However, it is difficult to predict the age pattern for naturalistic PM performance, due to the lack of distinction between the two time-based task variants in the current literature and the limited number of naturalistic studies that include event-based or time-check tasks. Thus, several alternative predictions regarding the naturalistic performance were put forth based upon the limited existing literature as well as the multiprocess model of PM (McDaniel & Einstein, 2000).

The first prediction was that once the methodological issues were addressed by comparing performance on analogous PM tasks, it was expected that the same age pattern would emerge in the naturalistic setting as in the laboratory, thereby eliminating the age-PM paradox. Another possibility is that the age-related benefits observed thus far in naturalistic studies can be attributed to the event-like quality of scheduled time-based tasks in everyday life. This event-like quality could benefit older adults in a number of ways, such as allowing for the use of contextual cues and environmental support to facilitate spontaneous intention retrieval, rather than relying on effortful and resource-demanding monitoring processes. Thus, the second alternative prediction was that if the event-like quality of a PM task is an important factor in older adults' naturalistic PM performance, then it was expected that age differences would be minimal on event-based tasks, small to moderate on scheduled time-based tasks, and greatest on time-check tasks. Furthermore, since time-check tasks do not possess an event-like quality and are subsequently unable to be supported by contextual cues even in a familiar environment, it was expected that young adults would outperform older adults on time-check tasks. Lastly, a further possibility is that the age-related benefits in naturalistic settings may reflect general advantages provided by everyday life. In this regard, being in a familiar environment or having more time to encode PM intentions could contribute to older adults' improved performance in naturalistic settings. Thus, the third alternative prediction was that older adults would demonstrate a global improvement on all PM tasks in naturalistic settings, including time-check tasks.

The secondary aim of the study pertained to the possibility that varying encoding abilities has contributed to the age-PM paradox. Older adults' improved performance in naturalistic settings could be influenced by enhanced encoding techniques made possible by the many environmental supports that are typically absent in laboratory paradigms. Previous research has shown that both young and older adults benefit from engaging in more detailed encoding of their PM intentions (Gillholm et al., 1999; Niedźwieńska et al., 2013) and from the use of the implementation intentions encoding strategy (Burkard et al., 2014; Chasteen et al., 2001; Chen et al., 2015; Gollwitzer & Sheeran, 2006; McFarland & Glisky, 2011, 2012; Meeks, Pitães, & Brewer, 2015; Schnitzspahn & Kliegel, 2009; Zimmermann & Meier, 2010). If differences in encoding abilities have contributed to the age-PM paradox, then the use of the implementation intentions encoding strategy could eliminate the discrepancy between the age differences in laboratory and naturalistic PM performance. Implementation intentions could potentially be more effective for reducing age differences on PM tasks with an explicit cue and possibly those with substantial environmental support, such as event-based and scheduled time-based tasks, as the strategy is thought to strengthen the association between the target cue and the intended action. Therefore, the implementation intentions encoding strategy is not predicted to improve PM performance on time-check tasks.

The Current Research

The current study aimed to address whether the lack of task comparability across settings has influenced the paradoxical findings of contrasting age differences observed in laboratory and naturalistic settings. Significant advancements were made to naturalistic studies of PM as novel naturalistic measures were developed to examine PM performance on event-based, scheduled time-based, and time-check tasks. The study is the first such systematic assessment of PM performances to be conducted across settings using the same sample of young and older adults. Consistent with the existing literature, age-related deficits were expected on all laboratory PM tasks. Using the multiprocess framework of PM and the existing, but limited, naturalistic research, several alternative predictions were made regarding PM performance in everyday life. Additionally, the current study investigated the effects of the implementation intentions encoding strategy on PM performance in both settings in order to examine the influence that encoding difficulties have potentially had on the age-PM paradox.

5.2 Method

Participants

Forty-one young adults (aged 19-30 years) and 53 older adults (aged 65-86 years) participated in the study. Young adults were recruited through the general community and the School of Psychology at Australian Catholic University. The young adult sample consisted of both undergraduate students (*n* = 25) and young professionals (*n* = 16). Older adults were community dwelling, and were recruited through the general community via recruitment flyers placed in recreation facilities, churches, the University of the Third Age, and a Probus group. Participants received $30 for their participation with the exception of the undergraduate students who obtained partial course credit for their participation. Of the young adult sample, one student participant was excluded based on age (older than 30 years). Exclusion criteria for the older population were based on age (at least 65 years) and a minimum score of 24 (out of 30) on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975). Twelve older adults were excluded: five declined to participate in the naturalistic portion, five completed less than one day of the naturalistic portion, and two were excluded due to current neurological conditions.

Characteristics of the study sample are summarised in Table 5.1. Consistent with previous research on ageing (Rendell, McDaniel, Forbes, & Einstein, 2007), older adults had a higher estimated IQ compared to young adults despite having had fewer years of formal education. The age groups did not differ on levels of anxiety or depression, self-ratings of health, or gender composition. Young adults reported using smartphones and tablets substantially more often than older adults.

Table 5.1

Characteristics of Participants

	Young Adults n = 40		Older Adults n = 41		t-test (df = 79)[a]		
Characteristic	*M*	*SD*	*M*	*SD*	*t*	*p*	*d*
Age (in years)	24.13	3.63	71.61	4.86			
Education (in years)	16.34	2.61	14.55	3.04	2.84	.01	0.63
Full Scale IQ[b]	103.13	9.44	111.67	6.86	4.66	< .001	1.03
Anxiety[c]	5.53	3.70	5.05	2.99	0.64	.53	0.14
Depression[c]	2.30	2.26	1.95	1.41	0.83	.41	0.19
Self-rated Health[d]							
Over last month	3.95	0.88	3.95	0.71	0.01	.99	< 0.01
Day of testing	4.08	0.86	3.90	0.80	0.94	.35	0.21
Dementia Screening[e]	–	–	29.07	0.93			
	%		%		X^2	*p*	
Sex					0.45	.51	
Male	25.0		31.7				
Female	75.0		68.3				
Smartphone Usage					35.99	< .001	
Never	2.5		46.3				
Weekly	–		7.3				
Every other day	–		2.4				
Once daily	–		9.8				
At least twice daily	97.5		34.1				
Tablet Usage[f]					14.25	.01	
Never	15.0		43.9				
Weekly	37.5		7.3				
Every other day	7.5		4.9				
Once daily	15.0		12.2				
At least twice daily	22.5		19.5				

Note. Cohen's *d* effect sizes: 0.2 = small; 0.5 = medium; 0.8 = large (Cohen, 1988) for independent *t*-tests. [a]Equal variances were not assumed for Depression; df = 65.27. [b]Full Scale Intelligent Quotient as estimated from the error score on the National Adult Reading Test. [c]Anxiety and Depression scores from the Hospital Anxiety and Depression Scale. [d]Self-rated health as measured on a 5-point scale: 1 = poor; 2 = not very good, 3 = good; 4 = very good; 5 = excellent. [e]Mini-Mental State Examination score; inclusion score $\geq$ 24. [f]Initial version of the questionnaire did not ask about tablet usage. Missing data for n_{young} = 1 and n_{older} = 5.

This study utilized a mixed design to investigate the effect of age, encoding condition, and, where applicable, task regularity on PM performance in both laboratory and naturalistic settings. PM performance in the laboratory was measured using a brief, computerised version of Virtual Week (Rendell & Craik, 2000). For event-based tasks, a novel approach was taken to capture PM performance in the naturalistic setting by utilizing the camera function of smartphones. A new smartphone application was developed to measure PM performance on both time-based task variants in the naturalistic setting (see Section 4.3).

Materials

Information letter and consent form. At the start of each testing session, participants were given an information letter that described the nature of the study (see Appendix A.2). Upon agreement to participate, informed consent forms were signed by both the participant and the researcher (see Appendix A.3). One copy of the form was kept by the researcher while the other copy was given to the participant.

Background questionnaire. Participants completed a background questionnaire (see Appendix B.2) for the purpose of collecting demographic information to characterise the sample. The background questionnaire included questions regarding participants' age, gender, education, neurological conditions, use of visual or hearing aids, as well as the use of smartphones and tablets. Those who reported using a visual or hearing aid were instructed to use the aid throughout the testing session.

Mood states. The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) was used to assess state anxiety and depression as experienced over the past week. It is a 14-item self-report scale; half of the items relate to anxiety and half relate to depression (see Appendix B.3). Participants rated items on a 4-point Likert scale. Both of the subscales range in scores from 0-21 with higher scores indicating greater symptom severity. Subscale scores are interpreted in ranges: normal levels of anxiety/depression (0-7), borderline abnormal levels of anxiety/depression (8-10), and abnormal levels of anxiety/depression (11-21). Both the anxiety and the depression subscales were found to have good reliability (α = .83 and α = .82 respectively) with a mean correlation of .56 (Bjelland, Dahl, Haug, & Neckelmann, 2002).

Estimated intelligence. The National Adult Reading Test (NART; Nelson, 1982) was used as a measure of estimated verbal intelligence (see Appendix B.4). It is a word-recognition test that requires participants to read aloud 50 irregular English words which do not follow normal phonetic rules (e.g., ‘heir’). The high correlation between reading ability and verbal intelligence allows for an estimated Wechsler Adult Intelligence Scale-Revised Full-Scale IQ to be acquired on the basis of total number of correct word pronunciations (Bright et al., 2002). Internal reliability has been estimated to be between .90 and .93 (Crawford et al., 1989) for this widely-used measure.

Global cognition. The Mini-Mental State Examination (MMSE) is a tool commonly used to assess five domains of cognitive functioning: orientation, registration, attention and calculation, recall, and language (Folstein et al., 1975). It served as a screening tool for dementia and mild cognitive impairment in the geriatric population. The 11 questions of the MMSE were administered to the older participants in approximately 5-10 minutes (see Appendix B.5). The maximum score possible on the MMSE is 30, and a score of 23 or lower indicates cognitive impairment (Mitchell, 2013). To be eligible to participate in this study, older adults had to obtain a score of at least 24; all participants in the study scored greater than 26. At a score of 27, the MMSE has a sensitivity of 79% and a specificity of 78% in relation to multiple-domain mild cognitive impairment (Pendlebury, Mariz, Bull, Mehta, & Rothwell, 2012).

Nominated activity list. A nominated activity list was created for the purpose of determining which naturally occurring events would be used as the cues for the naturalistic event-based tasks. The list comprised of common events and activities completed in everyday life which could be easily photographed (see Appendix C.3). Participants selected activities from the list that were extremely likely to occur over the three-day naturalistic study period of event-based PM tasks. Participants did not have access to the nominated activity list throughout the naturalistic study period.

Prospective memory measures.

Laboratory measure: Virtual Week. A brief, computerised version of Virtual Week (Rendell & Craik, 2000) was used as a measure of PM performance in the laboratory. For a detailed description of this measure and its development, see Section 4.1. For the current study, participants completed three virtual days: one practice day to ensure they understood the game's objectives, and two test days, which were used to measure PM performance. There were a total of 20 PM tasks to complete: eight event-based tasks (four regular, four irregular), eight scheduled time-based tasks (four regular, four irregular), and four time-check tasks (all regular).

Naturalistic measure of event-based tasks. A novel naturalistic measure of PM performance on event-based tasks was created for this study. For a detailed description of the measure and its development, see Section 4.2. Participants were to complete 12 event-based tasks in total (six regular, six irregular) over a three-day naturalistic study period. The PM task was to take a photograph of an event using the camera function on a provided smartphone. The specific events were determined by each participant using the nominated activity list during the testing session. The naturalistic measure was introduced during the testing session and participants practiced using the camera function on the smartphones on their own after receiving a demonstration.

Naturalistic measure of time-based tasks. A new smartphone application (referred to as the Quiz app) was created for the purpose of measuring PM performance on time-based tasks in naturalistic settings. For a more detailed description of the measure and its development, see Section 4.3. The application software was developed by Trevor Daniels in collaboration with the Cognition and Emotion Research Centre of the Australian Catholic University. Participants were to complete 12 time-based tasks (six scheduled, six time-check) over a three-day naturalistic study period. The PM task was to complete a very brief questionnaire using the Quiz app both at set times (scheduled time-based tasks) and after a certain time period had elapsed (time-check tasks). Participants' responses were recorded in real-time for verification of PM performance. The naturalistic measure was introduced during the testing session and participants practised responding to alerts and navigating the Quiz app on their own after receiving a demonstration.

Take-home guidelines. Guidelines regarding how to operate the smartphone in order to complete the naturalistic PM tasks were created. In consideration of participants who had less experience with smartphones, each instruction was written with minimal jargon and was accompanied by a photo of that step. The guidelines were used in the testing session when explaining the naturalistic tasks to the participants. Each participant's guidelines were marked to indicate the relevant study days as well as the expected date to return the smartphone. Two sets of guidelines were created to reflect the different instructions of each encoding condition (see Appendix C.4). The researcher's contact details were provided on the guidelines in case participants had any questions during the naturalistic portion of the study.

Smartphone. PM performance on naturalistic tasks was measured using smartphones. Ten smartphones (Optimus L3 II, model LG-E425f) and protective cases were purchased for use in this study. The devices operated on the Android™ 4.1 operating system; their dimensions were 6.11 cm (W) x 10.26 cm (H) x 1.19 cm (D). Each device featured an 8.13cm colour, touch screen and a 3.2 megapixel camera. The 1,540mAh lithium-ion battery in each smartphone provided 660 hours of stand-by time. The SIM cards did not contain any credit; therefore the smartphones were not able to make/receive phone calls. The homescreen on each smartphone included only the necessary applications in order to simplify its use for all participants. The chosen notification sound was 15 sec in duration and was set at a high volume to facilitate participants' perception. Each smartphone and each protective case was labelled with an identifying number and the researcher's contact information in case it was misplaced.

Procedure

Participants were tested individually in a 2-3 hour laboratory testing session followed by six days of naturalistic testing. The naturalistic period measured PM performance on event-based tasks over three days and PM performance on time-based tasks over an additional three days; the order of the naturalistic event- and time-based tasks measures were counterbalanced across participants. The laboratory testing session took place on the campus of the Australian Catholic University for all but two participants (one young adult and one older adult) who preferred to be tested at their homes. Participants were provided with breaks as needed throughout the testing session to minimise fatigue. At the onset of the testing session, participants were given a verbal description of the study in addition to the written information letter and informed consent. Consenting participants were then randomly assigned to an encoding condition which applied to both laboratory and naturalistic settings. Participants next completed the background questionnaire and the HADS. If the participant was an older adult, the MMSE was then administered. All participants subsequently completed the NART and their responses were recorded using a digital voice recorder to ensure accurate scoring.

The naturalistic measures were described to the participants and the take-home guidelines were introduced. The order of the instructions mirrored the order of the measures in the naturalistic study period. For example, if the participant was assigned to complete event-based tasks during the first three-day period, then the naturalistic event-based tasks were introduced and demonstrated before the naturalistic time-based tasks were introduced. Using the nominated activity list, participants determined which events or activities would be the cues for their naturalistic event-based tasks. Responses were clarified where necessary. The researcher demonstrated the functions necessary for task completion (i.e., how to respond to the alerts, how to use the camera function of the smartphone, and how to complete a quiz in the Quiz app). If the participant was assigned to the implementation intentions condition, additional instructions were provided on how to form the "When *X*, I will *Y*" statement and this was also reflected in the take-home guidelines. The researcher then programmed the smartphone's alert schedule during a planned testing break.

Following the break, participants were introduced to Virtual Week. Participants were taken through one practice day by the researcher to allow the participants to get accustomed to the game. During the practice day, participants were encouraged to ask any questions to ensure they understood the tasks required. For those in the implementation intentions condition, the practice day included additional instructions for encoding the PM tasks. The researcher ensured that participants used this encoding strategy correctly throughout the game. After completing the practice day, the participants completed two test days on their own with the researcher observing from a distance.

The naturalistic measures were then reintroduced and the participants practiced operating the smartphone, responding to alerts, and using both the camera function and the Quiz app until they felt comfortable. Participants were reminded that they could contact the researcher at any point over the naturalistic period if they had questions. Participants were shown how to charge the smartphone with the provided wall charger in case the battery ran low. The smartphones typically needed to be charged once during the naturalistic period. Participants who did not live close to the university were given a pre-paid, pre-addressed padded envelope to return the smartphone and charger to the researcher upon study completion. Data were extracted upon receipt of the smartphone.

5.3 Results

All statistical analyses were conducted using IBM SPSS version 22 software. Results are presented in subsections that correspond to the three PM tasks assessed (i.e., event-based, scheduled time-based, and time-check tasks). The primary analyses focused on age differences in PM performance separately for laboratory and naturalistic settings. Performance accuracy of the PM tasks, the dependent variable, was represented by the mean proportion of correct responses on the PM tasks. The mean proportion of missed responses on time-based tasks was used as another index of PM performance in the laboratory and was the dependent variable of additional analyses. *Age group* (young, older) and *encoding condition* (control, implementation intentions) were the between-groups variables. *Task regularity* (regular, irregular) was the within-group variable for analyses of event-based task performance, and for the analysis of laboratory PM performance on scheduled time-based tasks. The effect sizes of the analyses are represented as partial eta-squared (η_p^2). Cohen (1988) defines η_p^2 effect sizes of .01 as small, .059 as medium, and .138 as large. Two participants (one young adult and one older adult) were excluded from the analyses of laboratory performance as they did not complete the laboratory PM measure.

Event-based Tasks

Performance in laboratory setting. The effects of age group, encoding condition, and task regularity on PM performance were analysed in a 2 x 2 x 2 mixed factorial analysis of variance (ANOVA). There were 41 participants (20 young and 21 older adults) in the implementation intentions encoding condition, and 38 participants (19 young and 19 older adults) in the control condition. None of the two-way or three-way interaction effects were found (*ps* > .111). A large main effect of age group was found, F (1, 75) = 25.77, $p < .001$, $\eta_p^2 = .26$, with young adults ($M = .85$, $SD = .17$) performing more accurately on event-based tasks than older adults ($M = .55$, $SD = .34$). There was also a main effect of encoding strategy, F (1, 75) = 5.25, $p = .025$, $\eta_p^2 = .07$, with those using implementation intentions ($M = .76$, $SD = .26$) demonstrating superior performance than those using no strategy ($M = .63$, $SD = .35$). Task regularity did not have an effect on PM performance, F (1, 75) = 0.78, $p = .380$, $\eta_p^2 = .01$. Laboratory PM performance as a function of age group, encoding condition, and task regularity is shown in Figure 5.1.

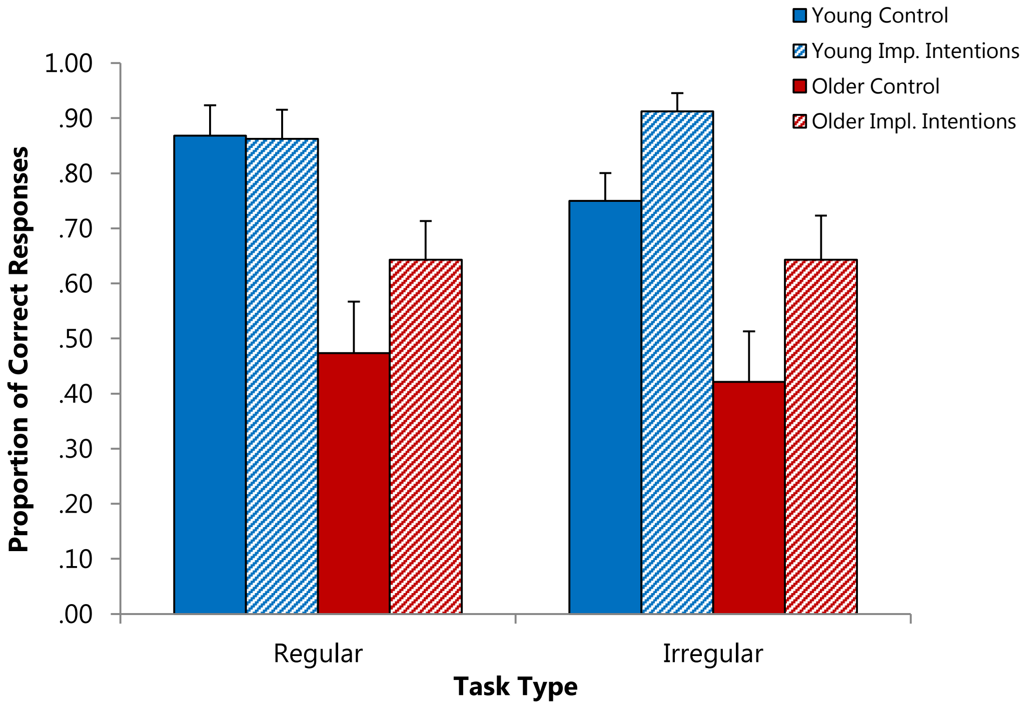

Figure 5.1. PM performance on laboratory event-based tasks: Mean proportion of correct responses as a function of age group, encoding condition, and task regularity. Error bars represent the standard error of the mean.

Performance in naturalistic setting. The photos captured for event-based task completion were classified according to the scoring criteria described earlier (see Section 4.2). To assess the reliability of the researcher's scoring, a second independent researcher who was blind to the experimental conditions classified the photos taken by a subset of 25 randomly selected participants. Inter-rater reliability was computed using Siegel & Castellan's (1988) variant of Cohen's kappa (1960) as the scoring was nominal and the design used a fully-crossed sample. Analyses for each event-based task yielded kappa values between 0.84 and 1.00, indicating excellent inter-rater reliability (Hallgren, 2012).

A 2 x 2 x 2 mixed factorial ANOVA was conducted to examine the effects of age group, encoding condition, and task regularity on PM performance. One older participant was excluded from the analyses due to incompletion of the event-based portion of the naturalistic measure. There were 40 participants (20 young and 20 older adults) in the implementation intentions encoding condition, and 40 participants (20 young and 20 older adults) in the control condition. None of the two-way or three-way interaction effects were found (*p*s > .133). Age group had no effect on PM performance in the naturalistic setting on event-based tasks, F (1, 76) = 1.69, p = .197, η_p^2 = .02, with older adults (M = .75, SD = .20) performing comparably to young adults (M = .69, SD = .22). There were also no main effects of encoding strategy, F (1, 76) = 0.03, p = .863, $\eta_p^2 < .001$, or task regularity, F (1, 76) = 1.47, p = .229, η_p^2 = .02. Naturalistic PM performance as a function of age group, encoding condition, and task regularity is shown in Figure 5.2.

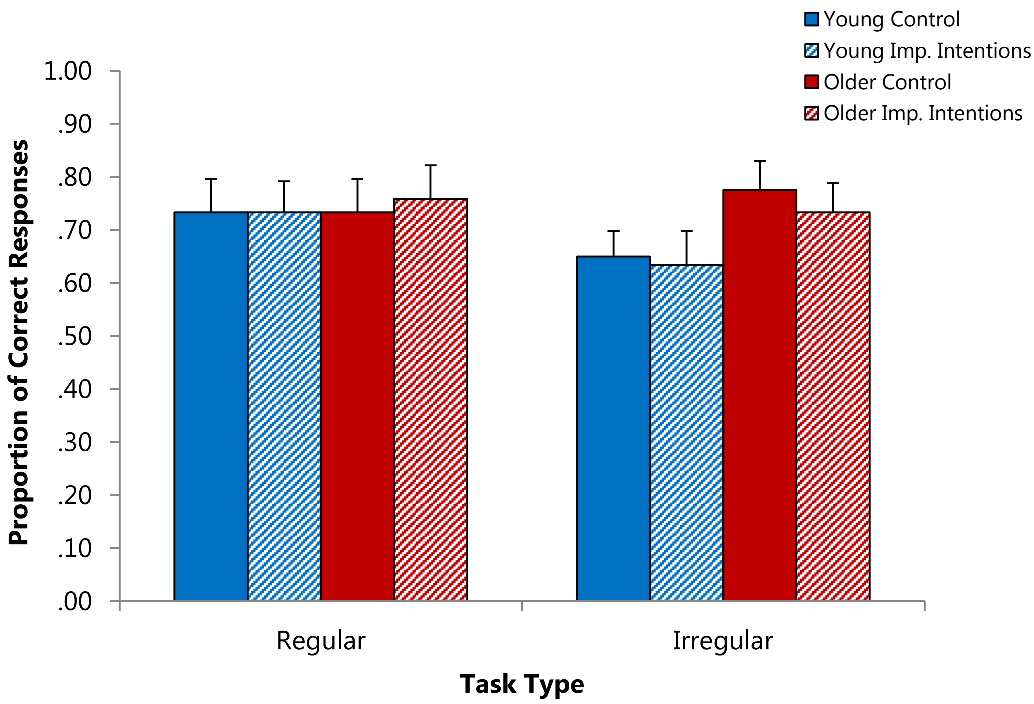

Figure 5.2. PM performance on naturalistic event-based tasks: Mean proportion of correct responses as a function of age group, encoding condition, and task regularity. Error bars represent standard error of the mean.

Descriptives for response categories. The mean proportions of responses according to the scoring criteria for the naturalistic event-based tasks are displayed in Table 5.2. This table shows that young and older adults made similar types of errors. Responses were scored as *missed* if there was no photo at all pertaining to the nominated event. Photos that indicated a forgotten intention (e.g., photo was of a note that said, “Forgot to take a photo of lunch”) were classified as *remembered forgetfulness*. Photos were scored as *contrived* if the photos were made to look as if the task was correctly completed, but the timestamp or other features indicated otherwise. An example of a contrived photo is a photograph of dinner at 8 p.m. trying to be passed off as the daily lunch photo. The *reminded by another task* category included photos that were taken within one minute of another task’s photo. For instance, if the participant took a photo of taking medication and less than a minute later the participant took a photo of watering the garden, the first photo was scored as *correct* while the second photo was scored as *reminded by another task* since it is likely that the completion of the first task prompted the participant to complete the other task. The *unable to take photo* category included photos of written notes where the participants stated either that the event did not occur that day or that the participants remembered their intention while engaged in the activity but was unable to take a photo at the time (e.g., photo of a note indicating the participant did not attend sociology class that day). The development of the scoring criteria is described in Section 4.2.

Table 5.2

Proportion of Naturalistic Event-based Task Responses based on Scoring Categorisation

	Young Adults		Older Adults	
	Control	Implementation Intentions	Control	Implementation Intentions
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Correct	.69 (.21)	.68 (.24)	.75 (.20)	.75 (.21)
Missed	.14 (.16)	.18 (.19)	.16 (.17)	.15 (.19)
Remembered Forgetfulness[a]	.05 (.06)	.07 (.08)	.01 (.03)	.01 (.04)
Contrived[b]	.05 (.07)	.04 (.05)	.05 (.09)	.04 (.08)
Reminded by Another Task[c]	.05 (.08)	.02 (.04)	.02 (.04)	.04 (.06)
Unable to Take Photo[d]	.01 (.03)	.00 (.02)	.00 (.00)	.01 (.03)

Note. Scoring categorisations described in detail in above text.
[a]Photos in this category indicated a forgotten intention. [b]Photos were made to look as though the tasks were correctly completed, but were in fact staged. [c]Photos were taken less than one minute after another task's photo. [d]Photos in this category indicated that either the event did not occur that day or the participant was unable to take a photo at the time.

Scheduled Time-based Tasks

Performance in laboratory setting. The effects of age group, encoding condition, and task regularity on PM performance were analysed in a 2 x 2 x 2 mixed factorial ANOVA. There were 41 participants (20 young and 21 older adults) in the implementation intentions encoding condition, and 38 participants (19 young and 19 older adults) in the control condition. No interaction effects were found (*p*s > .278). A large main effect of age group was found, F (1, 75) = 24.89, $p < .001$, $\eta_p^2 = .25$, with young adults ($M = .66$, $SD = .27$)

showing superior performance on scheduled time-based tasks compared to older adults (*M* = .37, *SD* = .25). Additionally, there was a large main effect of task regularity, *F* (1, 75) = 41.67, $p < .001$, $\eta_p^2 = .36$, with participants performing better on regular tasks (*M* = .63, *SD* = .34) than irregular tasks (*M* = .39, *SD* = .33). There was no effect of encoding condition on performance, *F* (1, 75) = 0.83, $p = .365$, $\eta_p^2 = .01$. Laboratory PM performance as a function of age group, encoding condition, and task regularity is depicted in Figure 5.3.

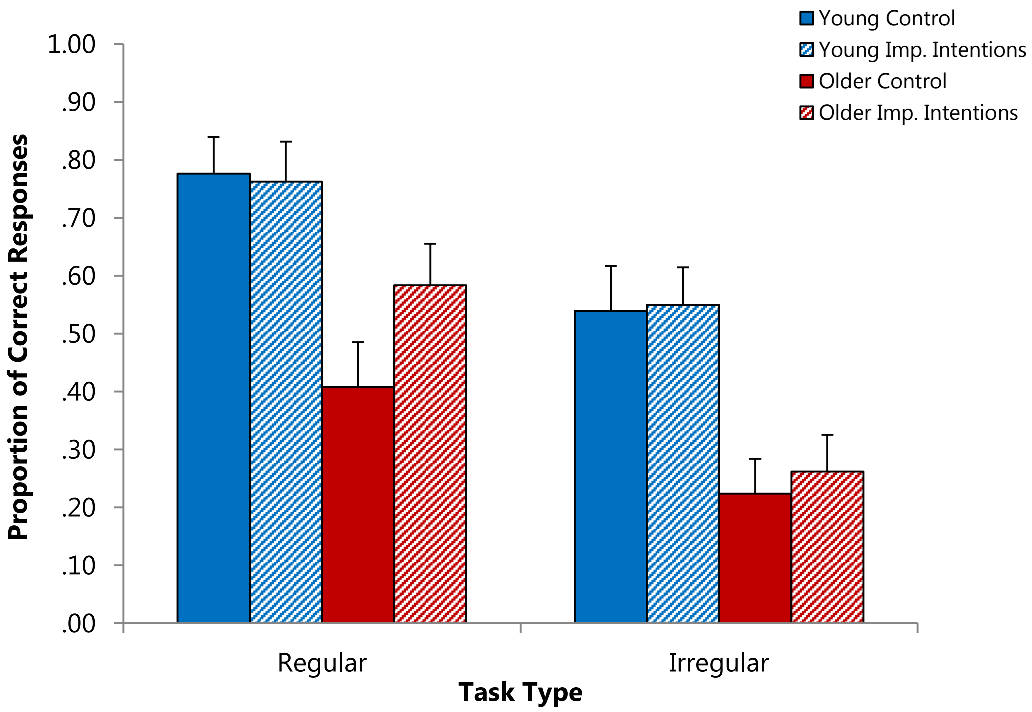

Figure 5.3. PM performance on laboratory scheduled time-based tasks: Mean proportion of correct responses as a function of age group, encoding condition, and task regularity. Error bars represent standard error of the mean.

Performance in naturalistic setting. Performance accuracy was determined by the timestamps which accompanied each response. Responses were correct if the quizzes were completed within 5 minutes before or after the target time. For further clarification of the scoring criteria, see Section 4.3. A two-way ANOVA was conducted to examine the effects of age group and encoding condition on PM performance. Two participants were excluded from the analyses of naturalistic performance on time-based PM tasks: one older participant ceased participation prior to the time-based portion of the naturalistic measure; the data of one young participant were excluded due to timing confusions resulting from daylight-savings time change. There were 40 participants (19 young and 21 older adults) in the implementation intentions encoding condition, and 39 participants (20 young and 19 older adults) in the control condition. A large main effect of age group was found, F (1, 75) = 15.47, $p < .001$, $\eta_p^2 = .17$, but the relationship between age group and performance was in the opposite direction than the relationship found in the laboratory. Older adults demonstrated superior performance on scheduled time-based tasks compared to young adults ($M = .65$, $SD = .27$ and $M = .39$, $SD = .30$ respectively) in naturalistic settings. Encoding condition was not a main effect, F (1, 75) = 1.46, $p = .230$, $\eta_p^2 = .02$, and did not interact with age group, F (1, 75) = 0.59, $p = .445$, $\eta_p^2 = .01$. The implementation intentions encoding strategy did not significantly improve performance in naturalistic settings.

Further analyses were conducted using the proportion of missed responses as an index of PM performance. Missed responses included tasks that were not completed at all or were completed > 60 minutes late. A two-way ANOVA was again employed to investigate the effects of age group and encoding strategy on PM performance. There was no interaction effect between age group and encoding condition, F (1, 75) < 0.01, $p = .983$, $\eta_p^2 < .01$. There was a large main effect of age group, F (1, 75) = 12.43, $p = .001$, $\eta_p^2 = .14$, with young adults ($M = .23$, $SD = .24$) missing significantly more scheduled time-based tasks than older adults ($M = .08$, $SD = .14$). Encoding condition again had no main effect on performance, F (1, 75) = 0.28, $p = .597$, $\eta_p^2 < .01$. The PM performance on naturalistic scheduled time-based tasks as represented by both the proportions of correct responses and missed responses is displayed in Figure 5.4.

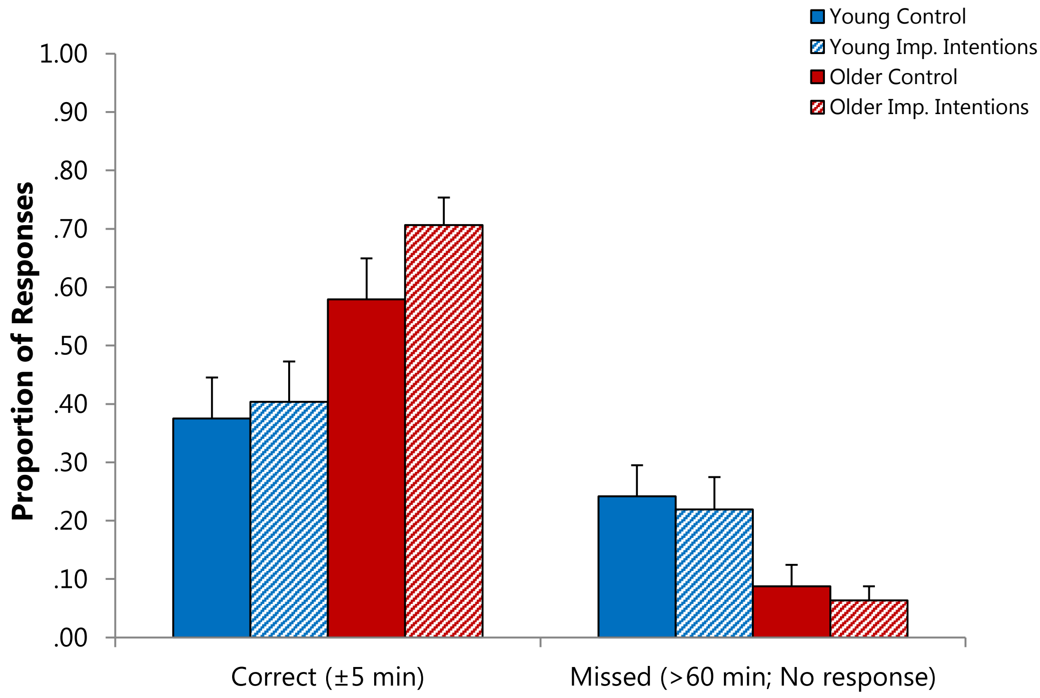

Figure 5.4. PM performance on naturalistic scheduled time-based tasks as a function of age group and encoding condition. Error bars represent standard error of the mean.

The average time deviation was calculated for all scheduled time-based tasks completed within 60 minutes of the target time. Another two-way ANOVA was conducted to examine the effect of age group and encoding strategy on the average time deviation. There was a large main effect of age group, F (1, 75) = 12.32, p = .001, η_p^2 = .14, with older adults deviating less from the scheduled time than young adults (in min:s; M = 06:59, SD = 06:24 and M = 15:26, SD = 13:36 respectively). Again, there was no interaction effect and also no effect of encoding condition on PM performance (ps < .310).

Pattern of errors. Although participants were to schedule their two scheduled time-based tasks upon receiving the 9 a.m. alert each day, some participants were very late in responding. This varied by age group: 30% of young adult responses and 11% of older adult responses were made more than an hour after the alert. Each PM task completion was categorised by the timeliness of participants' response. The pattern of response errors across all completion timeframes are presented in Table 5.3.

Table 5.3

Mean Proportions of Response Errors for Naturalistic Scheduled Time-based Tasks (Standard deviation of the means in parentheses)

		Completion Timeframes			
Age Group	Encoding Condition	Early >15 min	Little Early 5-15 min	Little Late 5-15 min	Late 15-60 min
Young	Control	.01 (.04)	.01 (.04)	.12 (.14)	.25 (.20)
	Imp. Intentions	.08 (.16)	.04 (.09)	.11 (.15)	.16 (.14)
Older	Control	.04 (.09)	.01 (.04)	.20 (.18)	.07 (.10)
	Imp. Intentions	.02 (.07)	.02 (.06)	.13 (.14)	.06 (.10)

Time-Check Tasks

Performance in laboratory setting. The effects of age group and encoding strategy on PM performance of laboratory time-check tasks were analysed in a two-way ANOVA. There were 41 participants (20 young and 21 older adults) in the implementation intentions encoding condition, and 38 participants (19 young and 19 older adults) in the control condition. No interaction effect was found between age group and encoding condition, F (1, 75) = 0.18, p = .673, $\eta_p^2 < .01$. There was a main effect of age group, F (1, 75) = 6.70, p = .012, $\eta_p^2 = .08$, with young adults (M = .61, SD = .32) once again outperforming older adults (M = .41, SD = .37) in the laboratory. Encoding condition had no effect on performance of time-check tasks, F (1, 75) = 0.22, p = .644, $\eta_p^2 < .01$.

Further analyses were conducted using the proportion of missed responses as an index of PM performance. A two-way ANOVA was again employed to investigate the effects of age group and encoding strategy on PM performance. No interaction effect between age group and encoding condition was found, F (1, 75) = 0.60, p = .442, $\eta_p^2 = .01$. There was a main effect of age group, F (1, 75) = 5.40, p = .023, $\eta_p^2 = .07$, with young adults (M = .07, SD = .16) missing significantly less time-check tasks than older adults (M = .21, SD = .33). Encoding condition had no effect on PM performance, F (1, 75) = 1.10, p = .297, $\eta_p^2 = .01$. The PM performance on laboratory time-check tasks as represented by both the proportions of correct responses and missed responses is shown in Figure 5.5.

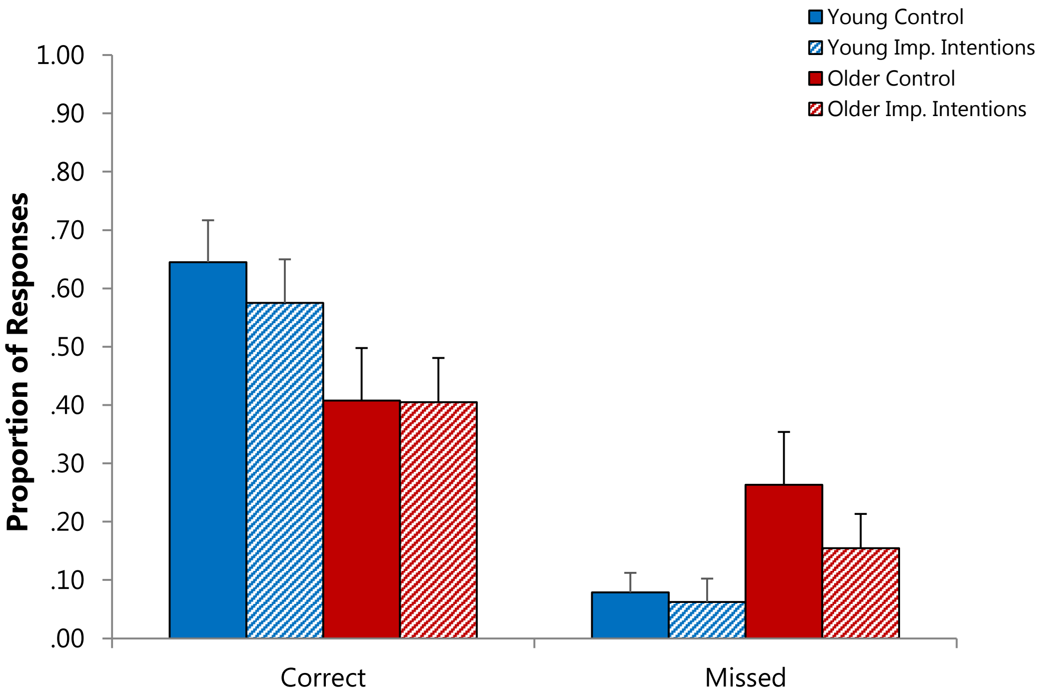

Figure 5.5. PM performance on laboratory time-check tasks as a function of age group and encoding condition. Error bars represent standard error of the mean.

Performance in naturalistic setting. The timestamps which accompanied each response verified the performance accuracy of the time-check tasks. Responses were correct if the quizzes were completed within 2 minutes either side of the target time. For the majority of responses, the target time was derived from the timepoint at which participants started the stop-clock and the instructed time-elapsed period pertaining to that given time-check tasks. However, in instances where the participants did not start the stop-clock before completing a quiz, the timing of the alert was used to score their performance. For example, if a participant did not initiate the stop-clock but did complete a quiz at 12:51 p.m. in response to an alert at 12:30 p.m. that had specified a time-elapsed period of 20 minutes, this response was scored as correct. For further clarification of the scoring criteria, see Section 4.3.

A two-way ANOVA was conducted to examine the effects of age group and encoding condition on PM performance. There were 40 participants (19 young and 21 older adults) in the implementation intentions encoding condition, and 39 participants (20 young and 19 older adults) in the control condition. There was no interaction effect between age group and encoding condition, F (1, 75) = 0.73, p = .395, η_p^2 = .01. There was also no main effect of age group, F (1, 75) < 0.01, p = .990, η_p^2 < .01, with young adults (M = .32, SD = .28) performing as poorly as the older adults (M = .32, SD = .31) on naturalistic time-check tasks. Encoding condition was also found to have no effect on PM performance, F (1, 75) = 0.12, p = .727, η_p^2 < .01.

In a separate two-way ANOVA, the proportion of missed responses was used as an index of PM performance. Missed responses included tasks that showed no participant engagement (i.e., no stop-clock initiated and no quiz completed). There was no interaction effect between age group and encoding condition, F (1, 75) = 0.19, p = .665, η_p^2 < .01. There was no main effect of age group, F (1, 75) = 3.39, p = .070, η_p^2 = .04, but there was a non-significant trend for older adults (M = .27, SD = .28) to miss a greater proportion of time-check tasks than young adults (M = .17, SD = .25). In all other cases of naturalistic PM performance, young adults either missed the same proportion of PM tasks as the older adults or they missed more tasks than the older adults. The time-check tasks appear to be quite unique from the other naturalistic tasks examined. Encoding strategy also had no effect on performance, F (1, 75) = 1.63, p = .205, η_p^2 = .02. The PM performance on naturalistic time-check tasks as represented by both the proportions of correct responses and missed responses is displayed in Figure 5.6.

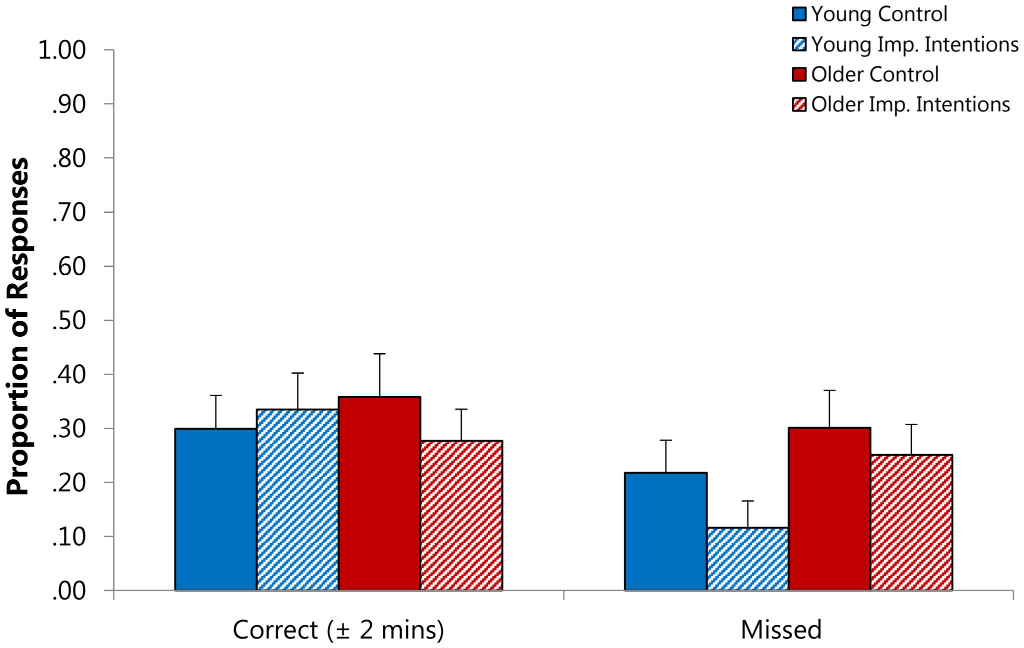

Figure 5.6. PM performance on naturalistic time-check tasks as a function of age group and encoding condition. Error bars represent standard error of the mean.

Pattern of errors. Each PM task completion was categorised by the timeliness of participants' response. The pattern of response errors across all completion timeframes are presented in Table 5.4. Procedural errors of task completion, such as failure to initiate the stop-clock feature and the incorrect selection of the time-elapsed period, accounted for 16% of young adult responses and 28% of older adult responses. However, the use of the timing of alerts, as mentioned earlier, permitted the scoring of most of these responses as either *early* or *correct*. Overall, the proportion of responses that were unable to be scored was similar across both age groups (4% of young adult responses and 5% of older adult responses).

Table 5.4

Mean Proportions of Response Errors for Naturalistic Time-Check Tasks (Standard deviation of the means in parentheses)

Age Group	Encoding Condition	Completion Timeframes: Early >2 mins	Little Late (2-5 mins)	Late (5-10 mins)	Very Late (>10 mins)	Forgotten[a]
Young	Control	.06 (.10)	.08 (.11)	.09 (.13)	.14 (.18)	.11 (.16)
	Imp. Intentions	.13 (.16)	.16 (.14)	.08 (.09)	.15 (.13)	.04 (.07)
Older	Control	.17 (.20)	.06 (.08)	.05 (.08)	.03 (.07)	.04 (.08)
	Imp. Intentions	.25 (.23)	.07 (.16)	.07 (.12)	.06 (.08)	.03 (.07)

[a]Forgotten timeframe indicates responses where participants started the stop-clock, but failed to complete the time-check task.

Performance using strict scoring criteria. The use of the alert timings in scoring participants' responses was only applicable for responses that could be categorised as *early* or *correct*. Responses that were late according to the alert timing were unable to be scored accurately; despite knowing that the 12:30 p.m. alert indicated a 20 minute time-elapsed period, it was unclear whether a response at 12:59 p.m. resulted from the participant not viewing the alert until 12:39 p.m. and the response is therefore *correct,* or if it is a late response that is late for some amount of time between 2-9 minutes. It could be argued that the previous scoring of time-check task performance was too generous and led to an underreporting of late responses. Further analyses were subsequently conducted to investigate whether the age pattern of PM performance would differ if more strict scoring criteria were employed.

A two-way ANOVA examined the effects of age group and encoding strategy on PM performance, however only the responses that were entirely compliant with procedural instructions (i.e., stop-clock was initiated and the correct time-elapsed period was selected) were included in the analyses. Compliant responses represented 68% of young adult responses and 48% of older adult responses overall. One young adult was removed from the sample as a result (young adults: n = 38; older adults: n = 40). There were 40 participants

(19 young and 21 older adults) in the implementation intentions encoding condition, and 38 participants (19 young and 19 older adults) in the control condition. Yet again, there was no interaction effect between age group and encoding condition, F (1, 74) = 1.07, p = .304, η_p^2 = .01. There was still no main effect of age group, F (1, 74) = 1.26, p = .266, η_p^2 = .02, with young adults (M = .27, SD = .27) performing as poorly as older adults (M = .35, SD = .35) on naturalistic time-check tasks. Encoding condition had no effect on PM performance, F (1, 74) = 0.01, p = .939, η_p^2 < .01.

Using the proportion of missed responses as an index of PM performance, another two-way ANOVA was conducted. To reiterate, missed responses indicated a lack of participant engagement (i.e., no stop-clock initiated and no quiz completed). No interaction effect was found between age group and encoding condition, F (1, 74) = 0.33, p = .566, η_p^2 < .01. There was a main effect of age group, F (1, 74) = 4.89, p = .030, η_p^2 = .06, with older adults (M = .37, SD = .35) missing more naturalistic time-check tasks than young adults (M = .21, SD = .31). However, since the strict scoring criteria resulted in the same number of missed responses but a decrease in the number of overall responses included, the proportions of missed responses were inflated. There was no main effect found for encoding condition, F (1, 74) = 1.22, p = .272, η_p^2 = .02.

Pattern of errors for compliant responses. To discern whether the strict scoring criteria would alter the pattern of error responses previously observed, the response errors of only compliant responses were considered. Each PM task completion was categorised by the timeliness of participants' response. The pattern of response errors for those responses that were compliant with procedural instructions are presented in Table 5.5. The one appreciable difference is that when only compliant responses were considered, older adults were less likely to complete the time-check tasks more than 2 minutes early. This is due to the exclusion of responses that were completed within 2 minutes of receiving the alert or starting the stop-clock, referred to in this thesis as *immediately executed* responses.

Table 5.5

Mean Proportions of Compliant Response Errors for Naturalistic Time-Check Tasks (Standard deviation of the means in parentheses)

		Completion Timeframes				
Age Group	Encoding Condition	Early >2 mins	Little Late (2-5 mins)	Late (5-10 mins)	Very Late (>10 mins)	Forgotten[a]
Young	Control	.04 (.08)	.11 (.17)	.10 (.12)	.14 (.19)	.10 (.16)
	Imp. Intentions	.10 (.16)	.14 (.15)	.10 (.11)	.17 (.15)	.04 (.09)
Older	Control	.04 (.10)	.10 (.15)	.04 (.10)	.01 (.05)	.01 (.06)
	Imp. Intentions	.11 (.16)	.07 (.16)	.08 (.14)	.05 (.10)	.02 (.06)

[a]Forgotten timeframe indicates responses where participants started the stop-clock, but failed to complete the time-check tasks.

Environmental influences. One possible explanation for the absence of an age deficit on time-check tasks is the potential difference between the age groups in terms of the context of their daily lives. To investigate the environmental influences of the daily lives of young and older adults, the location and ongoing activity at the time of task completion was further examined. The completion of each time-check task through the Quiz app included participants' self-report of their current location and activity. As this information was only provided upon task completion, there were no such data for *missed* and *forgotten* responses. The frequencies and proportions of the location responses at the time of time-check task completion are presented in Table 5.6. Both age groups most frequently reported being at "home" when completing the time-check tasks. The frequencies and proportions of the ongoing activity responses at the time of time-check task completion are presented in Table 5.7. Young adults most frequently reported being engaged in "work" or "relaxing/leisure" activities just prior to task completion, whereas older adults most frequently reported being engaged in "relaxing/leisure" activities or "chores/errands".

Table 5.6

Age Comparison of Participants' Location at Naturalistic Time-Check Task Completion

	Young Adults		Older Adults	
Location	Response Frequency	Overall Proportion	Response Frequency	Overall Proportion
Home	84	.49	110	.67
University	12	.07	0[a]	.00
Work	32	.19	6	.04
Out with Friends	25	.15	19	.12
Out by Myself	13	.08	17	.10
Family/Friend's Home	5	.03	11	.07
Total (*N* = 334)	171		163	

[a]One older adult response indicated "University", but this was scored as "Work" since it was his place of employment.

Table 5.7

Age Comparison of Participants' Ongoing Activity at Naturalistic Time-Check Task Completion

	Young Adults		Older Adults	
Activity	Response Frequency	Overall Proportion	Response Frequency	Overall Proportion
Chores/Errands	21	.12	41	.25
Relaxing/Leisure	50	.29	53	.33
Work	54	.32	21	.13
Volunteering	3	.02	5	.03
Caregiving	1	.01	3	.02
Eating	32	.19	31	.19
Commuting	10	.06	9	.06
Total (*N* = 334)	171		163	

Potential age differences in the effect that location and ongoing activity had on naturalistic time-check task performance was explored. Did young adults and older adults differ in their accuracy when they were at home, for example? The absolute time deviation (i.e., how far off the target time the response was regardless of whether early or late) was calculated for each task completion. The time deviations of several outliers were substituted with a maximum response time deviation of 30 minutes to reduce the skewness of each category. The time deviations were then categorised by location and ongoing activity, and the average time deviation was calculated for each category. Figure 5.7 shows the average absolute time deviations for each location category as a function of age group. Post-hoc analyses were conducted to see if there was an age difference between the time deviations when at a given location. Effect sizes are represented as Cohen's *d*; Cohen (1988) defines effect sizes as small (d = 0.2), medium (d = 0.5), and large (d = 0.8). An independent t-test found that when time-check tasks were completed at the participants' homes, older adults (in min:s; *M* = 4:29, *SD* = 5:46) performed more accurately than younger adults (*M* = 7:43, *SD* = 9:27; $t(129.17) = 2.77$, $p = .006$, $d = 0.43$). When participants completed the time-check tasks while they were out by themselves, older adults (*M* = 8:03, *SD* = 8:07) were significantly less accurate than the young adults (*M* = 2:55, *SD* = 3:34; $t(23.17) = -2.32$, $p = .029$, $d = 0.78$). However, several responses were identified as having been immediately executed by participants. Immediately executed responses indicate that the participant completed the time-check task less than two minutes after receiving the task's instructions or within two minutes of starting the stop-clock. In such cases, the retention period between intention formation and task execution is arguably too short for participants to re-engage in their ongoing activity, and therefore some researchers would not consider this to be a PM task. Alternatively, immediately executed responses should be considered separately from those tasks with longer retention intervals that better align with traditional definitions of what constitutes a PM task. When the immediately executed responses were excluded from the analyses, the response pattern across location categories remained unchanged. However, the age difference in the time deviations when participants completed the task while they were out by themselves was no longer significant ($t(24) = -1.17$, $p = .252$, $d = 0.46$). The response pattern was also similar when the median time deviations were considered for each location (see Appendix D.1).

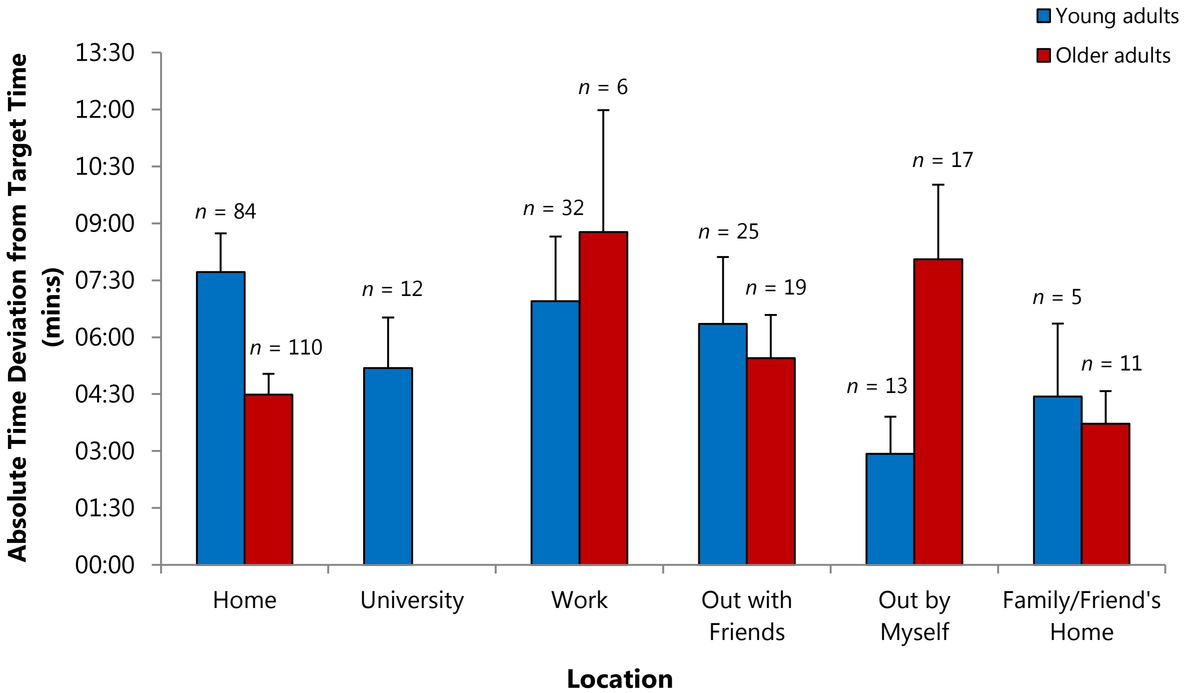

Figure 5.7. Mean time deviations as a function of age group and the location where naturalistic time-check task completion occurred. Each location varied in response frequency; the number of responses for each location are listed above the corresponding bar. Errors bars depict the standard error of the mean.

The average absolute time deviation for each ongoing activity category as a function of age group is presented in Figure 5.8. Independent t-tests found no significant age differences in performance accuracy regardless of the ongoing activity participants were engaged in prior to task completion. When participants reported being engaged in a "relaxing or leisure activity", there was a nonsignificant trend for older adults (M = 5:17, SD = 5:59) to perform more accurately compared to young adults (M = 8:20, SD = 9:33; $t(81.57) = 1.93$, $p = .057$, $d = 0.39$). When the immediately executed responses were accounted for and excluded from analyses, the age difference in performance accuracy while participants were relaxing became significant ($t(71.85) = 2.40$, $p = .019$, $d = 0.50$). Excluding immediately executed responses did not change the pattern of age differences across the ongoing activities. The response pattern was also similar when the median time deviations were considered for each ongoing activity (see Appendix D.1).

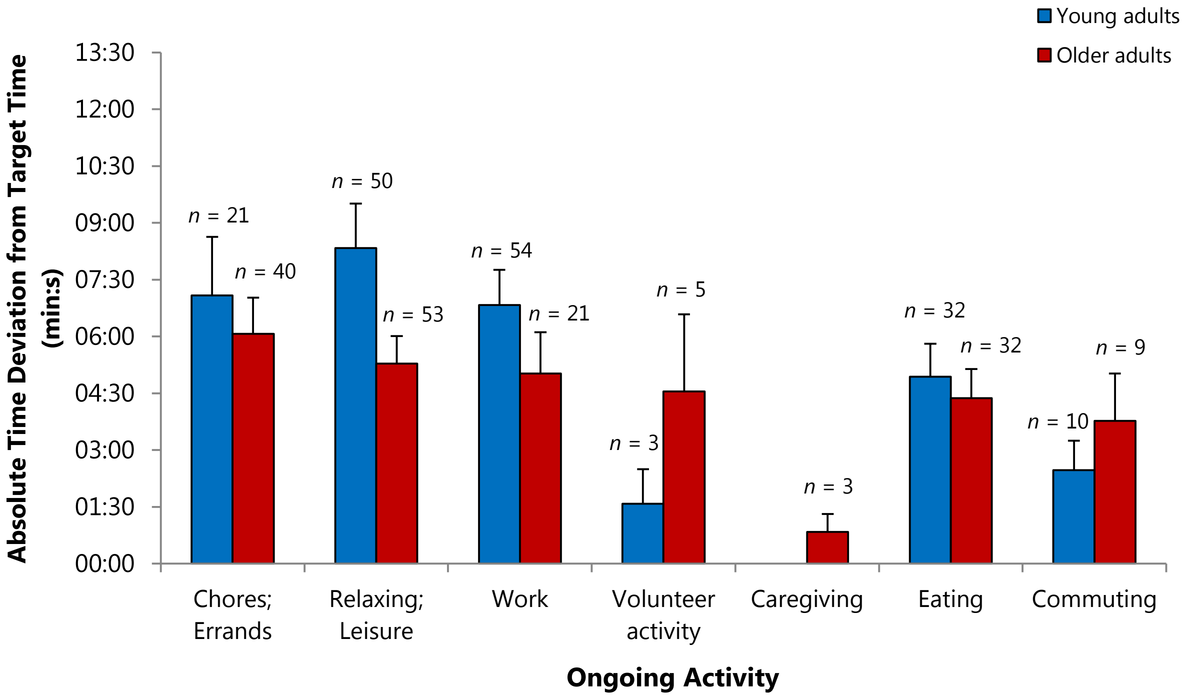

Figure 5.8. Mean time deviations as a function of the ongoing activity participants were engaged in prior to completion of the naturalistic time-check tasks and age group. Each ongoing activity varied in response frequency; the number of responses in each ongoing activity category are listed above the corresponding bar. Error bars depict the standard error of the mean.

Cross Setting Analyses

To investigate the suggestion that the age-PM paradox is merely an artefact resulting from the inappropriate comparison of dissimilar tasks, the novel naturalistic PM tasks in the current study were designed to more closely match the types of PM tasks frequently used in laboratory research. Additionally, the investigation used the same sample of young and older adults in both laboratory and naturalistic settings. Despite objectively assessing PM performance on a variety of PM tasks and within the same sample, age deficits observed in the laboratory were reversed in the naturalistic setting. Figure 5.9 shows the overall laboratory and naturalistic PM performances as a function of age. To confirm the apparent main effects and interactions of age group and *setting* (laboratory, naturalistic) on overall PM performance, 2 x 2 mixed factorial ANOVAs were conducted. These analyses collapsed across factors that were found to have non-significant effects (task regularity, encoding condition) in order to enhance statistical power. There was a main effect of age group, $F(1, 74) = 5.24$, $p = .025$, $\eta_p^2 = .07$, and the effect of setting approached significance, $F(1, 74) = 3.79$, $p = .055$, $\eta_p^2 = .05$; however, an interaction effect was found, $F(1, 74) = 38.65$, $p < .001$, $\eta_p^2 = .34$. Tests of simple effects showed that in the laboratory, young adults' overall PM performance ($M = .72$, $SD = .19$) was better than that of older adults ($M = .44$, $SD = .25$; $F(1, 74) = 30.87$, $p < .001$, $\eta_p^2 = .29$). However, the reverse was true in the naturalistic setting. When assessed in everyday life, older adults ($M = .58$, $SD = .19$) outperformed young adults ($M = .46$, $SD = .21$; $F(1, 74) = 6.11$, $p = .016$, $\eta_p^2 = .08$). Further tests of simple effects revealed a main effect of setting for both age groups. Young adults performed best in the laboratory, $F(1, 74) = 33.31$, $p < .001$, $\eta_p^2 = .31$, whereas older adults performed best in naturalistic settings, $F(1, 74) = 9.12$, $p = .003$, $\eta_p^2 = .11$. While it appears that the age-PM paradox has been confirmed within the same sample, the age differences on PM performance across settings were more diverse when the type of PM cue was considered.

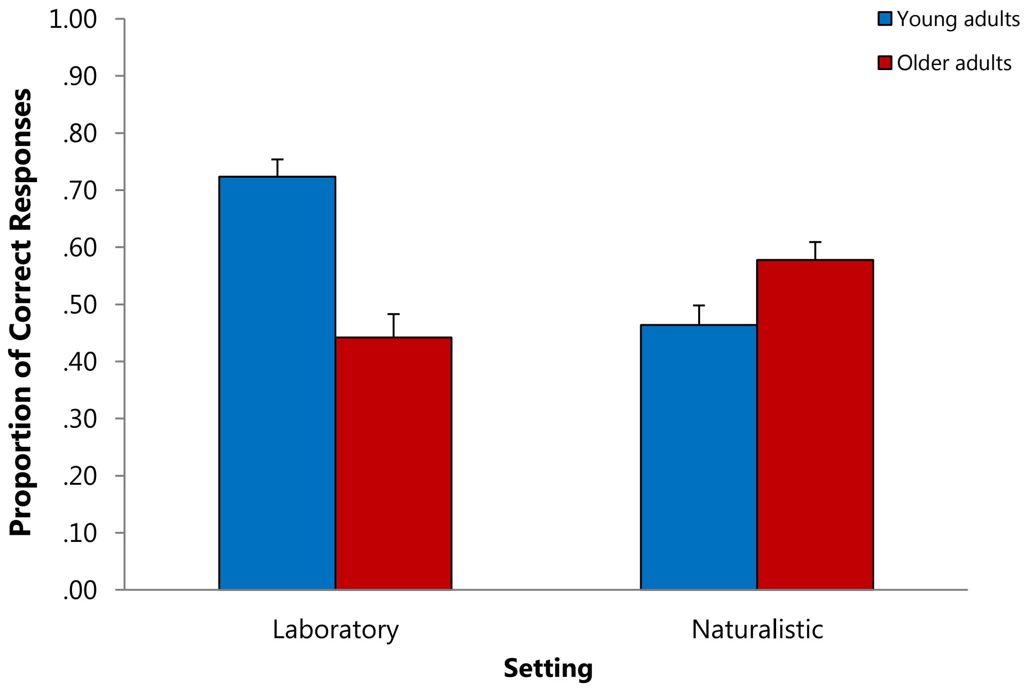

Figure 5.9. Age differences on overall PM performance as a function of setting: Mean proportion of correct responses on all laboratory and naturalistic PM tasks. Error bars depict standard error of the mean.

When the PM cue type was taken into account, the pattern of age differences in the laboratory differed dramatically from the pattern of age differences in the naturalistic setting. While it was no surprise that the type of PM cue greatly influenced PM performance, the contrasting interaction between age group and setting when examining each cue type separately was remarkable. PM performance as a function of cue type, setting, and age group is displayed in Figure 5.10. Thus far in the PM literature, the most frequent comparison of PM performance across settings has been the comparison of performance on laboratory event-based tasks with the performance on naturalistic scheduled time-based tasks. Even when consideration has been given to the influence of PM cue type by attempting to compare time-based task performance across settings, the resulting comparison has been between performance on laboratory time-check tasks with the performance on naturalistic scheduled time-based tasks, due to the lack of distinction between the time-based task variants in the literature. As illustrated in Figure 5.10, both of these standard comparisons in the current study resulted in age-related deficits in the laboratory and age-related benefits in naturalistic settings, which is consistent with previous findings of the age-PM paradox. However, when the type of PM cue was matched across settings for a more fitting comparison of laboratory and naturalistic performances, the age differences were more nuanced.

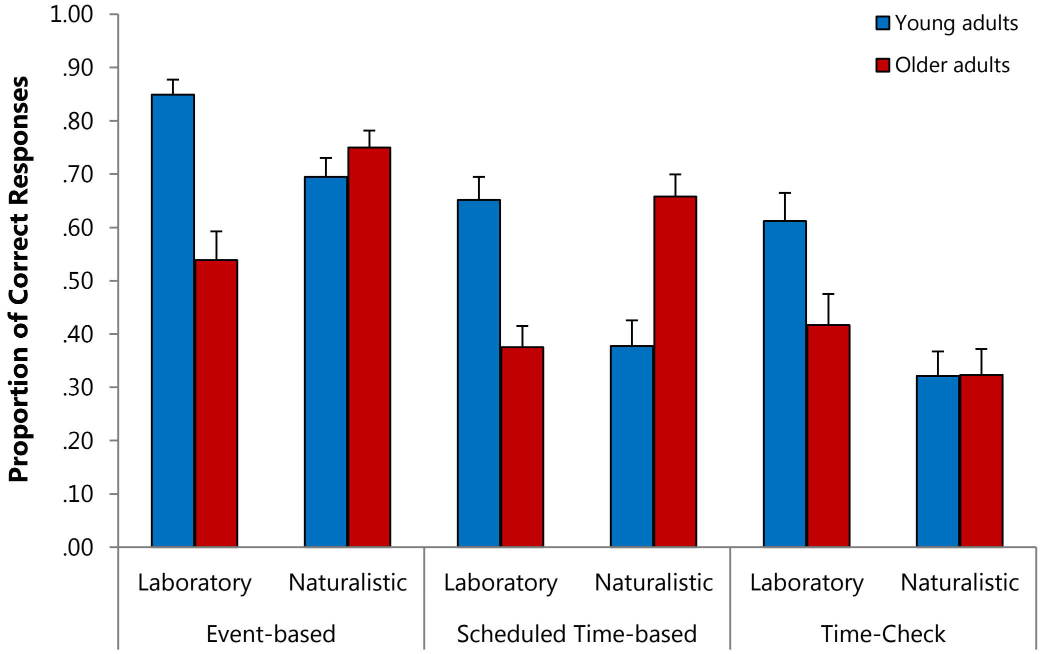

Figure 5.10. PM performance as a function of PM cue type (event-based, scheduled time-based, time-check), setting (laboratory/naturalistic), and age group (young/older adults). Errors bars depict standard error of the mean.

Performance on event-based tasks. A 2 x 2 mixed factorial ANOVA was conducted to analyse the impact of age group and setting on the performance of event-based PM tasks. A main effect of age was found, $F(1, 76) = 8.66$, $p = .004$, $\eta_p^2 = .10$, as well as an interaction effect, $F(1, 76) = 29.57$, $p < .001$, $\eta_p^2 = .28$. Tests of simple effects demonstrated a large main effect of age group in the laboratory setting, $F(1, 76) = 26.00$, $p < .001$, $\eta_p^2 = .26$, with young adults ($M = .85$, $SD = .17$) performing better than older adults ($M = .54$, $SD = .34$) on event-based tasks. However, in the naturalistic setting there was no simple main effect of age group, $F(1, 76) = 1.32$, $p = .253$, $\eta_p^2 = .02$, as young adults ($M = .69$, $SD = .22$) and older adults ($M = .75$, $SD = .20$) performed equally well on event-based tasks in everyday life. Further tests revealed a simple main effect of setting for both age groups. Young adults achieved better PM performance on event-based tasks when in the laboratory, $F(1, 76) = 10.56$, $p = .002$, $\eta_p^2 = .12$, whereas older adults performed best on event-based tasks in naturalistic settings, $F(1, 76) = 19.71$, $p < .001$, $\eta_p^2 = .21$.

Performance on scheduled time-based tasks. An additional 2 x 2 mixed factorial ANOVA was conducted to analyse the impact of age group and setting on the performance of scheduled time-based PM tasks. An interaction effect was found, $F(1, 75) = 43.50$, $p < .001$, $\eta_p^2 = .37$. Tests of simple effects revealed a large main effect of age group for both settings. In the laboratory, young adults ($M = .65$, $SD = .27$) outperformed older adults ($M = .38$, $SD = .25$) on scheduled time-based tasks, $F(1, 75) = 22.16$, $p < .001$, $\eta_p^2 = .23$. However, their performances were nearly identically reversed in the naturalistic setting. In everyday life, older adults ($M = .66$, $SD = .26$) demonstrated superior performance on scheduled time-based tasks compared to young adults ($M = .38$, $SD = .30$; $F(1, 75) = 19.41$, $p < .001$, $\eta_p^2 = .21$). Further tests of simple effects demonstrated a large main effect of setting for both age groups; young adults performed best when in the laboratory, $F(1, 75) = 20.78$, $p < .001$, $\eta_p^2 = .22$, whereas older adults' performance was stronger in the naturalistic setting, $F(1, 75) = 22.75$, $p < .001$, $\eta_p^2 = .23$.

Performance on time-check tasks. To examine the effect of age group and setting on the performance of time-check PM tasks, a final series of 2 x 2 mixed factorial ANOVAs were conducted. Again, an interaction effect was found, $F(1, 75) = 4.15$, $p = .045$, $\eta_p^2 = .05$. Tests of simple effects found a main effect of age group in the laboratory setting, with young adults ($M = .61$, $SD = .33$) performing better than older adults ($M = .42$, $SD = .36$) on time-check tasks in the laboratory, $F(1, 75) = 6.11$, $p =.016$, $\eta_p^2 = .08$. Strikingly, no such effect was found in the naturalistic setting, $F(1, 75) = 0.01$, $p = .979$, $\eta_p^2 < .01$. Both young adults ($M = .32$, $SD = .28$) and older adults ($M = .32$, $SD = .31$) performed poorly in everyday life. Further tests of simple effects showed that the setting of PM assessment had a large impact on the performance of young adults, $F(1, 75) = 17.83$, $p < .001$, $\eta_p^2 = .19$; young adults' performance in the naturalistic setting was markedly worse than their performance in the laboratory. Older adults, on the other hand, performed poorly on time-check tasks regardless of the setting, $F(1, 75) = 1.90$, $p = .172$, $\eta_p^2 = .03$.

Association between the laboratory and the naturalistic measures. Despite the considerable attempts to match methodological factors across many dimensions, why are there such striking differences between the pattern of age differences in naturalistic settings and those in laboratory settings? There is a possibility that laboratory and naturalistic assessments of PM are, in fact, measuring different cognitive processes. Pearson correlations were used to examine associations between the laboratory measure of PM and the naturalistic measure of PM, in order to assess whether laboratory performance was predictive of naturalistic performance for both age groups. The correlations are displayed in Table 5.8. Cue type variables (i.e., event-based, scheduled time-based, and time-check) were assessed for normality in both settings and within each age group. Composite scores were created for the overall PM performance in each setting (e.g., proportion of correct responses in the laboratory measure and the proportion of correct responses in the naturalistic measure) and were also assessed for normality. In the older adult group, all of the variables were normally distributed. In the young adult group, the laboratory event-based task data were negatively skewed. Skewness was corrected by adjusting a single outlier to two standard deviations below the mean (Tabachnick & Fidell, 2007). By and large, the laboratory PM measures did not correlate with the naturalistic PM measures, which suggests that older adults who performed poorly in the laboratory did not perform poorly in naturalistic settings. Even though performance comparisons were conducted using parallel tasks, there was still a discrepancy between the age differences observed in each setting. This finding suggests that there is an actual dissociation of age effects in PM performance, which cannot be explained by the comparison of disparate tasks.

Table 5.8

Correlations among the Laboratory and Naturalistic Measures of Prospective Memory

Variable	1	2	3	4	5	6	7	8
1. All Laboratory Tasks	-	.63**	.83**	.78**	.20	.38*	.17	-.03
2. Laboratory EBT	.89**	-	.23	.38*	.12	.22	.05	.05
3. Laboratory Scheduled TBT	.84**	.59**	-	.49**	.12	.24	.18	-.11
4. Laboratory Time-Check Tasks	.75**	.49**	.54**	-	.22	.40*	.14	.01
5. All Naturalistic Tasks	.09	.05	.01	.21	-	.68**	.80**	.81**
6. Naturalistic EBT	.30	.28	.20	.25	.62**	-	.29	.39*
7. Naturalistic Scheduled TBT	-.15	-.17	-.11	-.05	.72**	.15	-	.46**
8. Naturalistic Time-Check Tasks	.05	.03	-.09	.24	.84**	.39*	.37*	-

Note. Correlations for the young adult group are above the diagonal. Correlations for the older adult group are below the diagonal. EBT = Event-based tasks; TBT = Time-based tasks.
* $p < .05$. ** $p < .01$.

The lack of correlations between the laboratory and the naturalistic PM measures cannot be attributed to issues of reliability. It has been argued that many PM measures lack reliability, largely because of the few PM targets included in the measures (McDaniel & Einstein, 2007; Rendell & Henry, 2009). However, all of the PM measures used in the current study were found to have moderate to strong reliability as shown in Table 5.9. Both the laboratory measure and the novel naturalistic measures are reliable, and show internal consistency as evidenced by mostly significant correlations between tasks with different cues within each setting, yet show no consistency with each other, at least not at the individual difference level.

Table 5.9

Reliability of the Laboratory and Naturalistic Measures of Prospective Memory: Cronbach's α Assessing Internal Consistency for each Cue Type and Age Group

	Young adults	Older adults	Number of Tasks
Laboratory			
All Tasks	.77	.87	20
Event-based Tasks	.57	.84	8
Scheduled Time-based Tasks	.72	.66	8
Time-Check Tasks	.58	.72	4
Naturalistic			
All Tasks	.80	.77	24
Event-based Tasks	.71	.66	12
Scheduled Time-based Tasks	.68	.57	6
Time-Check Tasks	.57	.74	6

5.4 Discussion

The present study systematically investigated the age differences in PM performance across laboratory and naturalistic settings using the same sample of young and older adults. The study aimed to examine whether the dissociation between the age effects in the laboratory and in naturalistic settings, referred to in the literature as the age-PM paradox, can be explained by the comparison of dissimilar tasks across settings. In order to rigorously examine this methodological issue, PM tasks in both settings were distinguished into three categories: event-based, scheduled time-based, and time-check tasks. Naturalistic PM performance was assessed using novel, objective measures that captured these three types of PM tasks. Overall, the laboratory findings were consistent with the PM literature and the earlier prediction that young adults would outperform older adults on all laboratory PM tasks. In contrast, young adults did not outperform older adults on any naturalistic PM task. The naturalistic findings shed light on the importance in considering the type of PM cue and the environmental support available for PM tasks completed in everyday life. Lastly, in regard to the secondary aim, differences in encoding abilities did not appear to contribute to the age-PM paradox. However, there are several limitations regarding the use of the implementation intentions encoding strategy in the naturalistic portion of the current study which should be considered.

Event-based Tasks

Laboratory prospective memory performance. Older adults performed significantly worse than young adults on event-based tasks in the laboratory. This age-related deficit is consistent with the literature on PM and ageing using the Virtual Week measure (Rendell & Craik, 2000; Rendell & Henry, 2009; Rose et al., 2010). The implementation intentions encoding strategy improved PM performance overall. On irregular tasks, both young and older adults benefited from the implementation intentions encoding strategy. However, only older adults benefited on regular tasks, possibly because the young adults' performance was close to ceiling. Despite this pattern, no significant interaction effects were found between age group, encoding strategy, and task regularity. Perhaps an interaction effect would be apparent if a larger sample size was used. Contrary to previous investigations, PM performance did not vary according to task regularity. This suggests that older adults' poor PM performance on event-based tasks is not due to difficulties with the retrospective memory component of the PM task (i.e., remembering the content of the intention or what it is that needs to be performed). Previously reported effects of task regularity typically assessed its influence on the combined PM performance using both event- and time-based tasks. It is possible that the high demand placed on the retrospective memory component of irregular time-based tasks was most influential to the overall impact of task regularity in such studies (Rose et al., 2010).

Naturalistic prospective memory performance. The age deficit observed in the laboratory was non-existent in the naturalistic setting. Young and older adults performed equally well on event-based tasks. This finding is consistent with the work of Niedźwieńska and Barzykowski (2012) and Kvavilashvili et al. (2013), who conducted the only other studies that have assessed and verified event-based task performance across settings using the same sample of young and older adults. Unlike the naturalistic event-based tasks in the aforementioned studies, the event-based tasks used in this study could be argued to actually favour young adults. Compared to the older participants, the young participants had substantially more experience with smartphones and greater familiarity with how to operate the camera function. Yet even on an activity that young adults are accustomed to, they still did not perform better than older adults in naturalistic settings. One possibility is that the young adults' performance was hampered by having to remember to carry the study smartphone in addition to their own mobile device. However, both age groups remembered to carry the smartphone with them the vast majority of the time, as indicated by the low proportion of responses in which they were unable to perform the tasks. Moreover, in a naturalistic PM study by Aberle et al. (2010) in which young and older adults were required to use their own phones, not one provided to them, to send text messages to the experimenter at a scheduled time, older adults still outperformed young adults when there was no monetary incentive to perform the tasks. In addition to comparable levels of PM performance in the present study, both age groups committed the same types of errors and did so in a similar frequency.

Task regularity did not affect PM performance. If an age deficit existed in naturalistic settings, it should become apparent on irregular tasks given that irregular tasks present more challenges in the formation of PM intentions. Nonetheless, older adults performed well on irregular tasks, demonstrating their ability to withstand variations on retrospective memory demand and maintain their PM performance. The lack of an effect of task regularity could, however, be the result of several flaws in the study design. For example, perhaps regular tasks were not better encoded since both the regular and irregular tasks were encoded at roughly the same time, in a similar manner. It is possible that the temporal order of the task instructions, with the regular tasks reminder always appearing first, primed participants for the irregular tasks. Another possibility is that the naturalistic study period was not long enough to see an effect. On the first study day, regular and irregular tasks are essentially the same; the regular tasks have not occurred repeatedly yet. A more suitable comparison would be to examine the effect of task regularity on the final study day, but there would not be enough power for such an analysis in this study.

Implementation intentions did not enhance PM performance in naturalistic settings. Strengthening the association between the target cue and the future action, thereby ensuring strong encoding of the PM intention, did not improve young adults' performance despite their performance being below ceiling. This could be an indication that age differences in encoding abilities are not contributing to the age-PM paradox.

Pattern of age-related differences across settings. Consistent with previous studies (Bailey et al., 2010; Rendell & Craik, 2000), older adults demonstrated impaired PM in the laboratory compared to young adults, but this age deficit was not detected in the naturalistic setting. In relation to their laboratory performance, older adults' PM performance significantly improved in the naturalistic setting while young adults demonstrated a significant decline in performance, resulting in no age differences in naturalistic performance. Task regularity did not impact performance in either setting. Even the high monitoring load of irregular tasks was not enough to attenuate older adults' naturalistic performance. This lack of an effect suggests that older adults' poor laboratory PM performance could be indicative of difficulties with the retrieval of PM intentions rather than the encoding of them. The contrast between the success of the implementation intentions encoding strategy on laboratory PM and its ineffectiveness on naturalistic PM is further evidence that age differences in encoding abilities is not an underlying cause of the paradox. If the much reported age benefit in naturalistic settings is due to young adults not encoding their PM intentions as well as older adults, then young adults' performance would improve when implementation intentions is applied in everyday life. However, young adults' naturalistic performance was not better than that of older adults.

Implementation intentions arguably strengthen the association between the target cue and the intended action, yet the exact mechanism by which this encoding strategy is thought to improve PM performance remains unknown. One viewpoint is that implementation intention boosts PM performance in the laboratory by making the target cue (an abstract event) more salient or focal (for alternative viewpoints of possible mechanisms, see Lee et al., 2015). The presentation of a salient cue leads to intention retrieval through spontaneous processes which are less effortful than the strategic monitoring processes necessary for retrieval when presented with a nonfocal cue. Perhaps implementation intentions did not bolster PM performance in naturalistic settings because the salience of the target cues was already high to begin with. Event cues in the real world are also frequently accompanied by numerous preceding environmental cues, which may gradually increase the activation of the cue as the appropriate moment approaches. Even though the laboratory measure (Virtual Week) attempted to provide similar contextual support, it was still a simulation and quite abstract. Therefore, PM intentions for event-based tasks are more readily retrieved in everyday life than they are in the laboratory. Older adults could be achieving enhanced performance on naturalistic event-based tasks through an effective reliance on the automatic processing of target cues made possible by high salience of the cues and the presence of contextual supports.

Scheduled Time-based Tasks

Laboratory prospective memory performance. An age-related deficit was found on scheduled time-based tasks in the laboratory, with older adults performing significantly worse than young adults. This finding is in line with previous PM research (Niedźwieńska et al., 2014; Rendell et al., 2011). Implementation intentions did not benefit PM performance, which suggests that the contextual cues associated with the scheduled time-based tasks in Virtual Week were not enough to impart an event-like quality on the tasks, and that the encoding strategy is not effective for tasks that require time-monitoring skills (Cook, Marsh, & Hicks, 2005; Craik, 1986). Task regularity impacted PM performance; all participants performed better on regular tasks compared to irregular tasks. This suggests that performance on scheduled time-based tasks is sensitive to the level of demand placed on the retrospective memory component of the PM task.

Naturalistic prospective memory performance. The naturalistic performance pattern was a mirror image of the laboratory performances, with a striking age-related benefit found on scheduled time-based tasks in the naturalistic setting. Older adults excelled at completing these appointment-style tasks in daily life. Young adults, on the other hand, were not able to achieve the performance level of older adults even when using the implementation intentions encoding strategy. Young adults were also less accurate than older adults. The most common error committed by older adults was completing the PM task 5-15 minutes later than the scheduled time. However, young adults more commonly missed the task entirely (i.e., either failed to complete the task or did so more than an hour later than the scheduled time). When missed responses were excluded, young adults were still less accurate than older adults. In this case, young adults were on average more than 15 minutes off of the target time compared to just 7 minutes on average for older adults.

Pattern of age-related differences across settings. In line with the age-PM paradox, young adults demonstrated superior performance compared to the older adults in the laboratory, but they were outperformed by the older adults in the naturalistic setting. Older adults demonstrated significantly impaired PM performance in the laboratory compared to their performance in everyday life. In contrast, the reverse was true for young adults, with young adults performing their best in the laboratory rather than in the naturalistic setting. Contrary to earlier predictions, implementation intentions did not improve performance on scheduled time-based tasks in either setting. If implementation intentions were going to enhance performance on either time-based task, it would be more likely to improve performance on a scheduled time-based task in the naturalistic setting given that these appointment-style tasks can be linked with conjunction cues and are often accompanied by abundant environmental support. The lack of an effect of encoding strategy may suggest that differences in encoding abilities are not driving the age differences in PM performance. One possibility is that the flexibility of young adults' daily schedule could make it difficult for them to predict the environmental cues that could trigger intention retrieval at the appropriate time. However, another possibility, explored in further detail in the limitations section, is that participants did not apply the strategy correctly when left to their own devices in the naturalistic setting.

Time-Check Tasks

Laboratory prospective memory performance. Young adults continued to dominate in the laboratory, exhibiting superior performance compared to older adults on time-check tasks. Unsurprisingly, the implementation intentions encoding strategy did not improve PM performance for either age group since time-check tasks lack an explicit target cue, and as such time-check tasks rely on strategic monitoring processes for task completion, which require a high level of executive function (Brom & Kliegel, 2014; Hering, Rendell, Rose, Schnitzspahn, & Kliegel, 2014). The laboratory performance in the present study is in line with the prevailing literature, demonstrating that older adults struggle to a greater degree than young adults on tasks that require strategic monitoring (Einstein et al., 1995; Harris & Wilkins, 1982; Jäger & Kliegel, 2008).

Naturalistic prospective memory performance. Remarkably, there was no age difference observed in the naturalistic setting, with both age groups performing equally poorly on time-check tasks in everyday life. Once again, the implementation intentions encoding strategy proved to be ineffective at enhancing PM performance, although that was expected for time-check tasks. The instances of forgetfulness (i.e., started the stop-clock, but failed to complete a quiz) were very low overall and were especially low for older adults. Once participants engaged in the time-check task, they typically remembered to perform the task. The most common error for both age groups was missing the task entirely (i.e., never initiated the stop-clock and never completed a quiz). The second most common error for older adults was completing the task too early; for younger adults, it was completing the task more than 10 minutes late.

Post hoc analyses shed some light on how the participants' location and ongoing activity at the time of task completion might have influenced performance. The relatively small sample size of some of the response categories restricts how this data can be interpreted, but several speculations are offered. Location appeared to impact performance to a greater extent than the ongoing activity, particularly for older adults. There was much more variation in performance accuracy based upon the location of participants at the time of task completion. Compared to their younger counterparts, older adults benefitted more from being in a familiar environment; when both age groups were at home, older adults were more accurate on time-check tasks than the young adults. Alternatively, when participants were out by themselves, young adults were more accurate than older adults. This could suggest that older adults were devoting some of their attention to navigating their environment rather than on task completion. Another possibility could be that older adults' performance suffered because they were away from the reminders they typically rely upon (e.g., wall clock or spouse) to complete their PM tasks (Schaefer & Laing, 2000). The age difference observed when participants were out by themselves was no longer significant, however, when immediately executed tasks (i.e., tasks that were completed within two minutes of receiving the alert rather than waiting the specified time-elapsed period of 10, 15, or 20 minutes) were excluded. Older adults were more likely to immediately execute a task compared to young adults. Perhaps those older adults thought it was preferable to complete the task very early rather than risk forgetting the task entirely, a potential indication that older adults are aware of vulnerabilities in their PM. In future studies, it would be of interest to examine whether participants are more likely to immediately execute a task under certain circumstances. For instance, are participants more likely to immediately execute a task when they are engaged in an activity or in a location that requires more concentration (e.g., having to navigate an unfamiliar environment)? Are participants more likely to immediately execute a task when they are socialising so as not to be rude (e.g., one participant reported completing a task early because she did not want to disturb others in her bridge club)? More formal testing is certainly warranted to determine the influence of participants' location and ongoing activities on their PM performance, and the potential differences between young and older adults in metacognitive awareness of their PM abilities.

Pattern of age-related differences across settings. The age deficit observed in the laboratory on time-check tasks, did not exist in the naturalistic setting. In everyday life, young adults were not able to achieve the level of performance they had in the laboratory. Older adults' performance, however, did not differ across settings. Older adults performed poorly on time-check tasks in both settings, which suggests that older adults consistently struggle with tasks that require strategic monitoring processes. One possible explanation is that the lack of an event-like quality meant that older participants could not link the time-check tasks to any environmental cues to facilitate prospective remembering, and thus their performance suffered. It is unclear why young adults performed so much worse in everyday life, given that their monitoring skills were proven to be efficient in the laboratory. Differing environmental demands were considered by looking at the location and ongoing activity at the time of task completion. In other words, did the age groups differ in terms of where participants were and what they were doing while they waited either 10, 15, or 20 minutes to complete their task, and could this explain differences in their performance? Both age groups reported being at home the majority of time. However, even when in this similar and familiar environment, young adults were less accurate than older adults on time-check tasks. While the age groups engaged in the various ongoing activities at different frequencies, there were no overwhelming age differences in performance within each type of ongoing activity. The level of demand associated with the ongoing activity did not appear to impact participants' performance. Young adults' accuracy was just as bad when they were relaxing or engaged in a leisure activity as when they were engaged in a work-related activity. Thus, it does not appear that the diminished performance of young adults can be explained by their engagement in highly demanding ongoing activities.

Age Effects in Prospective Memory Performance

Consistent with the existing literature (Henry et al., 2004) and in support of the prediction regarding laboratory performances, young adults outperformed older adults on all three PM tasks in the laboratory. Despite systematically comparing PM performances across settings using parallel tasks, the age differences observed in the laboratory were dramatically different to the age differences observed in naturalistic settings. This finding did not support the first alternative prediction regarding age differences in naturalistic settings, which proposed that once the comparison of laboratory and naturalistic performances was conducted with the performances of analogous PM tasks, the same age pattern would be observed in both settings. Instead, the consistent age deficit found in the laboratory was not apparent in naturalistic settings. Previous studies of the age-PM paradox have typically compared the laboratory performance of event-based or time-check tasks to the naturalistic performance of scheduled time-based tasks. Upon examining these two comparisons in the current study, the findings demonstrated a significant age deficit in the laboratory but a significant age benefit in naturalistic settings. Older adults did not, however, demonstrate a universal benefit in naturalistic settings. Thus, the third alternative prediction was not supported by these findings. The systematic approach utilised in the present study revealed a more distinct pattern of performance.

The event-like quality of a PM task was proposed to be an important factor in older adults' performance due to the high level of environmental support available for such tasks. Thus, the second alternative prediction regarding performance in naturalistic settings was that the age difference would be minimal on event-based tasks and greatest on time-check tasks. This prediction was based on the notion that older adults would demonstrate strong performance on PM tasks with an explicit cue and high environmental support, but they would perform poorly on tasks that lack an external cue or environmental support because such tasks require strategic monitoring skills. The findings only partially supported this prediction. The event-like quality of a PM task did appear to be an important factor in older adults' naturalistic PM performance. Older adults' performance improved substantially in naturalistic settings when the PM task had an event-like quality, but their performance remained poor in both settings on tasks that did not possess an event-like quality (i.e., time-check tasks). The only instance where older adults outperformed young adults was on scheduled time-based tasks in everyday life. This could suggest that this variant of time-based tasks is less abstract with contextual or conjunction cues that allowed older adults to make use of spontaneous intention retrieval processes. However, this was not the case for young adults. Young adults performed similarly, and poorly, on both variants of time-based tasks in naturalistic settings. This suggests that young adults did not take advantage of the environmental support or contextual cues that can be associated with scheduled time-based tasks in everyday life. Thus, young adults' performance did not support the second alternative prediction. One possibility is that the arguably less routine nature of young adults' daily lives made it difficult to accurately identify the contextual cues that accompany scheduled time-based tasks (Phillips et al., 2008). Furthermore, young adults performed worse on all naturalistic PM tasks compared their laboratory performance. Young adults' diminished performance on time-check tasks in the naturalistic setting meant that despite older adults consistently performing poorly on time-check tasks, no age difference was observed on this task in the naturalistic setting, which opposed the earlier prediction.

Overall, the findings of the current study are consistent with the proposal that retrieval of PM intentions occurs through both spontaneous and strategic monitoring processes, and that performance is reduced when it relies on monitoring skills (McDaniel & Einstein, 2000). The findings suggest that young and older adults could potentially use different intention retrieval processes for the completion of scheduled time-based tasks in naturalistic settings. Older adults appeared to be able to utilise the contextual support available to scheduled time-based tasks in everyday life, although the precise nature of how this support facilitates successful task completion is not yet determined. It is possible that older adults were aware of their potential PM vulnerabilities and therefore developed strategies, such as detailed planning or rehearsals of PM intentions, which facilitated the completion of event-based and scheduled time-based tasks, but not time-check tasks. Thus, PM studies should further investigate what it is specifically about PM tasks with an event-like quality that allowed for older adults to perform particularly well on such tasks in naturalistic settings.

Limitations and Future Directions

While this study significantly advances the study of the age-PM paradox, there are several limitations to note. The ineffectiveness of the implementation intentions encoding strategy, particularly for event-based and scheduled time-based tasks in the naturalistic setting, could result from participants' lackadaisical effort. The implementation intentions encoding strategy was introduced to and employed by the participants in the laboratory testing session, where the researcher could instruct the participant on its correct usage.

However, even when prompted by the researcher, some participants struggled to use the encoding strategy in its proper format. Based on anecdotal evidence, it is suspected that participants may not have used this encoding strategy throughout the entire naturalistic period or they might have applied it incorrectly. Upon study completion, several participants reported inconsistent use of the encoding strategy. The frequent practice of the encoding strategy in the laboratory and the clear instructions within the smartphone notifications as well as within the provided take-home guidelines might not have been sufficient to ensure accurate use of the encoding strategy. Future studies should exercise greater control in this regard and could incorporate the smartphone technology as a means of verifying the encoding strategy was employed appropriately. For example, ask participants to make a voice recording when they form their PM intentions using the implementation intention encoding strategy.

Both the naturalistic and the laboratory measures of PM performance on event-based tasks contained a manipulation of task regularity. However, there are many other features of event-based tasks, such as cue focality, that could potentially influence PM performance. Consideration should be given to the other possible ways of classifying naturalistic tasks. One feature for further investigation could be the degree to which the participant has control over the occurrence of the target cues. This varied considerably in the naturalistic setting. For instance, participants can decide when to water their plants whereas they do not determine when a sporting event's halftime occurs. Less control over the occurrence of the target cue could sometimes result in a shorter window of opportunity to complete the PM task. More importantly, participants' lack of control over the occurrence of the target cue could be associated with less familiarity with the accompanying environmental cues as well. If a participant is less familiar with the environmental cues that surround the target cue, it could negatively impact their ability to prepare and plan for task completion. Weakened environmental support could pose difficulties in encoding, intention retrieval, and subsequent PM performance. Future studies should consider these factors of naturalistic event-based tasks and explore their impact on PM performance. In the current study, participants were asked to provide details of the event in cases where the participants had less control over the occurrence of the target cue (e.g., the halftime of a sporting event). This was done to assist the researcher in the verification process. However, providing more details of the target cue (e.g., which sporting event was to be photographed and when was it scheduled to start) may have enhanced the encoding of the PM intention for that task. Participants were only requested to provide more detail on certain irregular tasks and the results do not suggest that these tasks benefited from enhanced encoding. Still, this should be taken into consideration when designing future naturalistic studies of event-based tasks. The level of control possessed by participants is especially relevant given that the adequacy of planning has been suggested to influence PM performance (Gillholm et al., 1999; Niedźwieńska et al., 2013).

Conclusion

The study investigated whether the lack of task comparability across settings could explain the discrepancy between the age differences observed in the laboratory and those observed in naturalistic settings. A rigorous examination of PM performance on comparable tasks and within the same participant sample was conducted using novel naturalistic measures of PM. Young adults demonstrated superior performance compared to older adults on all laboratory PM tasks. However, young adults did not outperform older adults on any naturalistic PM task. Moreover, the age differences in naturalistic settings varied according to the type of PM cue and the available environmental support. In naturalistic settings, older adults performed as well as young adults on event-based tasks, superior to young adults on scheduled time-based tasks, and as poorly as young adults on time-check tasks. Older adults demonstrated strong performance on PM tasks that possess an event-like quality and could be supported through environmental and contextual cues in naturalistic settings. However, older adults' performance did not improve in naturalistic settings on PM tasks that have heavy monitoring demands (i.e., time-check tasks). This suggests that older adults struggle to perform PM tasks that are cognitively demanding and rely on strategic monitoring processes, regardless of the setting. Older adults' performance appeared to benefit from PM tasks that have external cues or environmental support (i.e., event-based and scheduled time-based tasks), possibly because such tasks can be completed through spontaneous intention retrieval processes. Young adults, however, did not appear to utilise the contextual support afforded to scheduled time-based tasks in naturalistic settings. Young adults performed similarly on both variants of time-based tasks that were examined, and they appeared to rely on their monitoring skills for task completion of both tasks. The systematic assessment of PM performance across settings did not resolve the age-PM paradox. Additionally, the study examined the possibility that difficulties in intention formation could have contributed to the age-PM paradox. Differences in encoding abilities did not appear to underlie the age-PM paradox, as the implementation intentions encoding strategy did not eliminate the discrepancies between the age differences in laboratory and naturalistic settings. Implementation intentions was only found to improve PM performance on event-based tasks that were completed in the laboratory. The encoding strategy did not improve PM performance on any task in naturalistic settings. However, these findings should be interpreted with caution as participants' adherence to the encoding strategy in naturalistic settings could be questioned.

Chapter 6: General Discussion

You are never too old to set another goal or to dream a new dream.

– Proverb

The current research sought to examine factors that potentially contribute to the puzzling and contrasting pattern of age differences observed in laboratory and naturalistic settings on PM performance, known in the literature as the age-PM paradox. This was first addressed by Study 1 that examined contextual factors in the everyday performance of PM tasks in both young and older adults. A thorough investigation of the possible contribution of methodological factors was then conducted in Study 2 by examining the age differences across laboratory and naturalistic settings using PM tasks that were matched by the type of PM cue.

The primary aim of Study 1 was to explore the differences in the daily lives of young and older adults which may contribute to age differences in naturalistic PM performance. This was addressed by utilising an experience-sampling method to capture participants' PM behaviours in real-time. Using the existing literature for guidance, several proposed factors thought to contribute to the age-PM paradox were examined. Specifically, Study 1 explored whether dissimilarity in the use of external reminders, the level of motivation, or the demands of everyday life might explain the age differences in naturalistic PM performance. The final aim of Study 1 was to identify the circumstances that lead to PM failures in daily life and whether those circumstances differ by age group.

The focus of Study 2 was to address the fundamental issue of the flawed comparison of disparate tasks across settings in the existing literature on the age-PM paradox. Its primary aim was to examine whether the age-PM paradox was evident once performance was compared using PM tasks that were matched more closely across settings. Study 2 aimed to systematically investigate age differences on event-based, scheduled time-based, and time-check tasks in both laboratory and naturalistic settings within the same participant sample. In order to conduct this rigorous assessment, new objective naturalistic measures of PM for all three types of PM tasks were developed. Finally, as potential age differences in encoding ability have been proposed to contribute to the age-PM paradox, a subsidiary aim of Study 2 was to examine the effects of the implementation intentions encoding strategy on PM performance in both laboratory and naturalistic settings.

6.1 Overall Review of Research Findings

Contextual Age Differences in Everyday Prospective Memory

To improve our understanding of the contextual factors that might contribute to the age-PM paradox, the descriptive Study 1 explored real-life PM behaviours in young and older adults. The findings indicate that both populations are not making many errors in PM in daily life, and contrary to popular belief (see Phillips et al., 2008), this is not due to a reliance on external memory aids. Whilst the existing literature is mixed in terms of which age group makes more use of external reminders (Jackson et al., 1988; Moscovitch, 1982; Rendell & Thomson, 1993, 1999), the current findings suggest that older adults do not use external aids more frequently than young adults. One of the intriguing and key outcomes of Study 1 is that both young and older adults report automatically remembering to complete their PM tasks the majority of the time. Thus, this is one piece of evidence to suggest that PM intentions in everyday life can be, and frequently are, retrieved spontaneously. However, older adults also report instances where they were thinking of their future plans just prior to the PM intention popping into their heads. Taken together, it appears that older adults perhaps also engage in more effortful strategies to retrieve their intentions. In line with this observation and consistent with the findings of Gardner and Ascoli (2015), older adults were found to rehearse their PM tasks more frequently than young adults. When asked throughout the study period, older adults reported recently rehearsing a PM task about 52% of the time compared to 36% for young adults. One possibility is that through experience, older adults are more aware of weaknesses in their ability to complete PM tasks successfully, and therefore they employ frequent rehearsals (Kvavilashvili & Fisher, 2007) and detailed planning (Niedźwieńska et al., 2013) as compensatory strategies in everyday life. The apparent age difference in the use of these compensatory strategies could potentially contribute to the age-PM paradox since precise planning of PM intentions improves PM performance (Einstein & McDaniel, 2014; Gillholm et al., 1999; Niedźwieńska et al., 2013). It is somewhat surprising that differences in planning could lead to an age-related benefit in naturalistic settings, given that previous laboratory studies have found that it is young adults who exhibit greater plan quality compared to older adults. This was evident by young adults' prioritisations and clarifications of necessary subtasks (Craik & Bialystok, 2006; Hering, Cortez, et al., 2014), whereas older adults were not as detailed in their planning (Einstein & McDaniel, 2014). However, more detailed and accurate planning of PM intentions is possible in everyday life compared to laboratory settings due to the ample environmental support available as well as the increased familiarity with the environment and target cues. The finding that young adults rehearse their PM tasks less frequently than older adults suggests that young adults do not appear to take advantage of the rich support provided by naturalistic settings in the same manner as older adults.

One possible explanation for why young adults do not appear to engage in rehearsals of PM intentions as frequently as older adults is that they lack the metacognitive awareness to realise when they need to implement such strategies in order to prevent memory lapses from occurring in everyday life. Meeks, Hicks, and Marsh (2007) argued that individuals must decide when forming a PM intention just how much effort and environmental support will be needed to complete the PM task. For example, an individual might decide not to write a grocery list if there are only two items to remember to purchase, as opposed to nine items. Perhaps young adults do not recognise the potential fallibility of their own PM capabilities. Moreover, the degree of effort expended or the amount of support put in place to facilitate PM task completion is influenced by the perceived importance of the task and one's motivation to complete the PM task successfully (Aberle et al., 2010; Walter & Meier, 2014). Previous studies have demonstrated that motivation and task importance influence PM performance in both laboratory and naturalistic settings (Hering et al., 2013; Ihle et al., 2012; Jeong & Cranney, 2009; Kliegel et al., 2001; Marsh et al., 1998; Moscovitch, 1982; Niedźwieńska et al., 2013). Another key outcome of Study 1, which is consistent with the existing literature, is the finding that compared to young adults, older adults more often considered the completion of their PM tasks to be important. Based on this finding, one possible conclusion is that perhaps older adults are more motivated than young adults to complete PM tasks in everyday life. While the relationship between these variables is speculative, older adults' high motivation and metacognitive awareness could promote the frequent rehearsals of their PM intentions in everyday life. Furthermore, the interplay between these factors could contribute to older adults' improved naturalistic PM performance, and this remains an area for future research.

Despite the popular proposal that young adults lead busier lives than older adults, as a potential explanation for young adults' inferior performance on naturalistic tasks, there has been little direct evidence to support this notion (Phillips et al., 2008; Rendell & Thomson, 1999). Previous research has suggested that older adults are better able to employ compensatory strategies in daily life due to their less demanding lifestyles compared to young adults (Martin & Park, 2003; Wilson & Park, 2008). However, the current findings did not support this claim. Older adults were not found to be less busy than young adults, and in fact older adults performed PM tasks more frequently than young adults. Therefore, the notion that older adults' improved PM performance in naturalistic settings is a result of their less demanding lifestyle is unsubstantiated according to the current research. Rather than this idea that older adults have a copious amount of leisure time which enables them to use compensatory strategies, perhaps older adults' having more PM intentions to remember and perform impacted their need for and frequency of PM rehearsals. Though Study 1 did not aim to specifically investigate age differences in the planning of future tasks, it is plausible that older adults' frequent rehearsals of PM tasks in everyday life have contributed to the age-PM paradox. Additional research is needed to determine precisely how young and older adults plan naturalistic PM tasks and what factors contribute to the effectiveness of their planning methods.

In summary, contextual age differences in motivation and the rehearsal of PM tasks may contribute to the age-PM paradox. However, the age differences in the use of external reminders and the demands of everyday life are not considered to be meaningful factors of the age-PM paradox. Both young and older adults are able to retrieve PM intentions through automatic processes in everyday life, although older adults also appear to employ effortful strategies to retrieve their PM intentions. Older adults' frequent rehearsals of PM tasks and their flexible use of retrieval processes are perhaps indicative of a greater metacognitive awareness compared to young adults (Schnitzspahn et al., 2011), who do not seem to incorporate or benefit from the environmental supports afforded by naturalistic settings. Finally, age differences in the planning of PM tasks was revealed as a potential factor of the age-PM paradox.

Systematic Assessment of the Age-Prospective Memory Paradox

Within the limited literature on the age-PM paradox, there are several methodological shortcomings that created gaps in the existing literature. Firstly, naturalistic PM performance have almost exclusively been assessed using only scheduled time-based tasks and/or measures of self-report (for exceptions, see Cavuoto et al., 2015; Niedźwieńska & Barzykowski, 2012; Rendell & Craik, 2000). Secondly, remarkably few studies have investigated the age-PM paradox using the same participant sample across settings (for exceptions, see Niedźwieńska & Barzykowski, 2012; Rendell & Thomson, 1999; Schnitzspahn et al., 2011; for an exception with a clinical population, see Weber et al., 2011). To address these shortcomings and the possibility that the age-PM paradox is a result of the comparison of incongruous tasks throughout the literature, Study 2 systematically examined age differences in both laboratory and naturalistic settings within the same participant sample and using PM tasks that were matched on PM cue type. This is the first systematic matching of PM tasks (i.e., event-based, scheduled time-based, and time-check tasks) between the laboratory and the real world. The first alternative prediction for Study 2 was that the age-PM paradox would be resolved by addressing the aforementioned methodological shortcomings. Remarkably, the pattern of age differences in the laboratory and in naturalistic settings generally supported the typical dissociation of age effects seen in previous studies reporting the age-PM paradox. Age-related deficits were consistently found in the laboratory, while there were no age-related deficits in the naturalistic setting. However, there is one crucial discovery within these findings: compared to their performance in the laboratory, older adults did not perform better on all naturalistic tasks. Older adults performed poorly on time-check tasks both in the laboratory as well as in everyday life. This contradicts the third alternative prediction, which stated that older adults would show a global improvement on all PM tasks in naturalistic settings, perhaps due to their motivation or the tasks being carried out in a familiar environment. The poor performance of older adults on time-check tasks is consistent with the hypothesis that such tasks are thought to be cognitively demanding, involve executive functioning, and rely solely on self-initiated monitoring processes for intention retrieval (Craik, 1986; Einstein & McDaniel, 2014). However, the lack of an age difference on time-check task performance in naturalistic settings is quite startling. In the existing literature, which predominantly focuses on this PM task type only in the laboratory, young adults typically outperform older adults

(Henry et al., 2004; Rendell & Craik, 2000; Yang et al., 2013). While it is not clear why young adults performed so poorly on time-check tasks in naturalistic settings, there are several possible explanations, such as attentional demands and low motivation, to consider.

Time-check tasks are very rarely investigated in naturalistic settings. However, one of the only studies to examine young and older adults' performances on time-check tasks both in and outside the laboratory found a similar performance pattern as that in Study 2 (Rendell & Craik, 2000). Rendell and Craik (2000) found that young adults outperformed older adults on time-check tasks when in the laboratory, but in everyday life young adults performed just as poorly as adults over 75 years of age. Again, similar to the findings of Study 2, older adults' performance was consistently poor across settings, while the naturalistic performance of young adults represented a dramatic reduction from their laboratory performance. Rendell and Craik (2000) proposed that one possible explanation for the diminished performance of young adults on time-check tasks in everyday life is that there are many other activities or tasks in everyday life which compete for young adults' attention. However, the retention periods of the time-check tasks in Study 2 are shorter than those used in Rendell and Craik's study (e.g., 10, 15, or 20 minutes compared to 30 or 60 minutes). Additionally, young adults in the current study were often engaged in relaxing or leisure activities during the retention period. Moreover, while young adults could have many competing demands of their attention in everyday life, the results of Study 1 suggest that their attentional demands are not greater than those of older adults. Thus, the findings of Study 2 perhaps demonstrate how easily it is to get distracted in everyday life. Young adults' working memory capacity and executive functioning allows them to perform well on monitoring tasks in the laboratory, as they do not have to maintain the activation of intentions for long periods of time (Einstein & McDaniel, 2014). However, while 10 minutes is a relatively short time frame in the real world, it is sufficiently long enough to produce deficits, perhaps indicating that individuals can become re-absorbed with their ongoing activity quite quickly. Out of the three types of

PM tasks currently investigated (i.e., event-based, scheduled time-based, and time-check tasks) the only PM tasks that both age groups struggled with in everyday life were time-check tasks. Future investigations should consider how long PM intentions can be retained in daily life before deficits are evident, not only in older adults, but also in young adults.

As the findings from Study 1 suggest that motivation may contribute to the age-PM paradox, its potential influence in the naturalistic performance shown in Study 2 will be discussed. Aberle et al. (2010) suggested that young adults' suboptimal performance in naturalistic settings can be attributed to their low level of motivation to complete the PM tasks. Aberle et al. (2010) also argued that motivation levels might be particularly low when course credit is the incentive given to perform the PM tasks, as is typically the case when undergraduate students compose the entire young adult sample. Moreover, by providing monetary incentive to their young adult sample, Aberle and colleagues were able to eliminate the age benefit in naturalistic settings. However, the young adult sample in Study 2 consisted of both undergraduate students and young professionals, and the latter was given the same monetary incentive as the older adults. Additionally, the PM tasks in both settings were set by the experimenter, as opposed to participants' own PM tasks, therefore participants should arguably have similar levels of motivation in terms of task completion, since the consequence of a failed PM task is minimal in both settings. Anecdotal evidence suggests that at least some young adults were quite motivated to complete, or pretend to complete, the PM tasks in naturalistic settings. Upon study completion, one young participant confessed to contriving one of his event-based tasks. The participant was to take a photo of when he "tapped on" with his transit card to access the train station on his morning commute. The participant, however, forgot to do so. When he realised his forgetfulness while at work, rather than take a photo indicating he now remembered his forgotten task, which was an option explained to all participants, this young man searched online for an image of the transit card reader. He then staged the photo to look as though he was “tapping on” when in reality his card was carefully positioned in front of a computer monitor! This account shows a great deal of effort and the lengths to which even the young adults went in order to appear as though they had not forgotten to complete a PM task. Differences in motivation do not appear to explain the reduced performance of young adults in naturalistic settings.

Another indication that motivation is not the primary determinant of young adults’ naturalistic performance is that the magnitude of the decline in their performance was influenced by the nature of the PM cue. When consideration is given to the nature of the PM cue, it is evident that the decline of young adults’ naturalistic performances was greater on time-based tasks than on event-based tasks. Intriguingly, the type of time-based task did not differentially affect young adults’ performance in either setting. Within each setting, there was no meaningful difference between their performance on scheduled time-check tasks and their performance on time-check tasks. Young adults performed reasonably well on both time-based tasks in the laboratory, and they performed poorly on both time-based tasks in naturalistic settings. This lack of performance difference is not that surprising in the laboratory, where scheduled time-based tasks are still quite abstract, despite the simulated contextual cues provided by Virtual Week. Older adults also did not benefit from these simulated contextual cues; their performances on both time-based tasks were also similar in the laboratory. Given this lack of differentiation between the performances on scheduled time-based tasks and time-check tasks in the laboratory, the question is raised of whether the distinction between the two variants of time-based tasks was justified.

Although there is some doubt when only considering laboratory performance, the distinction between the two variants of time-based tasks was instrumental in detecting the variation of age differences in naturalistic settings. One of the key outcomes of Study 2 is how much older adults outshine their younger counterparts on scheduled time-based tasks in everyday life. Conversely, this is not the case when completing time-check tasks. Older adults' performance is strikingly different on these two variants in naturalistic settings. Distinguishing between scheduled time-based tasks and time-check tasks reveals that older adults' performance is not universally improved when they are in naturalistic settings. In terms of everyday life performance, scheduled time-based tasks are the only PM task type where older adults outperform the young adults. To speculate on what might explain this finding, it is important to consider where older adults demonstrate improved PM performance in naturalistic settings compared to the laboratory. A major finding of Study 2, which partially confirmed the second alternative predication, is that older adults perform well on naturalistic PM tasks when the tasks have an event-like quality. One possibility is that older adults are better able than young adults to use the available environmental support afforded to such tasks in order to facilitate their prospective remembering.

In everyday life, the specific target cues of event-based tasks and scheduled time-based tasks do not occur in isolation, but instead are accompanied by many contextual cues. For example, the task of remembering to take a photo when using your transit card is preceded by the walk to the train station, approaching the ticket machine, seeing other passengers use their transit cards, etc. These situational cues can increase the activation of the specific target cue, promote spontaneous retrieval of PM intentions, and can allow for more detailed and advanced planning in many cases (Kuhlmann & Rummel, 2014). In naturalistic settings, it would be adaptive to use the event-like quality of scheduled time-based tasks to encode these tasks using the associated context, taking advantage of the environmental supports (Cook et al., 2005). One speculation is that older adults could be *recoding* the specified time cue as an event cue in everyday life. For example, forming an intention to complete a task at 6 p.m. could be recoded as remembering to complete said task when the evening news comes on the television. By connecting a specific time-of-day cue to other events in their lives, older adults could potentially be able to rehearse schedule time-based tasks more effectively. Furthermore, the rehearsal of PM tasks could also be enhanced by the structure of older adults' day-to-day lives.

Older adults are thought to have a more structured lifestyle compared to young adults (Aberle et al., 2010; Phillips et al., 2008). Anecdotally, this was also evident in Study 2 as older participants were able to foresee their agenda for the upcoming week, whereas young adults' schedule appeared to be more flexible. The routine nature of their everyday lives could allow older adults to better predict the circumstances in which they will encounter a target cue for a PM task, thus allowing for enhanced encoding of their intentions. Their structured lifestyle would especially benefit the completion of scheduled time-based tasks as older adults could more accurately predict where they will be and what they will be doing when the appropriate time for task completion occurs (Kuhlmann & Rummel, 2014; Sohn et al., 2005). Older adults' rehearsals of PM tasks would, therefore, also be more accurate. As older adults were found in Study 1 to rehearse PM tasks more frequently than young adults, and to do so for PM tasks in the distant future, it is reasonable to assume that the accuracy of their rehearsals is important in the successful completion of their PM tasks. Although the flexible nature of young adults' everyday lives could seemingly allow for the re-prioritisation of PM tasks, deviation from previously developed plans regarding task completion leads to errors in PM performance (Hannon & Daneman, 2007; Logie et al., 2011). Therefore, the structured and routine nature of older adults' everyday lives likely influences their ability to incorporate PM tasks into their daily activities. The apparent incorporation of event-based and scheduled time-based PM tasks into older adults' routine, as well as the use of environmental supports and frequent rehearsals, could explain why older adults perform so well on these PM tasks in everyday life. Older adults' superior performance on scheduled time-based tasks compared to young adults in naturalistic settings perhaps shows that older adults have greater insight and metacognitive awareness in regards to their PM capabilities and how to complete this type of PM task.

Older adults have greater experience in completing PM tasks than young adults, which potentially results in a greater understanding of not only their PM abilities, but also how to best complete the various types of PM tasks (Ihle et al., 2012; Schnitzspahn et al., 2011; Schnitzspahn et al., 2015). Some evidence consistent with this notion comes from older adults' frequent use of rehearsals as a possible compensatory strategy, and also from the different manner in which older adults use external reminders. Older adults have been found to effectively use external cues and to alter their use of external and conjunction cues after an instance of memory failure (Maylor, 1990; Phillips et al., 2008). Although the findings of Study 1 suggest that young and older adults largely do not rely on external cues to trigger completion of PM tasks, there was an important age difference observed when participants reported using external cues. Intriguingly, older adults used a wide variety of external cues, but the external cue that young adults most frequently utilised was a clock for monitoring the time. This suggests that young adults do not reflect on which external cue will best facilitate PM task completion, but instead young adults rely on their ability to monitor the passing of time and subsequently check the time throughout the day to trigger retrieval of their PM intentions. Perhaps young adults are overconfident in their own ability to effectively monitor the passage of time. A recent study by Mioni and Stablum (2013) showed that when permitted to freely monitor a clock during a time-monitoring task (i.e., pressing a designated key every 5 minutes), older adults checked the clock more frequently than young adults. Although this compensatory strategy was ineffective for older adults, this behaviour is an indication that older adults possibly have greater insight into how difficult it is for them to complete PM tasks when they are reliant solely on fragile monitoring processes. In the study by Mioni and Stablum (2013), the time-monitoring skills of young adults were sufficient as demonstrated by their high PM accuracy. However, as their performance was assessed in the laboratory, young adults were only required to use their monitoring skills for a relatively short period of time. In naturalistic settings, where the retention period is of a longer duration, it is less feasible to rely on such cognitively demanding processes. Overconfidence in their monitoring abilities could potentially explain young adults' poor performance across all time-based tasks in everyday life.

The poor performance of young adults on both variants of time-based tasks in naturalistic settings potentially indicates that young adults are unable to utilise the environmental support afforded to scheduled time-based tasks to facilitate intention retrieval. One possible explanation is that there is less contextual support for young adults' scheduled time-based tasks because they are not able to predict the context in which they will occur due to having a less structured lifestyle that is more subject to change than older adults'. If young adults' daily lives are less routine, then efficiently planning scheduled time-based tasks is difficult. Another possibility is that young adults are overconfident in their PM abilities and thus they are not applying sufficient strategies to complete these PM tasks. Young adults could attribute memory lapses to external causes or interpret a memory lapse as a once-off occurrence (Maylor, 1998; Vestergren & Nilsson, 2011). Upon study completion, one young participant relayed to the experimenter that she forgot the study phone at home one morning. As she realised that she would not be returning in time for the first scheduled time-based task, the participant called her mother to ask if she would be at home at the scheduled time of 11 a.m. in hopes that her mother could complete the quiz on her behalf. The mother agreed and the participant said she would call again at 11 a.m. to instruct her mother on how to complete the quiz. Despite her recent memory lapse, the participant thought she would remember, but lo and behold, around 11:15 a.m. she realised she had forgotten to call her mother. When her mother answered the phone, she replied, "I've been waiting!"

The findings of Study 2 demonstrate that older adults' PM performance benefits when there are environmental supports available, when the tasks can be incorporated into their structured lives, and when compensatory strategies such as rehearsals can be efficiently implemented. However, when PM task completion is reliant on monitoring processes, such as on time-check tasks, older adults' performance suffers. Young adults appear to struggle with scheduled time-based tasks in everyday life possibly due to their underestimation of the difficulties in completing such tasks or the inability to incorporate the tasks into a routine. Young adults do not appear to adequately utilise the environmental supports afforded to scheduled time-based tasks in naturalistic settings, and instead they continue to rely on fragile monitoring processes for PM task completion. This finding is essential to our understanding of the age-PM paradox and the potential factors that differentially contribute to PM performance in naturalistic settings for both young and older adults.

6.2 Implications and Contributions of the Findings

Theoretical Implications

The research conducted in this thesis raises serious questions about how PM performance is currently assessed and subsequently compared across laboratory and naturalistic settings. The prevailing categorisation of PM tasks as either event-based or time-based has led to substantial progress in our conceptual understanding of PM and its underlying cognitive processes (Einstein & McDaniel, 1990). However, previous studies have argued that the distinction between event- and time-based PM tasks fail to explain the age-PM paradox (Henry et al., 2004; Park et al., 1997; Rendell & Craik, 2000). The current research proposed the additional distinction between the two time-based task variants (i.e., scheduled time-based and time-check tasks) based on the proposal that these PM tasks are potentially completed through different intention retrieval processes, especially in naturalistic settings. In the literature, older adults have been shown to perform well on scheduled time-based tasks in everyday life (Henry et al., 2004; Kvavilashvili & Fisher, 2007; Niedźwieńska & Barzykowski, 2012; Schnitzspahn et al., 2011). However, would older adults still show improvement in naturalistic settings when the PM task requires them to rely on strategic monitoring skills, with minimal environmental support available? According to the multiprocess model (McDaniel & Einstein, 2000) and Craik's theory of memory (1986), memory failures are more likely to occur when the individual is reliant upon self-initiated intention retrieval or strategic monitoring processes. Additionally, older adults are thought to be more susceptible to PM failures when strategic monitoring processes are required, and greater age differences have been observed on such PM tasks (Einstein & McDaniel, 1990; Einstein et al., 1995). Thus, the separation of the two types of time-based tasks was essential in the investigation of the age-PM paradox, and represents a significant conceptual contribution to the literature.

Of the three task types investigated, time-check tasks were the only PM tasks where older adults did not demonstrate improved performance in naturalistic settings compared to laboratory settings. Regardless of the setting, older adults showed poor performance when they had to rely on their monitoring skills. Astonishingly, there was no age difference in the performance of time-check tasks in everyday life because young adults performed as poorly as the older adults in naturalistic settings. In contrast, both age groups demonstrated strong performance on event-based tasks in everyday life. As event-based tasks in naturalistic settings often have salient cues and are accompanied by environmental support, it is probable that both age groups completed these PM tasks through spontaneous retrieval processes. Taken together, these findings suggest that PM can be achieved through both spontaneous and strategic monitoring processes, which fits the multiprocess framework of PM. The findings also illustrate that monitoring processes are indeed quite fragile (Einstein & McDaniel, 2014). However, it remains unclear why young adults were not able to achieve the level of performance they exhibited when in the laboratory, and this remains an important area to be addressed by further research. One possibility is that young adults found it challenging to maintain their monitoring efforts over the longer timespan of the naturalistic study period compared to the shorter laboratory session.

In consideration of the overall PM performance pattern in each setting, the age-PM paradox was evident in Study 2 with consistent age-related deficits observed on all task types in the laboratory, and no such deficits observed in naturalistic settings. As previously noted, in everyday life, both age groups demonstrated strong performance on event-based tasks and poor performance on time-check tasks. However, young and older adults' naturalistic performances of scheduled time-based tasks were not comparable. On the contrary, their performances were in complete opposition; the large age deficit observed in the laboratory became a large age benefit in everyday life. This begs the question, what is it about scheduled time-based tasks that leads to such contrasting age differences in everyday life? Are young and older adults retrieving their intentions for scheduled time-based tasks through different processes in naturalistic settings? PM performance is thought to be more susceptible to errors when individuals rely solely on strategic monitoring processes as opposed to more spontaneous intention retrieval processes, which is possible when there is environmental support available (Craik, 1986; G. Smith et al., 2000). Young adults' performances suggest that they might rely on strategic monitoring processes for both types of time-based tasks. Alternatively, older adults' exceptional performance on scheduled time-based tasks in everyday life, suggests that they are able perhaps to use the environmental support, their structured lives, or their metacognitive awareness to retrieve these PM intentions through spontaneous retrieval processes or by implementing appropriate strategies. The findings of this research open many new avenues for PM research, particularly in regard to intention retrieval processes in naturalistic setting and its role in the age-PM paradox. Future investigations could examine the potential costs induced in the ongoing task by the performance of the PM tasks and how the cost might differ across the three types of PM tasks (Zimmermann & Meier, 2010). The dramatically different pattern of age differences across settings also highlights the importance of assessing PM in naturalistic settings in order to update and further test PM theories that were based solely on laboratory investigations. Although the current research did not set out to directly test the multiprocess framework of PM, the results lend further support for this theoretical model.

Methodological Implications

The many methodological strengths of the current research project have significantly advanced the field of PM. Perhaps the greatest impact stems from the methodological approach of Study 2, which addressed the flawed comparison of disparate tasks across settings as well as the need for objective naturalistic measures of PM. The findings of Study 2 demonstrate the palpable importance of systematically assessing PM using a range of tasks. The rigorous assessment of PM tasks that varied by cue type was particularly valuable in naturalistic settings. There are several challenges associated with designing a naturalistic study that assesses the performance of event-based tasks, such as establishing controlled tasks that can be objectively verified. As such, the typical comparison made across settings in the existing literature has been between laboratory performance on event-based tasks and naturalistic performance on scheduled time-based tasks. Previous investigations that focused only on time-based tasks in an attempt to match PM cue type across settings were also flawed as no distinction was made between the two variants of time-based tasks despite the fundamental differences between these tasks (Schnitzspahn et al., 2011). This thesis argued that in order to clarify the age-PM paradox it was necessary to address these methodological shortcomings in the existing literature and to develop naturalistic measures that allowed for more appropriate comparisons of PM performances across settings. One of the alternative predictions of Study 2 was that by matching PM tasks by cue type across laboratory and naturalistic settings, the age-PM paradox would be eliminated. However, the same pattern emerged with age-related deficits in the laboratory that were not apparent in naturalistic settings. Furthermore, distinctive patterns of PM performances, both across task types and across settings, were discovered. The findings from Study 2 emphasize the need for future studies to carefully consider the different types of PM tasks when investigating age differences in PM.

Another strength of Study 2, which has important methodological implications, is the assessment of performance on these various PM tasks using the same sample of young and older adults in both laboratory and naturalistic settings. Only a handful of previous studies of the age-PM paradox have systematically assessed laboratory and naturalistic PM using the same sample in both settings (Kvavilashvili et al., 2013; Niedźwieńska & Barzykowski, 2012; Rendell & Thomson, 1999; Schnitzspahn et al., 2011). This left the role that individual differences might play in the apparent contrasting performances unresolved. The results of Study 2 corroborate the findings of these few existing investigations to reveal that even when the same sample is tested in across settings, the dissociation between laboratory and naturalistic performances of PM still exists. To tease apart what factors may or may not be contributing to the age-PM paradox, future research should continue to investigate PM performances on a variety of laboratory and naturalistic PM tasks within the same sample. For example, future investigations could consider cue focality, the demands of the ongoing task, and whether PM is associated with a cost to the performance of the ongoing task.

The development of objective naturalistic measures for all three types of PM tasks is a huge contribution to the study of everyday PM. No longer will naturalistic studies have to rely on the participants to accurately remember and report their PM performances. While these novel measures are still in their infancy and could benefit from further development, they show great promise and could be utilised for many more investigations of naturalistic PM. For instance, the findings of Study 1 suggest further consideration should be given to the effect of motivation on everyday PM performance and its role in the age-PM paradox. By manipulating the instructions or potential performance feedback given to the participants through the smartphone application, researchers will be able to further examine the effect of motivation on naturalistic PM, as well as any age differences in motivation. The smartphone application also has the potential to become an appropriate baseline and outcome measure for interventions aimed to improve PM performance in daily life.

Increasingly, smartphone applications and other electronic memory aids are used to assist with difficulties in everyday memory. As the use of smartphones becomes more ubiquitous in modern society, their potential to enhance the performance of PM tasks in everyday life becomes greater (Fernandez, Johnson, & Rodebaugh, 2013; Sohn et al., 2005; Vemuri & Bender, 2004; Wang & Pérez-Quiñones, 2014). The prevalence of smartphones is a relatively recent occurrence, so although it is a growing area of interest, there are not yet many research studies that focus on the evaluation of smartphone applications that are designed to improve PM performance (Ferguson, Friedland, & Woodberry, 2015; Recio-Rodríguez et al., 2014; Van den Broek, Downes, Johnson, Dayus, & Hilton, 2000). While researchers have long recommended the use of external memory aids to facilitate PM, there has been some hesitation regarding the use of electronic aids and smartphone applications in the assessment and measurement of PM. In fact, there has generally been an active avoidance of incorporating such technology into naturalistic PM studies, so as to avoid an effect of unfamiliarity in the elderly population (Ellis & Kvavilashvili, 2000). One study that did use mobile phones to assess naturalistic event-based tasks, and notably also found an age-related benefit, restricted their older adult sample to those who used a mobile phone regularly (Niedźwieńska & Barzykowski, 2012). Although intuitively one might speculate that young adults' greater familiarity with smartphones might benefit their PM performance, one concern is that the novelty of using a smartphone might cause older adults to pay more attention to the device, and thus it is actually older adults' PM performance that benefits. Such criticism could be made of Study 2 as there was a vast difference between the age groups in their reported familiarity and usage of smartphones. However, there are two points that address this concern. Firstly, carrying the smartphone throughout the day could serve as a physical reminder, but this would also be true for the young adults. The smartphone application was installed on a study device and not on participants' own phones, and the latter would be less associated with the study or PM task completion. Therefore, all participants carried a new study device which had the potential to act as a trigger for the young as well as the older adults. Secondly, and perhaps more importantly, the pattern of the results of Study 2 are an indication that familiarity with smartphones did not have an overall effect on PM performance. If being less accustomed to using or carrying around a smartphone led older adults to devote more attention to the completion of the PM tasks, then one would expect older adults' performance to be elevated overall, not to vary according to PM cue type. However, this was not the case as is evident by the distinct pattern of performance between PM tasks found within the older adults in naturalistic settings. Older adults performed poorly on naturalistic time-check tasks, and while this performance was comparable to their laboratory performance of such tasks, it was much worse than their naturalistic performance of scheduled time-based tasks. Taken together, the lack of familiarity with smartphones did not appear to differentially affect young and older adults' performance on PM tasks. Future PM research should capitalise on the possibilities that new technology has to offer, particularly in the area of naturalistic assessment.

Rapid advancements in technology will greatly benefit the measures and designs of future PM studies, as is evident by the current research. The capabilities of existing handheld devices and wearable technologies are staggering. Importantly, these technologies are also becoming more intuitive and user-friendly with interfaces that are simple and relatively straightforward to use. This is a crucial aspect to consider when designing a study with an elderly population. In the current research, great consideration was given to the features of the smartphones and the Quiz application to ensure that difficulties with managing these functions did not lead to false errors in PM. For example, the size of the screen, font, and response buttons were designed to minimise the effects of poor visual perception and fine motor skills (Glasgow & Higgins, 2013). The frequency and duration of the alert were chosen in an effort to address potential difficulties in auditory perception thought to be common in older adults (Conner & Lehman, 2012). These considerations likely contributed to the demonstrated proficiency of older adults in the operation of a smartphone and its applications, despite having less experience and familiarity with the devices. New technologies can now capture naturalistic human behaviours and experiences more accurately and with richer detail than ever before. No doubt such technologies will be at the forefront of future naturalistic studies of PM.

Applied Implications

For the general population, the take-home message of this research is that failures in everyday PM are more likely to occur when we rely solely on our monitoring skills for intention retrieval and task completion. This is true for both young and older adults as illustrated by their poor performances on time-check tasks in naturalistic settings. Thus, to avoid the dangers associated with failing to remember and complete PM intentions, individuals are recommended to approach prospective remembering with strategies that promote the spontaneous retrieval of PM intentions. In everyday life, young and older adults develop a variety of scaffolding and supports to ensure that their PM intentions are performed accurately. Although there are no specific strategies that have been definitively determined to promote the spontaneous retrieval of PM intentions in everyday life, there are several helpful suggestions based upon the findings of the current research as well as those in the existing PM literature.

Regardless of age, individuals' PM performance benefits from the presence of an external trigger that is associated with the PM tasks. However, many everyday PM tasks must be performed at set times of the day, for which there is no explicit target cue that would trigger spontaneous retrieval of PM intentions. By using contextual information and environmental supports, it is possible to link such PM tasks with salient cues in one's environment, which in turn can improve the performance of these PM tasks (Cook et al., 2005; Craik, 1986; Gilbert, 2015; Kuhlmann & Rummel, 2014; Maylor, 1990). This is especially relevant for younger adults who perhaps are overconfident in their monitoring skills when they must perform a PM task at a scheduled time. In the same vein, individuals are encouraged to incorporate their knowledge of the context in which PM tasks are meant to occur into their planning of future intentions. Forming future intentions and thinking of upcoming intentions should be enriched with as much contextual detail as possible. However, there is a caveat with this last suggestion. If the context surrounding task completion is likely to change, it would not only be difficult to implement detailed planning of the future intention, but the task is also subject to a higher probability of failure as it will be more difficult to determine or detect the appropriate target cue. For instance, an individual may form the intention to buy milk on the way home from work. When forming the intention, the individual could consider potential triggers such as the sign outside the shopping centre or the aisle in which milk can be found. However, if traffic caused the individual to take a detour on the way home, the target cue would never be encountered and the individual will likely arrive home empty-handed. Thus, increasing the specificity of formulated intentions comes with limitations in terms of its ability to improve everyday PM.

The research undertaken in this thesis not only makes significant contributions to the PM literature and the understanding of naturalistic PM, but it also has implications that reach the everyday lives of young and older adults. PM tasks that require the use of strategic monitoring processes were confirmed to be an area of particular vulnerability for both age groups. Additionally, the results suggest that scheduled time-based tasks can in fact be supported by the familiarity and predictability of one's environment, possibly through the use of conjunction cues or the ability to engage in more specific planning. This thesis reiterates the importance of not relying on one's monitoring skills to complete PM tasks where possible, so as to minimise the risk of PM failure. The current research has advanced the study of everyday PM through its many strengths; however, there are some limitations which should be addressed by future research.

6.3 Limitations and Future Directions

Methodological Considerations

The rigorous assessment and matching of PM tasks in laboratory and naturalistic settings has revealed nuanced age differences in the performance of PM tasks of varying cue types. However, the design of the naturalistic study period could have unintentionally produced naturalistic PM tasks that were less parallel to those in the laboratory than initially intended. The naturalistic study period was divided according to the types of PM tasks, meaning participants completed event-based tasks on separate days from the time-based tasks. This separation was largely due to limitations in the functioning of study's smartphone application (e.g., character limits and programming difficulties). The order of the naturalistic PM measures was counterbalanced to prevent the performances from being unevenly influenced by participants becoming more comfortable or familiar with using the smartphone, especially the older participants. However, in the laboratory measure, participants must complete all three PM task types in the same virtual day and in a short time frame. The high demands of the laboratory PM tasks, which help to avoid ceiling effects, are more likely to reveal an age deficit. Thus, it is possible that the naturalistic measures did not place enough demand on working memory and executive functions to elicit age-related declines in PM. Furthermore, differences in the cognitive load of the PM measures could potentially explain the lack of correlation between the laboratory and naturalistic measures in Study 2. To address this issue, future naturalistic studies on age differences in PM should incorporate all three task types within one real day. The smartphone application created for use in this research project is currently being updated to allow for such investigations. By mimicking laboratory conditions in terms of the demands and multitasking nature of Virtual Week, perhaps the next version of the naturalistic measures will challenge participants and push them to their limits. Testing individuals at their limits enables researchers to identify where vulnerabilities lie in PM, which is crucial since such areas of vulnerability likely lead to failures in PM in everyday life. Given the potential severity of the consequences associated with PM failures, it is vitally important to continue examining the constraints of individuals' PM capacity.

Another limitation of the current research is the lack of cognitive measures outside of PM. In particular, it would be of interest to assess retrospective memory and areas of executive functioning (e.g., working memory, planning, inhibition, and cognitive flexibility) as they could have a moderating effect on PM performance. The current findings suggest that successful completion of PM tasks could be related to one's planning and monitoring skills, therefore executive functions may play an important role in PM performance (d'Ydewalle et al., 2001). However, the research literature on the moderating effect of cognitive functioning on everyday PM performance is quite limited. Recent findings suggest that the relationship between cognitive functioning and everyday PM differs by age group (Schnitzspahn et al., 2015). Level of inhibition, short-term memory, and long-term memory were positively correlated with PM performance in young adults, but this was not the case for the older adults. Additional research is needed to examine the relationships between naturalistic PM performance and the aforementioned areas of cognitive functioning. Specifically, potential age differences in such relationships should be investigated. The inclusion of additional measures of cognitive abilities would provide a clearer picture of the potential contributors to the observed dissociation.

Considerations for Prospective Memory in Old Age

The older adult samples used in the current research project consisted solely of healthy, cognitively-intact older adults. Future directions of research should consider examining less functional older adults to discover any differences in the pattern of PM performances across PM cue types and also across setting. Laboratory measures of PM require participants to complete PM tasks within ongoing activities and situations that are designed to be cognitively demanding and taxing on working memory capacity. Neuroimaging studies have found that individual differences in working memory capacity are associated with the rostral prefrontal cortex (Gilbert et al., 2006; Minamoto, Yaoi, Osaka, & Osaka, 2015). Additionally, there is a consistent relationship between the activation of this brain region and the performance of PM tasks (Burgess, Gonen-Yaacovi, & Volle, 2011; Okuda et al., 2007). From a neurological perspective, this could explain why age deficits are observed in the laboratory. Poor PM performance could result from the competition for neural resources that arise from attempting to complete PM tasks while engaged in an ongoing task that also requires working memory and other executive functions. By contrast, PM performance in naturalistic settings often consists of more manageable tasks that are spread out in non-cognitively demanding scenarios. Therefore, neurologically intact older adults should be able to perform reasonably well in naturalistic settings when the neural resources can be occupied by the PM task at hand. Older adults with mild cognitive impairments, however, have been found to exhibit more consistent deficits in PM, regardless of the setting in which the assessment takes place (Thompson, Henry, Withall, Rendell, & Brodaty, 2011; Will et al., 2009). McFarland and Glisky (2009) found that older adults with high frontal lobe functioning not only outperformed those with low-frontal functioning, but their performance was similar to that of young adults. Thus, there is evidence to suggest that the onset of decrements in frontal functioning could correspond with deficits in PM of older adults. Future research could investigate this possibility through a longitudinal study that examines if or when naturalistic PM performance declines in older adults and whether there is any variation in the declines according to the type of PM task. For example, is there a point at which older adults no longer demonstrate superior performance on event-based and scheduled time-based PM tasks? A longitudinal study of older adults could also help to identify the appropriate time to apply interventions in order to prolong adequate PM performance and stave off impairment.

Conclusion

To clarify the contrasting age effects observed in laboratory and naturalistic settings, the current research investigated factors that potentially contribute to the age-PM paradox. Consideration was given to contextual factors, such as the demands of everyday life, motivation, and the use of external aids, as possible factors for the age difference observed in naturalistic PM performance. Dissimilarities between young and older adults in terms of demanding lifestyles and their usage of memory aids were not substantial. Compared to their young counterparts, older adults more frequently viewed their PM intentions as important, which could indicate that motivation contributes to the improved PM performance of older adults in naturalistic settings. Initial evidence suggests that both age groups spontaneously retrieve their PM intentions quite frequently in everyday life. However, older adults were also found to rehearse their PM intentions more often than young adults. It is possible that through their experiences, older adults develop a greater metacognitive awareness of their PM abilities, and thus, employ compensatory strategies in everyday life. The research identified age differences in the planning of PM tasks as a potential factor of the age-PM paradox.

Further consideration was given to the lack of task comparability across settings in the existing PM literature as a probable factor of the age-PM paradox. This research was the first to conduct a thorough assessment of PM performance using tasks that were matched according to PM cue type and using the same participant sample in both laboratory and naturalistic settings. The novel naturalistic measures developed for this thesis significantly advance PM research as the overwhelming majority of naturalistic studies have only captured PM performance on one type of PM task due to difficulties in verification and the lack of distinction between the time-based task variants. Despite addressing the methodological issues that were prevalent in most investigations of age effects on PM, the age differences found in the laboratory were vastly different from the age differences found in naturalistic settings. Consistent with the prevailing literature, young adults demonstrated superior performance on event-based, scheduled time-based, and time-check tasks in the laboratory. However, young adults did not outperform older adults on any naturalistic PM task. No age differences were observed on event-based or time-check tasks, and a large age benefit was found on scheduled time-based task in naturalistic settings. Older adults demonstrated improved performance when the PM tasks were accompanied by environmental support, when the tasks could be incorporated into their routine, and when compensatory strategies such as rehearsals could be implemented. In contrast, older adults' PM performance did not improve in naturalistic settings when the PM task required effortful monitoring processes for successful completion. Thus, the current research suggests that compared to young adults, older adults may be more proficient in utilising the environmental support available in naturalistic settings, or they may be more aware that such support is necessary. The relatively novel distinction between scheduled time-based tasks and time-check tasks, which is rarely considered in the PM literature, was particularly important in the examination of older adults' naturalistic PM performance. A key finding was that older adults exhibited a dramatic improvement on scheduled time-based tasks in everyday life, but performed consistently poorly on time-check tasks across settings. While the traditional event- versus time-based task distinction showed a marked difference in the naturalistic PM performance of young adults, the distinction of the time-based task variants was instrumental in understanding older adults' naturalistic PM performance. The investigations undertaken in the current thesis significantly contribute to the literature on PM and ageing. The unique findings provide greater understanding of age effects on PM, particularly in naturalistic settings. The current research has clear theoretical and methodological implications as well as provides a foundation for future investigations of the age-PM paradox.

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A. Ethics and Recruitment Materials

A.1 Ethics Approval

ACU
AUSTRALIAN CATHOLIC UNIVERSITY

Human Research Ethics Committee

Committee Approval Form

Principal Investigator/Supervisor: PERENDELL Melbourne Campus

Co-Investigators: Melbourne Campus

Student Researcher: Melissa Bugge, Clare Ryrie Melbourne Campus

Ethics approval has been granted for the following project:
Remembering everyday tasks

for the period: 03.05.10 - 30.08.10

Human Research Ethics Committee (HREC) Register Number: V2010 37

The following <u>standard</u> conditions as stipulated in the *National Statement on Ethical Conduct in Research Involving Humans* (2007) apply:

(i) that Principal Investigators / Supervisors provide, on the form supplied by the Human Research Ethics Committee, annual reports on matters such as:
- security of records
- compliance with approved consent procedures and documentation
- compliance with special conditions, and

(ii) that researchers report to the HREC immediately any matter that might affect the ethical acceptability of the protocol, such as:
- proposed changes to the protocol
- unforeseen circumstances or events
- adverse effects on participants

The HREC will conduct an audit each year of all projects deemed to be of more than low risk. There will also be random audits of a sample of projects considered to be of negligible risk and low risk on all campuses each year.

Within one month of the conclusion of the project, researchers are required to complete a *Final Report Form* and submit it to the local Research Services Officer.

If the project continues for more than one year, researchers are required to complete an *Annual Progress Report Form* and submit it to the local Research Services Officer within one month of the anniversary date of the ethics approval.

Signed: .... Date: ....03.05.2010...........
(Research Services Officer, Melbourne Campus)

From: Gabrielle Ryan [mailto:Gabrielle.Ryan@acu.edu.au]
Sent: Monday, 5 December 2011 11:38 AM
To: Peter Rendell
Subject: Modification

Dear Peter Gregory,

V2010 37
Remembering everyday tasks

Thank you for submitting the request to modify form for your project V2010 37 Remembering everyday tasks .

The Chair of the Human Research Ethics Committee has approved the following modification(s):
* Change of student investigator from Melissa Bugge and Claire Ryrie (deleted from the project) to Susan Sapega.
* Addition of co-supervisor Professor John Gleeson
* Revision to the take home task by replacing the original PDA device with a GPS device

We wish you well in this ongoing research project.

Kind regards,
Gabrielle Ryan

Ethics Officer | Research Services
Office of the Deputy Vice Chancellor (Research)
Australian Catholic University
Locked Bag 4115, Fitzroy, VIC, 3065
T: 03 9953 3150 F: 03 9953 3315

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AUSTRALIAN CATHOLIC UNIVERSITY

Human Research Ethics Committee
Modification Approval Form

Principal Investigator/Supervisor: Professor Peter Rendell
Co-Investigators: Skye McLennan, John Gleeson, Nathan Rose
Student Researcher: Susan Sapega

Ethics approval has been granted for the following project:
Remembering everyday tasks

for the period: 31/12/2016

Human Research Ethics Committee (HREC) Register Number: V2010 37

Modification Approved 15/05/2014

The Chair of the Human Research Ethics Committee has approved the following modification(s):

1. Addition of student investigator - Ms Renee Gergis.
2. Revise the take home component of the project.
3. Add two additional prospective memory (PM) measures (The Cambridge prospective memory test and the memory for intentions screening test).

K. Pashley.

Signed: .... Date: .... 04/03/2016.....
(Research Ethics Officer, McAuley Campus)

From: Ms Pratigya Pozniak
To: Peter Rendell; John Gleeson; Susan Randall; Nathan Rose; Skye McLennan; Ms Melissa Bugge; Ms Clarw Ryrie; Ms Sheree Amon; Ms Alexandra Felix-Faure
Cc: Pratigya Pozniak
Subject: V2010 37 Extension approved
Date: Wednesday, 13 January 2016 2:50:18 PM

Dear Peter Gregory,

Ethics Register Number : V2010 37
Project Title : Remembering everyday tasks
Data Collection Date Extended : 31/12/2016

Thank you for returning the Ethics Progress Report for your project.

The Deputy Chair of the Human Research Ethics Committee has approved your request to extend the project. The new expiry date for the project is the 31/12/2016 .

We wish you well in this ongoing project.

Kind regards,
Ms Pratigya Pozniak

Ethics Officer | Research Services
Office of the Deputy Vice Chancellor (Research)

, , ,
T: F:

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A.2 Information Letter

ACU
AUSTRALIAN CATHOLIC UNIVERSITY

PARTICIPANT INFORMATION LETTER

PROJECT TITLE: Remembering everyday tasks
PRINCIPAL INVESTIGATOR: Prof Peter Rendell
SUPERVISOR: Dr Skye McLennan
ASSOC. RESEARCHERS: A/Prof Julie Henry, Prof Thomas Suddendorf, Prof Michael Corballis
STUDENT RESEARCHER: Miss Susan Sapega; Miss Renee Gergis
STUDENT'S DEGREE: Masters of Psychology (Clinical)/Doctor of Philosophy; Bachelor of Psychological Science (Honours)

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?
This is a research project designed to study prospective memory. Prospective memory refers to remembering to carry out future intentions such as keeping appointments or taking medication.

Who is undertaking the project?
Susan Sapega is completing this study as part of her research project for the Masters of Psychology (clinical) / Doctor of Philosophy degree. Renee Gergis is completing this study as part of her Bachelor of Psychological Science (honours) degree. The project is part of ongoing research investigating prospective memory by Professor Peter Rendell (School of Psychology, Australian Catholic University).

Are there any risks associated with participating in this project?
There are no foreseeable risks in participating in this project.

What will I be asked to do?
During the session we will ask you a few background questions about age, gender, years of education and general health. We will then ask you to complete several short paper and pencil tasks, such as word solving puzzles and memory tests. One task requires that you read words aloud. We will need to record your responses for this task via audiotape in order to ensure accurate scoring. We are also interested in learning more about how you personally have been feeling lately, so we will ask you to complete a short questionnaire that asks you to rate your mood and feelings over the last week. Participants will complete a task on a computerised game board. As you move around the board, you will be given options for daily activities, and you will be required to indicate your choice of activity. In addition, you will be given things to remember to do as you move around the board.

Some participants will be asked to complete a take home task. If you agree to participate in the take home task, you will be given the option to use your own phone or one of our mobile phones which functions as a multiple choice questionnaire completed in real time. You will be prompted about three times a day for up to six days, to answer a few questions. You will also be asked to take photos with the phone to show tasks you have completed. Only those who are comfortable with the mobile phone will be asked to participate. Participants will be given a briefing during testing and a chance to practice the first questionnaire. You will also be provided with a contact phone number in case assistance is needed during the six day period. Participants will meet very briefly with the researcher at the end of this period in order to transfer data and/or return the study phone.

How much time will the project take?
Participants will be asked to complete a single testing session of two to three hours, during which there will be opportunities for taking breaks. The testing session will either be at ACU's Melbourne Campus or at a mutually convenient place that may include your home. Participants will be reimbursed up to $30 for their involvement in this study.
For the take home component, participants will be required to answer questionnaires on mobile phones for up to six days after the initial testing session. The total amount of time required to complete the questionnaires each day will be no more than 5 minutes per day.

What are the benefits of the research project?
There are no immediate benefits to the participant. Broadly, however, this project will provide a theoretical understanding of encoding strategies within prospective memory. It will also be one of the first studies to assess these strategies in real life situations, as compared to tests undertaken in the lab.

Can I withdraw from the study?
Participation in this research project is voluntary. You are free to withdraw from the study at any stage without giving any reason. If you are an ACU student withdrawal from this study will in no way affect your ACU studies. Confidentiality will be maintained during the study and in any report.

Will anyone else know the results of the project?
All participants will be given a code and names will not be retained with the data. The students will be reporting the findings in a thesis and we plan to also report the findings at a conference and/or in a scientific journal. It is emphasized that individual participants will not be able to be identified in any report of the study, as only aggregate data will be reported.

Will I be able to find out the results of the project?
Findings of the study will be made available to participants upon request.

Who do I contact if I have questions about the project?
Any questions regarding this project can be directed to the Principal Investigator: Professor Peter Rendell in the School of Psychology, St. Patrick's Campus (Australian Catholic University, Level 5, The Daniel Mannix Building, Young Street, Fitzroy 3065, phone 03 9953 3126).

ACU
AUSTRALIAN CATHOLIC UNIVERSITY

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at Australian Catholic University (approval number V2010 37). If you have any complaints or concerns about the conduct of the project, you may write to the Chair of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Chair, HREC
c/o Office of the Deputy Vice Chancellor (Research)
Australian Catholic University
Melbourne Campus
Locked Bag 4115
FITZROY, VIC, 3065
Ph: 03 9953 3150
Fax: 03 9953 3315
Email: res.ethics@acu.edu.au

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

I want to participate! How do I sign up?

If you are willing to participate please sign the attached informed consent forms. You should sign both copies of the consent form and keep one copy for your records and return the other copy to the staff supervisor. Your support for the research project will be most appreciated.

Yours Sincerely,

______________________	______________________
Susan Sapega Student Researcher	Professor Peter Rendell Principal Investigator
______________________	______________________
Renee Gergis Student Researcher	Dr Skye McLennan Supervisor

Professor Peter Rendell
Tel: 03 9953 3126 **Fax:** 03 9953 3205
Email: peter.rendell@acu.edu.au **Web:** www.acu.edu.au

Dr Skye McLennan
Tel: 03 9953 3124 **Fax:** 03 9953 3205
Email: skye.mclennan@acu.edu.au

Australian Catholic University Limited, ABN 15 050 192 660
Melbourne Campus, 115 Victoria Parade Fitzroy Vic 3065, Australia
Locked Bag 4115 Fitzroy MCD VIC 3065 Australia
CRICOS registered provider: 00004G, 00112C, 00873F, 00885B1

A.3 Consent Forms

CONSENT FORM

Copy for Researcher

TITLE OF PROJECT: Remembering everyday tasks

PRINCIPAL INVESTIGATOR: Professor Peter Rendell

SUPERVISOR: Dr Skye McLennan

ASSOC. RESEARCHERS: A/Prof Julie Henry, Prof Thomas Suddendorf, Prof Michael Corballis

STUDENT RESEARCHERS: Miss Susan Sapega and Miss Renee Gergis

I .... *(the participant)* have read (*or, where appropriate, have had read to me)* and understood the information provided in the Letter to Participants. Any questions I have asked have been answered to my satisfaction. I agree to participate in the activities as outlined in the information letter that involves completing a single testing session of two to three hours. This session will comprise of undertaking several short pencil and paper tests, playing a computerised board game, and answering some background questions. I also agree for my responses to one of the background tests to be recorded on audiotape. I understand that I can withdraw my consent at any time (without adverse consequences). I agree that research data collected for the study may be published or may be provided to other researchers in a form that does not identify me in any way.

☐ I agree to participate in an additional take home task involving answering questions and taking photos on a mobile phone for a period of 6 days. I understand that I will be given opportunity to practice using the mobile phone during the testing session (please tick the box if you agree to participate in this task).

NAME OF PARTICIPANT: ....

SIGNATURE .... **DATE** ....

SIGNATURE OF PRINCIPAL INVESTIGATOR (or SUPERVISOR): ....

DATE ....

SIGNATURE OF STUDENT RESEARCHER: ....

DATE ....

AUSTRALIAN CATHOLIC UNIVERSITY

CONSENT FORM

Copy for Participant to Keep

TITLE OF PROJECT: Remembering everyday tasks

PRINCIPAL INVESTIGATOR: Professor Peter Rendell

SUPERVISOR: Dr Skye McLennan

ASSOC. RESEARCHERS: A/Prof Julie Henry, Prof Thomas Suddendorf, Prof Michael Corballis

STUDENT RESEARCHERS: Miss Susan Sapega and Miss Renee Gergis

I .... *(the participant)* have read (*or, where appropriate, have had read to me)* and understood the information provided in the Letter to Participants. Any questions I have asked have been answered to my satisfaction. I agree to participate in the activities as outlined in the information letter that involves completing a single testing session of two to three hours. This session will comprise of undertaking several short pencil and paper tests, playing a computerised board game, and answering some background questions. I also agree for my responses to one of the background tests to be recorded on audiotape. I understand that I can withdraw my consent at any time (without adverse consequences). I agree that research data collected for the study may be published or may be provided to other researchers in a form that does not identify me in any way.

☐ I agree to participate in an additional take home task involving answering questions and taking photos on a mobile phone for a period of 6 days. I understand that I will be given opportunity to practice using the mobile phone during the testing session (please tick the box if you agree to participate in this task).

NAME OF PARTICIPANT: ....

SIGNATURE .... **DATE** ....

SIGNATURE OF PRINCIPAL INVESTIGATOR (or SUPERVISOR): ....

DATE ....

SIGNATURE OF STUDENT RESEARCHER: ....

DATE ....

B. Background Measures

B.1 Background Questionnaire (Study 1)

Background Information

It would be much appreciated if you could provide some brief information about yourself. Your answers will be anonymous and confidential.

1. Initials: ___________________________

2. Date of birth: _______________

3. Gender: Male ☐ Female ☐

4. How many years of full-time education have you had? (for example, if you went to school at 5, left at 15 and did no further study that would be 10 years; if you went to school at 5, left at 18 and did a 3 year course at college or university that would be 16 years).

   Number of years of education: ________

5. Is English your first language? Yes / No

6. If you answered 'No' to the previous question, please circle the response that best describes your English fluency.

1	2	3	4	5	6	7	8	9
Not fluent I have significant problems with reading, writing, listening and speaking.				**Moderately fluent** I have some problems with reading, writing, listening and speaking.				**Highly fluent** My reading, writing, listening and speaking skills are at native-speaker level.

7. Please circle the response that best describes how good you consider your health to be

Very poor			Average			Excellent
1	2	3	4	5	6	7

8. Have you ever been diagnosed with a mental illness or experienced a neurological condition such as a minor stroke?

   ____

B.2 Background Questionnaire (Study 2)

Participant ID Number ………..……… Date ……………….

Demographic Information

1. Age: ……………….. Date of birth: …………………………

2. Gender: ○ Male ○ Female ○ Other

3. How many years of full-time education have you had? (excluding any gaps in time)

   Number of years of education: ………………….

4. a) Is English your first language? ○ Yes ○ No

   b) If not, please circle the number that best describes your English fluency.

1	2	3	4	5	6	7	8	9
Not fluent				**Moderately fluent**				**Highly fluent**

5. How would you describe your state of health:

   a) Today?
   Excellent *Very Good* *Good* *Not Very Good* *Poor*

   b) Over the last month?
   Excellent *Very Good* *Good* *Not Very Good* *Poor*

6. Have you ever experienced a head injury or been <u>diagnosed</u> with a neurological condition (e.g., stroke, epilepsy, Parkinson’s, etc.)? Please specify:

   ……………………………………………………………………………………

   ……………………………………………………………………………………

7. Do you currently have a <u>diagnosed</u> psychiatric illness (e.g., major depression, generalized anxiety, psychosis)? Please specify:

   ……………………………………………………………………………………

   ……………………………………………………………………………………

8. Do you use any visual or hearing aids? Please specify:

   ……………………………………………………………………………………

   …………………………………..…………………………………………………

9. How comfortable are you using a smartphone? Using a tablet or iPad?

…………………………………………………………………………………………....

10. How frequently do you use a smartphone?

○ More than twice a day ○ Once daily ○ Every 2nd day ○ Weekly ○ Never

11. How frequently do you use a tablet or iPad?

○ More than twice a day ○ Once daily ○ Every 2nd day ○ Weekly ○ Never

B.3 Hospital Anxiety and Depression Scale

HADS

Please read each item below and tick the reply which comes closest to how you have been feeling in the past week. Don't take too long with your replies, your immediate reaction will probably be more accurate than a long thought-out response.

1. I feel tense or 'wound up'
- ○ Most of the time
- ○ A lot of the time
- ○ From time to time, occasionally
- ○ Not at all

2. I still enjoy the things I used to enjoy
- ○ Definitely as much
- ○ Not quite so much
- ○ Only a little
- ○ Hardly at all

3. I get a sort of frightened feeling as if something awful is about to happen
- ○ Very definitely and quite badly
- ○ Yes, but not too badly
- ○ A little, but it doesn't worry me
- ○ Not at all

4. I can laugh and see the funny side of things
- ○ As much as I always could
- ○ Not quite so much now
- ○ Definitely not so much now
- ○ Not at all

5. Worrying thoughts go through my mind
- ○ A great deal of the time
- ○ A lot of the time
- ○ Not too often
- ○ Very little

6. I feel cheerful
- ○ Never
- ○ Not often
- ○ Sometimes
- ○ Most of the time

7. I can sit at ease and feel relaxed
- ○ Definitely
- ○ Usually
- ○ Not often
- ○ Not at all

8. I feel as if I am slowed down
- ○ Nearly all the time
- ○ Very often
- ○ Sometimes
- ○ Not at all

9. I get a sort of frightened feeling like 'butterflies' in the stomach
- ○ Not at all
- ○ Occasionally
- ○ Quite often
- ○ Very often

10. I have lost interest in my appearance
- ○ Definitely
- ○ I don't take as much care as I should
- ○ I may not take quite as much care
- ○ I take just as much care as ever

11. I feel restless as if I have to be on the move
- ○ Very much indeed
- ○ Quite a lot
- ○ Not very much
- ○ Not at all

12. I look forward with enjoyment to things
- ○ As much as I ever did
- ○ Rather less than I used to
- ○ Definitely less than I used to
- ○ Hardly at all

13. I get sudden feelings of panic
- ○ Very often indeed
- ○ Quite often
- ○ Not very often
- ○ Not at all

14. I can enjoy a good book or radio or television programme
- ○ Often
- ○ Sometimes
- ○ Not often
- ○ Very seldom

B.4 National Adult Reading Test

National Adult Reading Test (NART)
SECOND EDTION
Word Card
Hazel E Nelson

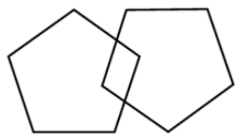
CHORD	SUPERFLUOUS
ACHE	SIMILE
DEPOT	BANAL
AISLE	QUADRUPED
BOUQUET	CELLIST
PSALM	FAÇADE
CAPON	ZEALOT
DENY	DRACHM
NAUSEA	AEON
DEBT	PLACEBO
COURTEOUS	ABSTEMIOUS
RAREFY	DÉTENTE
EQUIVOCAL	IDYLL
NAÏVE	PUERPERAL
CATACOMB	AVER
GAOLED	GAUCHE
THYME	TOPIARY
HEIR	LEVIATHAN
RADIX	BEATIFY
ASSIGNATE	PRELATE
HIATUS	SIDEREAL
SUBTLE	DEMESNE
PROCREATE	SYNCOPE
GIST	LABILE
GOUGE	CAMPANILE

B.5 Mini-Mental State Examination

Screening Tool: The Mini-Mental State Examination (MMSE)

Patient ______________________________ Examiner _________________________ Date __________

Maximum	*Score*	
		Orientation
5		• What is the (year) (season) (date) (day) (month)?
5		• Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3		• Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat until he/she learns all 3. Count trials and record. Trials _______________
		Attention and Calculation
5		• Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3		• Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2		• Name a pencil and watch.
1		• Repeat the following "No ifs, ands or buts."
3		• Follow a 3-stage command: "Take a paper in your hand, fold it in half and put it on the floor."
1		• Read and obey the following CLOSE YOUR EYES.
1		• Write a sentence.
1		• Copy the design shown.



__________ **Total Score**

ASSESS level of consciousness along a continuum __________________________

Alert Drowsy Stupor Coma

"Mini-Mental State." A Practical Method for Grading the Cognitive State of Patients for the Clinician. *Journal of Psychiatric Research*, 12(3): 189-198, 1975.
Used with permission.

more information on reverse

B.6 Addenbrooke's Cognitive Examination-Revised

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C. Material for Prospective Memory Measures

C.1 Complete Electronic Prospective Memory Questionnaire (Study 1)

Overview of Task

Participants who agree to the take home task will be given a personal data assistant (PDA) device, which functions as a multiple choice questionnaire completed in real time. Participants will be asked questions regarding their planned tasks (e.g. "In the last few hours, did you execute any planned tasks?" and "In the last few hours did you forget to do anything that you had planned to do?") and will also be asked to use a Likert-scale (1 to 5 scale) to rate their agreement with statements regarding their emotions (e.g. "In the last few hours I have felt unpleasant." and "Completing this task made me feel good." Participants will be prompted by the PDA to answer questions three times a day during waking hours for a period of 5 days. Participants will be given a briefing during testing and a chance to practice the first questionnaire. Participants will also be given the student researchers' contact details in case they need assistance during the 5 day period.

Note, the script below gives the full set of questions. There will be three times a day when participants are prompted to respond. At each of these occasions, participants only are required to answer a small selection of these questions detailed below. The core questions that are presented at each prompt (regardless of the participants' individual responses) are listed in bold.

Script of Questions Presented on PDA

The first <u>six</u> questions were presented in a randomised order

1) **In the last few hours I have felt HAPPY**
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
2) **In the last few hours I have felt UNPLEASANT**
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
3) **In the last few hours I have felt PLEASANT**
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
4) **In the last few hours I have felt ANGRY**
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
5) **In the last few hours I have felt AFRAID**
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
6) **In the last few hours I have felt SAD**
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree

7) **In the last few hours did you REHEARSE any planned tasks?**
   No | Yes
   (If "No" selected, skip to Question 32)
8) How many tasks did you rehearse?
   1 | 2 | 3 | 4 | More than 4
   (If "1" selected, skip next statement)

Please respond to the following questions in regard to only the MOST RECENT task that you REHEARSED | OK

9) What TYPE of planned task did you REHEARSE?
   Intention to take medicine | Intention to communicate | Intention to study or work | Intention to complete | Intention to commit | Commitment or Appointment | Other intention

10) How often do you usually carry out this task? (please select ONE, then press Done)
   This was the first time | At least once a year | Every week | Every day | More than once a day

11) This planned task 'popped' into my head automatically.
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
   (If "Strongly disagree", "Disagree", or "Neutral" selected, skip to Question 13)

12) What were you THINKING about when this task 'popped' into your head? (select ONE, then press Done)
   Future plans or making plans | Other intentions or tasks | Work or uni | Time, timetables, deadlines, dates | What happened today or yesterday | Other

13) Something reminded me of this task.
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
   (If "Strongly disagree", "Disagree", or "Neutral" selected, skip to Question 15)

14) What was it that reminded you of this planned task? (please select ONE, then press Done)
   Phones and phoning | Diaries | Time | This study | People or places | Other cues

15) This is a task I will complete for:
   Myself | Another person
   (If "Myself" selected, skip to Question 18)

16) Is this other person a friend or partner?
   No | Yes

17) Please rate how close you are to this person (0 = Not at all; 7 = Extremely close).
   0 | 1 | 2 | 3 | 4 | 5 | 6 | 7

18) Completing this planned task is important to me.
   Strongly agree | Agree | Neutral | Disagree | Strongly disagree

19) I'm looking forward to completing this task.
   Strongly agree | Agree | Neutral | Disagree | Strongly disagree

20) Thinking about this planned task makes me feel GOOD.
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree

21) Thinking about this planned task makes me feel BAD.
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree

22) Were you with other people when you REHEARSED this planned task?
    No | Yes
    (If "No" selected, skip to Question 24)

23) Who were you with? (please select ONE, then press Done)
    Partner only | Partner and other family | Family and not partner | Friend(s) | Co-worker | Other

24) I was busy when I REHEARSED this planned task? (please select ONE, then press Done)
    Strongly agree | Agree | Neutral | Disagree | Strongly disagree

25) What were you doing when you REHEARSED the planned task? (please select ONE)
    Housework/chores | Transportation | Resting | Recreation | Eating | Work/Study
    (If "Housework/chores", skip to Question 26; if "Transportation", skip to Question 27; if "Resting", skip to Question 28; if "Recreation", skip to Question 29; if "Eating", skip to Question 30; if "Work/Study", skip to Question 31)

26) What sort of housework? (please select ONE, then press Done)
    Dishes | Laundry | Cleaning | Cooking | Other

Please press OK to continue
(Skip to Question 32)

27) What sort of transportation? (please select ONE, then press Done)
    Car | Bus | Walking | Train | Bike | Other

Please press OK to continue
(Skip to Question 32)

28) What sort of resting? (please select ONE, then press Done)
    TV | Listening to music (only) | Reading magazines | Reading book | Computer | Other

Please press OK to continue
(Skip to Question 32)

29) What sort of recreation? (please select ONE, then press Done)
    Exercise | Performing music/art | Shopping for fun | Playing games | Socialising | Other

Please press OK to continue
(Skip to Question 32)

30) Where were you eating? (please select ONE, then press Done)
    At home | Out-fast food | Out-dining | Out-snack | Out-coffee | Other

Please press OK to continue
(Skip to Question 32)

31) Where were you working or studying? (please select ONE, then press Done)
    At work/uni | At home | Other location indoors | Other location outdoors

32) **In the last few hours, did you EXECUTE any planned tasks?**
No | Yes
(If "No" selected, skip to Question 60)

33) How many planned tasks did you EXECUTE?
1 | 2 | 3 | 4 | More than 4
(If "1" selected, skip next statement)

Please respond to the following questions in regard to only the MOST RECENT task that you EXECUTED | OK

34) What TYPE of planning task was this?
Intention to take medicine | Intention to communicate | Intention to study or work | Intention to complete | Intention to commit | Commitment or Appointment | Other intention

35) How often do you usually carry out this task? (please select ONE, then press Done)
This was the first time | At least once a year | Every week | Every day | More than once a day

36) I automatically remembered to complete this task.
Strongly disagree | Disagree | Neutral | Agree | Strongly agree
(If "Strongly disagree", "Disagree", or "Neutral" selected, skip to Question 38)

37) What were you THINKING about when you remembered to complete this task? (select ONE, then press Done)
Future plans or making plans | Other intentions or tasks | Work or uni | Time, timetables, deadlines, dates | What happened today or yesterday | Other

38) Something reminded me to complete this task.
Strongly disagree | Disagree | Neutral | Agree | Strongly agree
(If "Strongly disagree", "Disagree", or "Neutral" selected, skip to Question 40)

39) What was it that reminded you to complete this task? (please select ONE, then press Done)
Phones and phoning | Diaries | Time | This study | People or places | Other cues

40) How many times did you rehearse this task TODAY before you completed it?
1 | 2 | 3 | 4 | 5 or more

41) How many times did you rehearse this task in JUST THE LAST HOUR?
1 | 2 | 3 | 4 | 5 or more

42) This is a task I completed for
Myself | Another person
(If "Myself" selected, skip to Question 45)

43) Is this other person a friend or partner?
No | Yes

44) Please rate how close you are to this person (0 = Not at all; 7 = Extremely close).
0 | 1 | 2 | 3 | 4 | 5 | 6 | 7

45) Completing this task was important to me.
Strongly agree | Agree | Neutral | Disagree | Strongly disagree

46) I looked forward to completing this task.
Strongly agree | Agree | Neutral | Disagree | Strongly disagree

47) Completing this task made me feel GOOD.
Strongly disagree | Disagree | Neutral | Agree | Strongly agree

48) Completing this task made me feel BAD.
Strongly disagree | Disagree | Neutral | Agree | Strongly agree

49) Were you with other people when you completed this task?
No | Yes
(If “No” selected, skip to Question 51)

50) Who were you with? (please select ONE, then press Done)
Partner only | Partner and other family | Family and not partner | Friend(s) | Co-worker | Other

51) Did you complete this task on time?
Yes | No, more than 15min late | No, more than 30min late | No, more than 1hr late | No, more than 1 day late

52) I was busy just before I completed this task? (please select ONE, then press Done)
Strongly agree | Agree | Neutral | Disagree | Strongly disagree

53) What were you doing just before completing the task? (Please select ONE)
Housework/chores | Transportation | Resting | Recreation | Eating | Work/Study
(If “Housework/chores”, skip to Question 54; if “Transportation”, skip to Question 55; if “Resting”, skip to Question 56; if “Recreation”, skip to Question 57; if “Eating”, skip to Question 58; if “Work/Study”, skip to Question 59)

54) What sort of housework? (please select ONE or MORE, then press Done)
Dishes | Laundry | Cleaning | Cooking | Other

Please press OK to continue
(Skip to Question 60)

55) What sort of transportation? (please select ONE, then press Done)
Car | Bus | Walking | Train | Bike | Other

Please press OK to continue
(Skip to Question 60)

56) What sort of resting? (please select ONE, then press Done)
TV | Listening to music (only) | Reading magazines | Reading book | Computer | Other

Please press OK to continue
(Skip to Question 60)

57) What sort of recreation? (please select ONE, then press Done)
Exercise | Performing music/art | Shopping for fun | Playing games | Socialising | Other

Please press OK to continue
(Skip to Question 60)

58) Where were you eating? (please select ONE, then press Done)
At home | Out-fast food | Out-dining | Out-snack | Out-coffee | Other

Please press OK to continue
(Skip to Question 60)

59) Where were you working or studying? (please select ONE, then press Done)
At work/uni | At home | Other location indoors | Other location outdoors

60) **In the last few hours did you FORGET to do anything that you had planned to do?**
No | Yes
(If "No" selected, skip to Question 82)

61) How many tasks do you estimate forgetting to complete?
1 | 2 | 3 | 4 | 5 or more
(If "1" selected, skip next statement)

Please think only about the task you most recently forgot to do for the following questions | OK

62) Why did you forget to complete this task? (please select ONE, then press Done)
Completely forgot | Reprioritised | Someone else cancelled it | Other circumstances

63) What TYPE of planned task was this?
Intention to take medicine | Intention to communicate | Intention to study or work | Intention to complete | Intention to commit | Commitment or Appointment | Other intention

64) How often do you usually carry out this task? (please select ONE, then press Done)
This was to be the first time | At least once a year | Every week | Every day | More than once a day

65) This is a task I will complete for
Myself | Another person
(If "Myself" selected, skip to Question 68)

66) Is this other person a friend or partner?
No | Yes

67) Please rate how close you are to this person (0 = Not at all; 7 = Extremely close).
0 | 1 | 2 | 3 | 4 | 5 | 6 | 7

68) Completing this task was important to me.
Strongly agree | Agree | Neutral | Disagree | Strongly disagree

69) I looked forward to completing this task.
Strongly agree | Agree | Neutral | Disagree | Strongly disagree

70) Completing this task will make me feel GOOD.
Strongly disagree | Disagree | Neutral | Agree | Strongly agree

71) Completing this task will make me feel BAD.
Strongly disagree | Disagree | Neutral | Agree | Strongly agree

72) Were you using an aid (e.g. diary) to remember this task or were you trying to remember on your own?
On my own | With an aid
(If "On my own" selected, skip to Question 74)

73) What type of memory aid were you supposed to use? (please select ONE, then press Done)
Phones and phoning | Diaries | Time | This study | People or places | Other cues

74) I was busy when I forgot to complete this task.
Strongly agree | Agree | Neutral | Disagree | Strongly disagree

75) What were you doing when you forgot this task? (Please select ONE)
Housework/chores | Transportation | Resting | Recreation | Eating | Work/Study
(If "Housework/chores", skip to Question 76; if "Transportation", skip to Question 77; if "Resting", skip to Question 78; if "Recreation", skip to Question 79; if "Eating", skip to Question 80; if "Work/Study", skip to Question 81)

76) What sort of housework? (please select ONE or MORE, then press Done)
Dishes | Laundry | Cleaning | Cooking | Other

Please press OK to continue
(Skip to Question 82)

77) What sort of transportation? (please select ONE, then press Done)
Car | Bus | Walking | Train | Bike | Other

Please press OK to continue
(Skip to Question 82)

78) What sort of resting? (please select ONE, then press Done)
TV | Listening to music (only) | Reading magazines | Reading book | Computer | Other

Please press OK to continue
(Skip to Question 82)

79) What sort of recreation? (please select ONE, then press Done)
Exercise | Performing music/art | Shopping for fun | Playing games | Socialising | Other

Please press OK to continue
(Skip to Question 82)

80) Where were you eating? (please select ONE, then press Done)
At home | Out-fast food | Out-dining | Out-snack | Out-coffee | Other

Please press OK to continue
(Skip to Question 82)

81) Where were you working or studying? (please select ONE, then press Done)
At work/uni | At home | Other location indoors | Other location outdoors

82) **Did you RESET this device before answering this set of questions?**
No | Yes

83) **Were you at home when you answered this set of questions?**
No | Yes

C.2 Take-Home Instructions (Study 1)

PALM PILOT INSTRUCTIONS

To start the first questionnaire tomorrow morning press the ESP icon on your palm pilot. You will hear an alarm 3 times a day for 5 days, between 9am and 6pm on weekdays and 10am and 6pm on weekends.

When you have finished with the PDA you can return it in the envelope provided.

PLEASE DO NOT PRESS ANY OF THE ICONS ON THE BLACK SECTION AT THE BOTTOM OF YOUR SCREEN AS CERTAIN COMBINATIONS OF THESE ICONS WILL RESET THE EXPERIMENT.

A 'FATAL ALERT' may appear on the screen of your palm pilot:

What to do: Press 'Reset' and WAIT while screen goes through resetting process. Then the location, date and time will appear on the screen and you should press 'Done'. Then press the picture of the House in the bottom left of the screen. Then "Tap screen to begin" should appear on the screen, and you can proceed as usual.

Please don't hesitate to contact Susan on 04xx xxx xxx or sssape001@myacu.edu.au with any problems.

DEFINITIONS

PROSPECTIVE MEMORY: Remembering to carry out a planned activity or task (e.g., Taking your medication at 9am; Attending a lecture in the afternoon; Going to the hairdressers on Saturday; Visiting your friend after work)
REHEARSAL: planning a future task
EXECUTION: carrying out your plans
TYPES OF PLANNED TASKS:

1. Commitment or appointment (e.g., Attend a dentist appointment or lecture or party)
2. Intention to commit (e.g., to organise an appointment)
3. Intention to complete (e.g., to return something or borrow something from a friend)
4. Intention to study or work (e.g., to do an assignment or to complete some housework)
5. Intention to communicate (e.g., to write, telephone, send a letter)
6. Intention to take medication
7. Other intention (e.g., to feed a friend's pet)

CUES THAT REMIND YOU OF A PLANNED TASK

EXTERNAL (something in your environment reminded you of the task):

- Phones and phoning (e.g., phone ringing, seeing a phone or a phone number, someone mentioning a phone call or a phone number, wake up calls in a hotel, making a phone call, checking calls on the answering machine)
- Diaries (e.g., seeing a personal diary, calendar, reminder note, or other diaries in a shop, someone mentioning diaries)
- Time (e.g., looking at or seeing a clock or watch, hearing or setting an alarm, coming across the word week or time, a friend saying he would visit on a particular day)
- This study (e.g., seeing the PDA, someone asking you about this study, seeing the information sheet for this study)
- People or places (e.g., seeing a photo of someone)
- Other cues

INTERNAL (you thought of the task yourself and were not prompted by anything in your environment):

- Future plans or making plans (e.g., thinking of plans for Sunday, thinking of plans for today, thinking of plans in general)
- Thinking of Other intentions or tasks (i.e., thoughts about remembering to perform other tasks that are unrelated to the task you were reminded of, e.g. if you were reminded of a doctor's appointment when thinking about returning a library book)
- Work or uni (e.g., thinking about assignments, lectures, or courses taught at uni, thinking about the PDA, our testing session or this information sheet, thinking about household chores or how you would get to work)
- Time, timetables, deadlines or dates (e.g., seeing the time or a calendar)
- What happened today or yesterday
- Other thoughts

C.3 Nominated Activity List

Day ....

1. Lunch ____________
2. Teeth / Meds / Landmark
3. ____________________
4. ____________________

Day ....

1. Lunch ____________
2. Teeth / Meds / Landmark
3. ____________________
4. ____________________

Day ....

1. Lunch ____________
2. Teeth / Meds / Landmark
3. ____________________
4. ____________________

Please select <u>THREE</u> tasks that you are <u>extremely likely</u> to complete once during the days indicated above:

- ➢ Watch a *specific* tv show/news program
- Withdraw your pension or money from an ATM/bank
- ➢ Go to the gym / exercise class
- Attend church
- ➢ Check the halftime score for *specific* AFL, rugby, etc. game
- Put out your bin on bin night
- ➢ Attend a recreational activity
  Examples: Book club, bible study, lawn bowling, etc.
- Top up your Myki card; Use your Myki to travel
- ➢ Attend class
  Which class? ______________________________
- When you start the washing machine/dishwasher
- ➢ Attend a scheduled appointment
  When/where? ______________________________
- Complete your timesheet

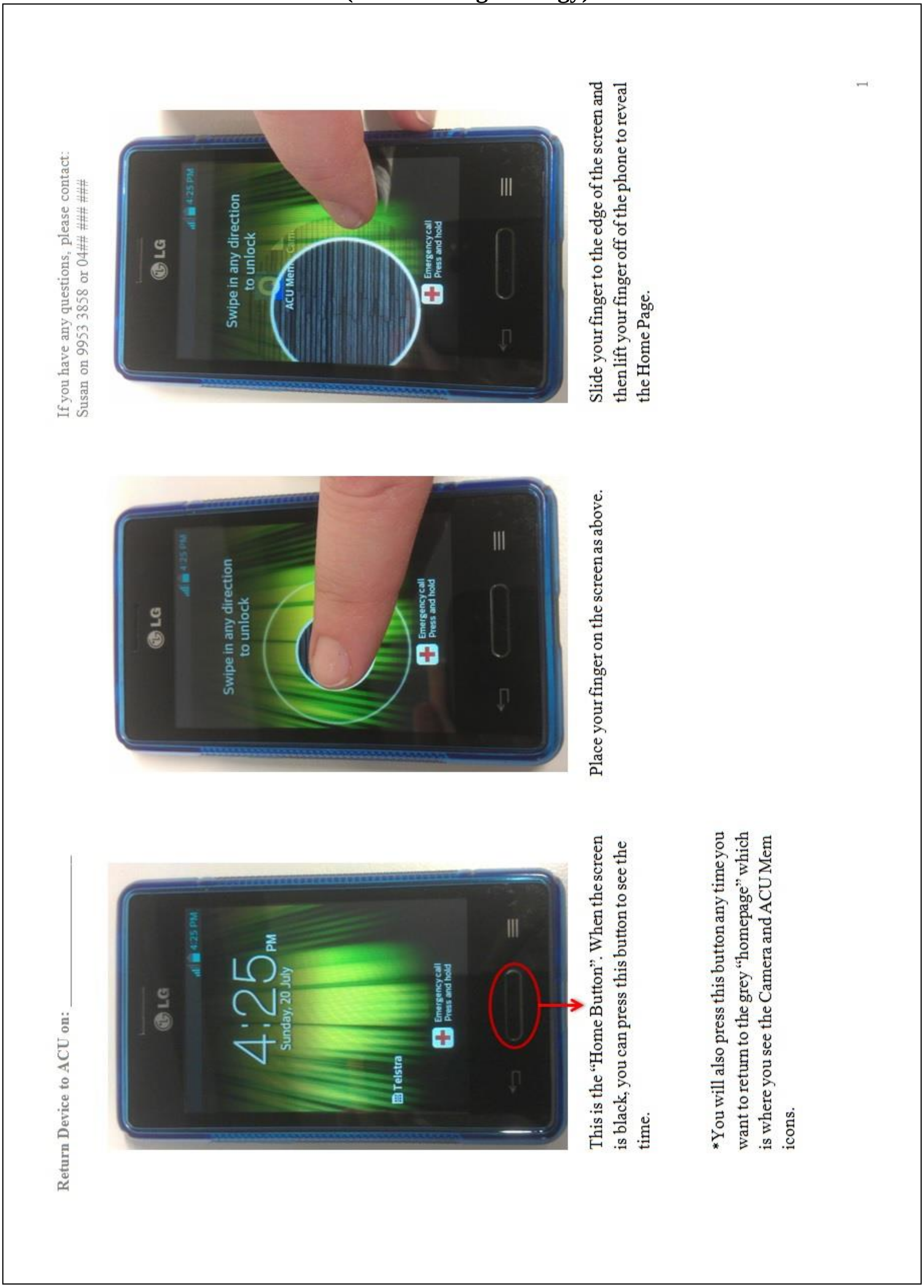
Please select <u>THREE</u> tasks that you are <u>extremely likely</u> to complete once during the days indicated above:

- Collect mail from the letterbox
- Charge your phone/tablet
- Pack lunch for next day
- Make your bed
- Water the plants; Garden work
- Feed your pet; Refill pet's water bowl
- Check your lotto numbers
- Post a package/letter
- An errand:
  Examples: grocery shop, pay a bill, sweep kitchen, etc.
- Practice a musical instrument

Participant ID / Device Number: ....

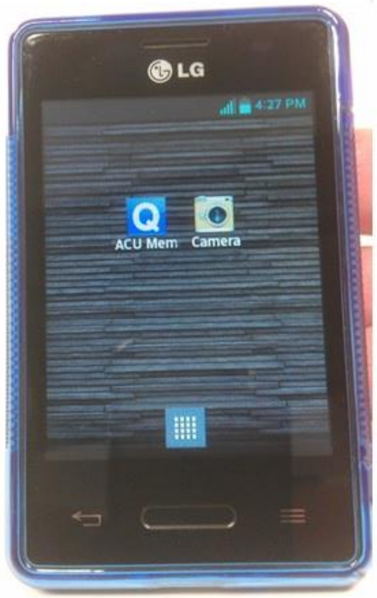
C.4 Participant Guidelines (Study 2)

C.4.1 Control Condition (No Encoding Strategy)



Return Device to ACU on: ________________

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###



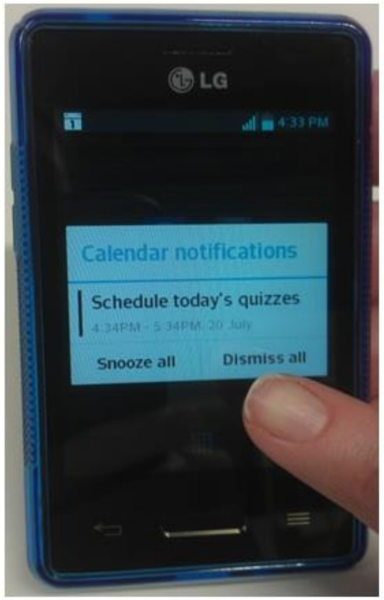
This is the **Home Page**.

There are two icons on it which you will need for this study.

On Quiz Days, you will use the **Quiz icon** which is the blue square with a white "Q". It has the words ACU Mem written underneath.

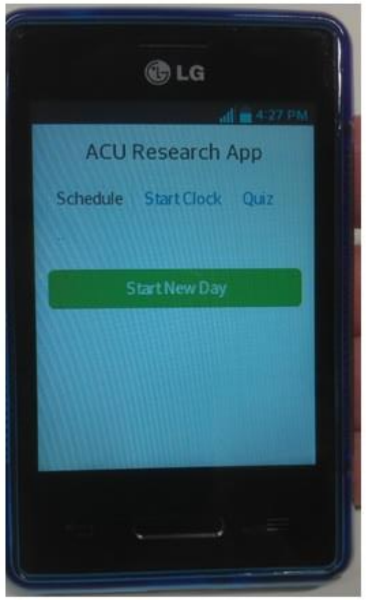
On Photo Days, you will use the small **Camera icon**.

Quiz Days:



At 9:00 each morning, you will receive an alert like the one above. Read what the message says, then gently press the words "Dismiss all".

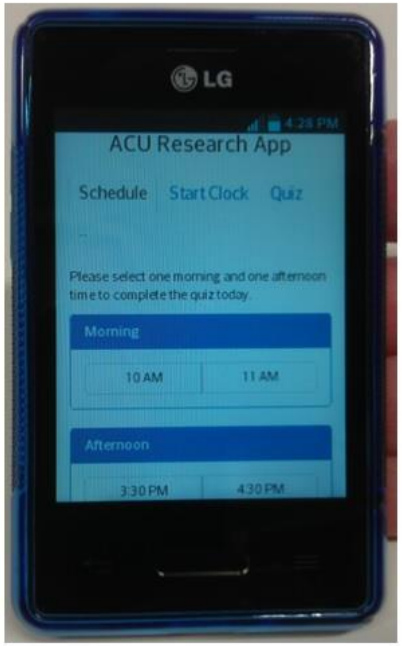
Now, on the Home Page, gently tap the **Quiz icon** to open the Quiz program.



This screen will appear. To schedule today's quizzes, press the green button that says, "**Start New Day**".

Return Device to ACU on: ___________________

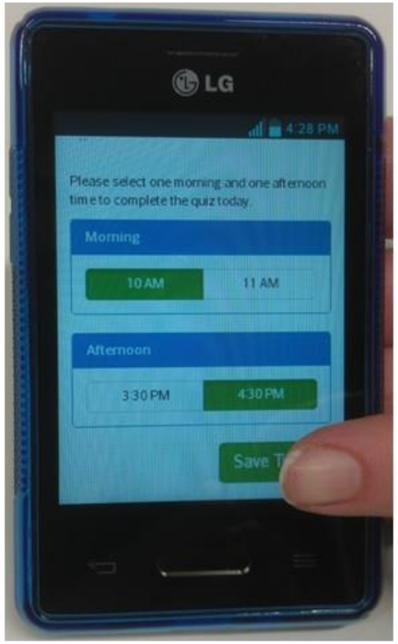
If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###



Please select one morning and one afternoon time to complete your <u>Scheduled Quizzes</u> by gently pressing the time you'd like.

The time you select will turn green.

Place your finger on the screen and slide it to the top, to read the bottom of the page.



Press the "**Save Times**" button.
Read the alert and press OK. The screen will now say, "Today's schedule is set."

These are the times you have selected for TODAY. You can select different times tomorrow.

*Please note: you will **NOT** receive an alert to tell you when it is time to complete your Scheduled Quiz.

Once you have saved your times, you can return to the Home Page by pressing the Home Button. The screen will turn off after a few minutes.

When it is the time you selected for your Scheduled Quizzes, you will return to the Quiz program by tapping on the **Quiz icon**.

For example: 10am and 4:30pm was selected in the previous picture. So at those times of day, you will tap on the **Quiz icon** to complete a Scheduled Quiz.

Return Device to ACU on: ____________________

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

When the program opens, press the word "Quiz" at the top right.

There are three quiz questions.

The first question asks about the type of quiz you are completing. In this instance, you are completing a <u>Scheduled Quiz</u> because at the start of the day you scheduled to complete this quiz at your selected times (e.g., 10am and 4:30pm).

Place your fingertip on the screen and slide it to the top, to continue the quiz.

Your answers will appear in **green** once you've selected them. If they do not turn green, try to tap your answer again.

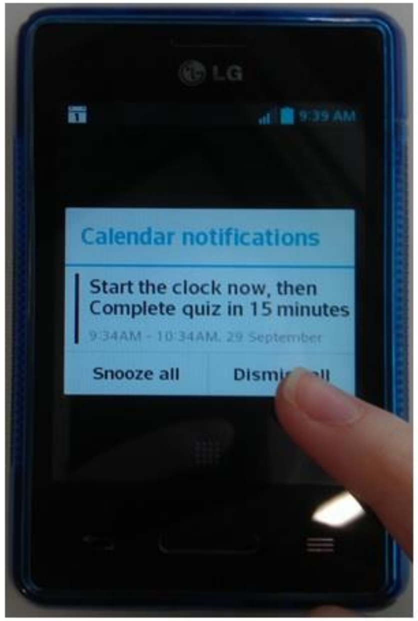
Press **Submit Quiz**, then press OK and return to the Home Page by pressing the home button.

If the quiz does not submit, double-check that you have a green answer to <u>each</u> question, and try to Submit Quiz again.

4

Return Device to ACU on: ___________________

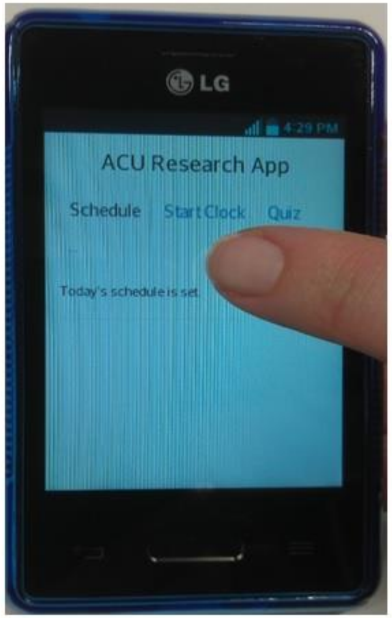
If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###



At two random times each day, you will receive an alert like the one above.

It will ask you to **Start the Clock** now, then complete a quiz after either 10, 15, or 20 minutes have passed.

These are alerts for your two Pop Quizzes. (It's called a pop quiz because you do not know when the alert will "pop" up.) After reading the alert, tap "Dismiss all". Once on the Home Page, gently tap the **Quiz icon**.



When the program opens, press the words "**Start Clock**".

Select the time that was given in the alert.

Once you select this time, the clock will start counting the time.

*Please note: there will **NOT** be an alert once that time has passed.

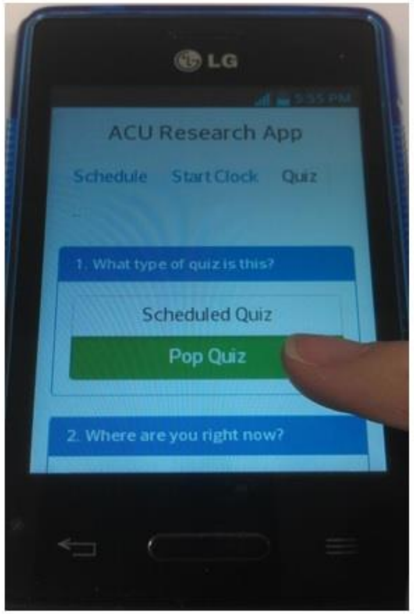
5

Return Device to ACU on: ___________________

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

<u>After this time period has passed</u>, you will return to the Quiz program and press the word "Quiz" in the upper right corner.

For example: 15 minutes was selected in the previous picture. So 15 minutes after you selected that response, you will tap on the word "Quiz" to complete a <u>Pop Quiz</u>.



The quiz will always be the same three questions, but your responses will vary depending on the type of quiz, where you are when you complete the quiz, and what you are doing at that time (besides completing the quiz).

Tips:

- Whenever you hear an alert, it's important to read the notification and respond accordingly.

- Tap the icon, but do NOT hold it down for too long. If you press the icon and hold it for too long, a purple circle will appear in the upper right hand corner of the icon. If this happens, just press the Home Button, and try to tap the icon quickly.

Frequently Asked Question:

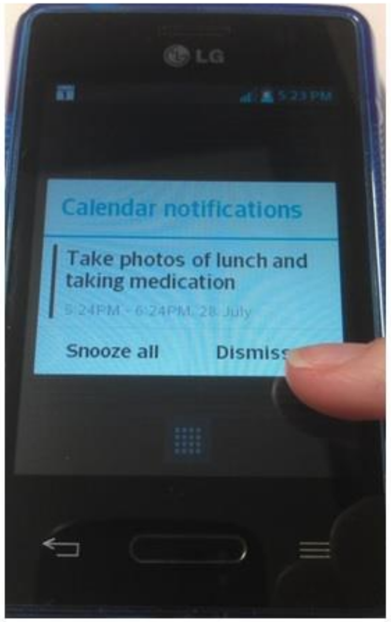
Q: I didn't hear the alert and when I checked the phone there was a "Start the clock now, then Complete quiz in 15 min" notification from earlier. What do I do?

A: The clock/timer does not start until you select the time from the Start Clock feature on the Quiz program. Whenever you see the notification, follow the steps on page 5 to select the time for your Pop Quiz. Then return to the program to complete your Pop Quiz after 15 minutes has passed.

Return Device to ACU on: ___________________

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

Photo Days:



At 9:00 and 9:30 each morning, you will receive an alert like the one above. Read what the message says, then gently press the words "Dismiss all".

Later in the day, when you are doing the activities mentioned in the alert, you will take a photo of the activity.

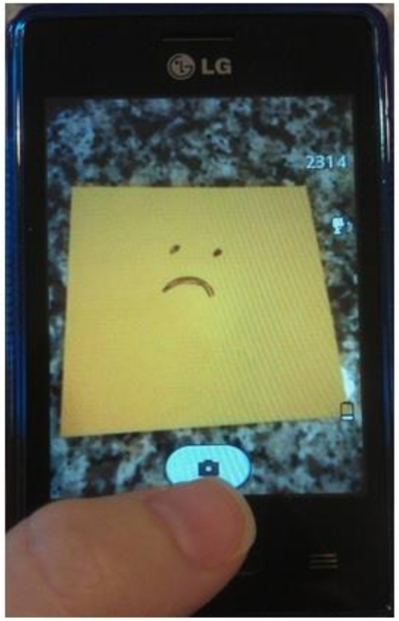
To take a photo, first gently tap the **Camera icon** on the Home Page to open the camera program.

Then tap the grey camera button on the bottom of the screen.

*Please note: The 9:00 alert will tell you the activities that happen each day. The 9:30 alert will tell you the activities that are specific to that day.

Return Device to ACU on: ____________________

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###



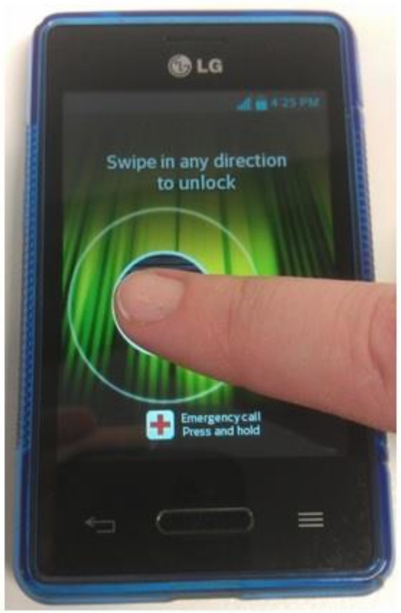
If you forget to take a picture when you completed your activity, but you remember it later on in the day, you can take a picture of your thumb pointing down, or of a sad smiley face.

C.4.2 Implementation Intentions Encoding Condition

Return Device to ACU on: __________________

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

This is the "Home Button". When the screen is black, you can press this button to see the time.



Place your finger on the screen as above.

Slide your finger to the edge of the screen and then lift your finger off of the phone to reveal the Home Page.

*You will also press this button any time you want to return to the grey "homepage" which is where you see the Camera and ACU Mem icons.

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

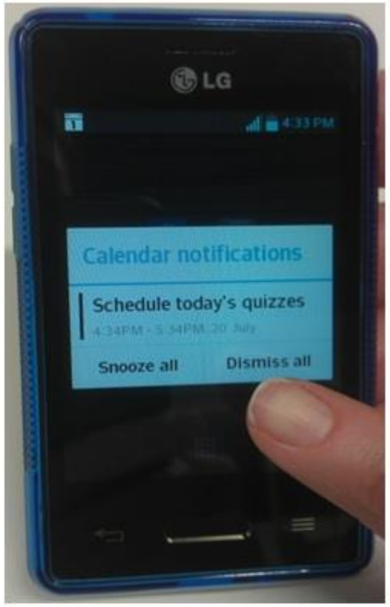
Quiz Days:

This is the **Home Page**.

There are two icons on it which you will need for this study.

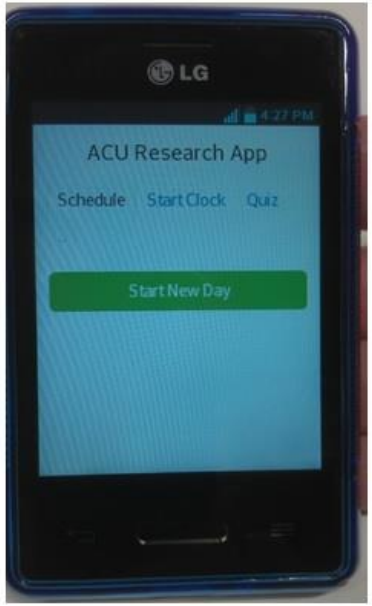
On Quiz Days, you will use the **Quiz icon** which is the blue square with a white "Q". It has the words ACU Mem written underneath.

On Photo Days, you will use the small **Camera icon**.



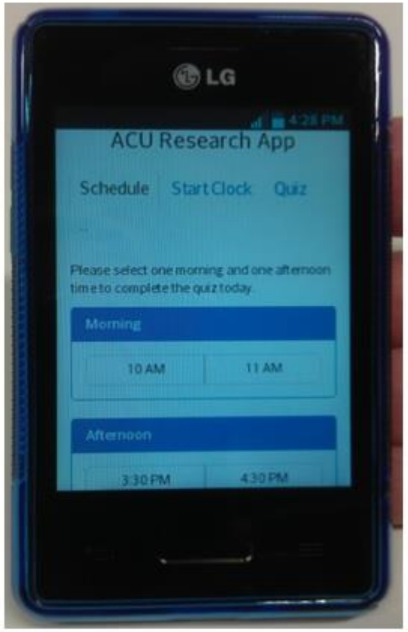
At 9:00 each morning, you will receive an alert like the one above. Read what the message says, then gently press the words "Dismiss all".

Now, on the Home Page, gently tap the **Quiz icon** to open the Quiz program.



This screen will appear. To schedule today's quizzes, press the green button that says, "**Start New Day**".

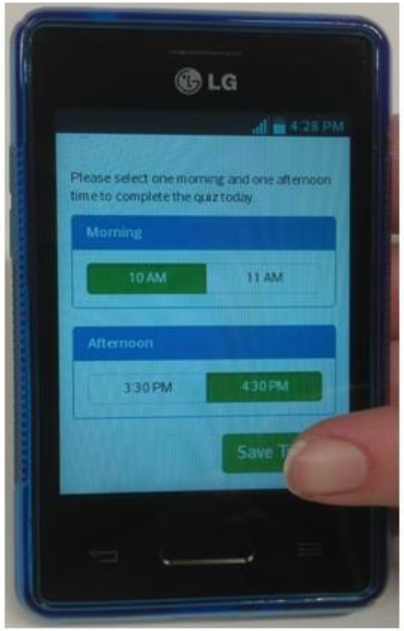
If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###



Please select one morning and one afternoon time to complete your Scheduled Quizzes by gently pressing the time you'd like.

The time you select will turn green.

Place your finger on the screen and slide it to the top, to read the bottom of the page.



Press the "**Save Times**" button.
Read the alert and press OK. Make sure you say your "When it is ____, I will complete the quiz" statement 3 times out loud while you visualise where you will be and what you will be doing at that time of day.

The screen will now say, "Today's schedule is set." These are the times you have selected for TODAY. You can select different times tomorrow.

***Please note**: you will **NOT** receive an alert to tell you when it is time to complete your Scheduled Quiz.

Once you have saved your times, you can return to the Home Page by pressing the Home Button. The screen will turn off after a few minutes.

When it is the time you selected for your Scheduled Quizzes, you will return to the Quiz program by tapping on the **Quiz icon**.

For example: 10am and 4:30pm was selected in the previous picture. So at those times of day, you will tap on the **Quiz icon** to complete a Scheduled Quiz.

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

When the program opens, press the word "Quiz" at the top right.

There are three quiz questions.

The first question asks about the type of quiz you are completing. In this instance, you are completing a <u>Scheduled Quiz</u> because at the start of the day you scheduled to complete this quiz at your selected times (e.g., 10am and 4:30pm).

Place your fingertip on the screen and slide it to the top, to continue the quiz.

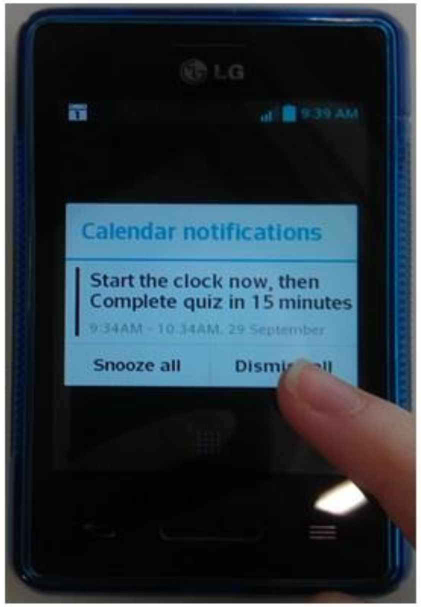
Your answers will appear in **green** once you've selected them. If they do not turn green, try to tap your answer again.

Press **Submit Quiz**, then press OK and return to the Home Page by pressing the home button.

If the quiz does not submit, double-check that you have a green answer to <u>each</u> question, and try to Submit Quiz again.

4

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###



At two random times each day, you will receive an alert like the one above.

It will ask you to **Start the Clock** now, then complete a quiz after either 10, 15, or 20 minutes have passed.

These are alerts for your two Pop Quizzes. (It's called a pop quiz because you do not know when the alert will "pop" up.) After reading the alert, tap "Dismiss all". Once on the Home Page, gently tap the **Quiz icon**.

When the program opens, press the words "Start Clock".

Select the time that was given in the alert.

Once you select this time, the clock will start counting the time.

Make sure you say your "When ____ minutes pass, I will complete the quiz" statement 3 times out loud while you visualise where you will be and what you will be doing at that time of day.

*Please note: there will **NOT** be an alert once that time has passed.

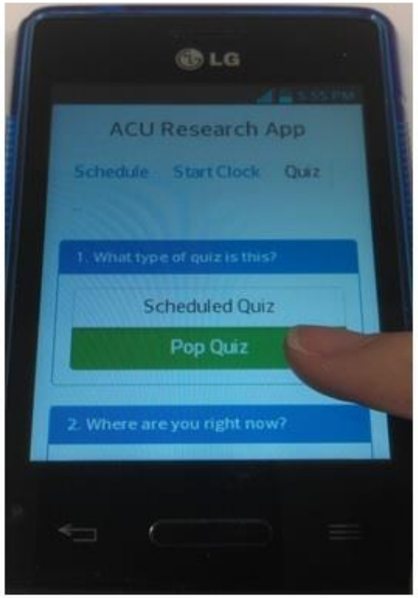
5

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

<u>After this time period has passed</u>, you will return to the Quiz program and press the word "Quiz" in the upper right corner.

For example: 15 minutes was selected in the previous picture. So 15 minutes after you selected that response, you will tap on the word "Quiz" to complete a <u>Pop Quiz</u>.

If you were taken back to the Home Page, tap on the **Quiz icon** to open the Quiz program, and then complete your Pop Quiz.



The quiz will always be the same three questions, but your responses will vary depending on the type of quiz, where you are when you complete the quiz, and what you are doing at that time (besides completing the quiz).

Tips:

- Whenever you hear an alert, it's important to read the notification and respond accordingly.

- Tap the icon, but do NOT hold it down for too long. If you press the icon and hold it for too long, a purple circle will appear in the upper right hand corner of the icon. If this happens, just press the Home Button, and try to tap the icon quickly.

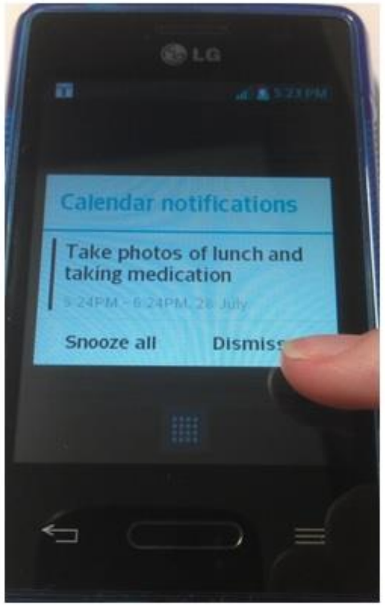
Frequently Asked Question:

Q: I didn't hear the alert and when I checked the phone there was a "Complete quiz in 15 min" notification from earlier. What do I do?

A: The clock/timer does not start until you select the time from the Start Clock feature on the Quiz program. Whenever you see the notification, follow the steps on page 5 to select the time for your Pop Quiz. Then return to the program to complete your Pop Quiz after 15 minutes has passed.

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

Photo Days:



At 9:00 and 9:30 each morning, you will receive an alert like the one above. Read what the message says, then gently press the words "Dismiss all".

Make sure you say your "When ____, I will take a photo" statement 3 times out loud while you visualise where you will be and what you will be doing at that time of day.

For example: You would say aloud 3 times, "When I am eating lunch, I will take a photo."

Visualise where you will be eating lunch, what your meal will be, who you will be eating with, etc. Visualise yourself taking a photo in that setting.

Then say aloud 3 times, "When I am taking medication, I will take a photo."

Visualise where you will be taking your medication, what your medication looks like, etc. Visualise yourself taking a photo when you take your medication.

*Please make these statements for **each** activity you will be taking a photo of later in the day.

Later in the day, when you are doing the activities mentioned in the alert, you will take a photo of the activity.

To take a photo, first gently tap the **Camera icon** on the Home Page to open the camera program.

Then tap the grey camera button on the bottom of the screen as in the picture above.

If you have any questions, please contact:
Susan on 9953 3858 or 04## ### ###

*Please note: The 9:00 alert will tell you the activities that happen each day. The 9:30 alert will tell you the activities that are specific to that day.

If you forget to take a picture when you completed your activity, but you remember it later on in the day, you can take a picture of your thumb pointing down, or of a sad smiley face.

D. Additional Data Analyses

D.1 Naturalistic Time-Check Task Performance in Study 2

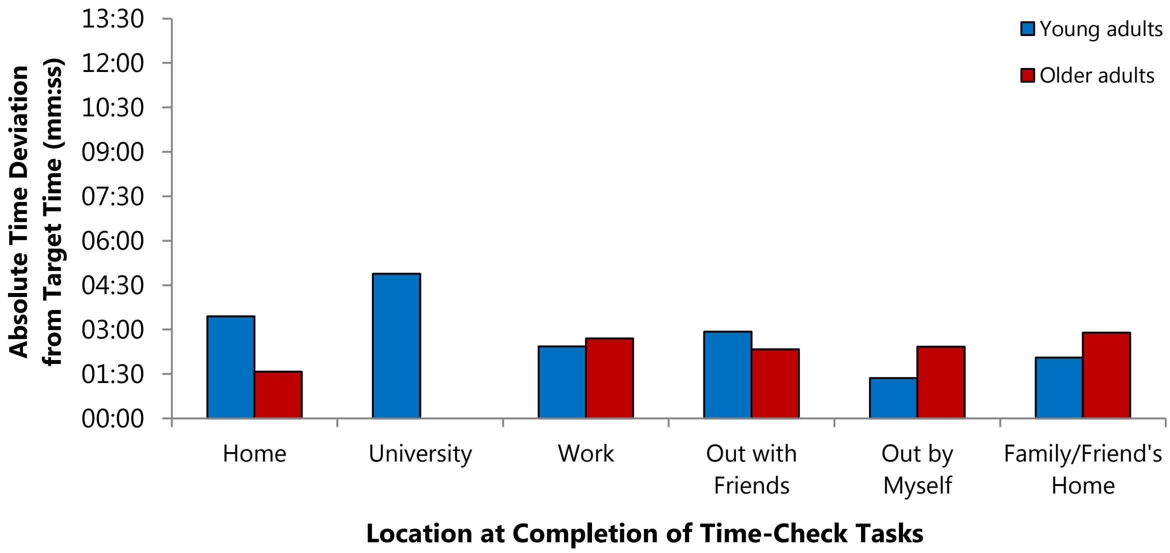


Figure D-1. Median absolute time deviations as a function of age group and the location where naturalistic time-check task completion occurred. Immediately executed responses were excluded and individual response outliers were adjusted to a maximum response time of 30 min.

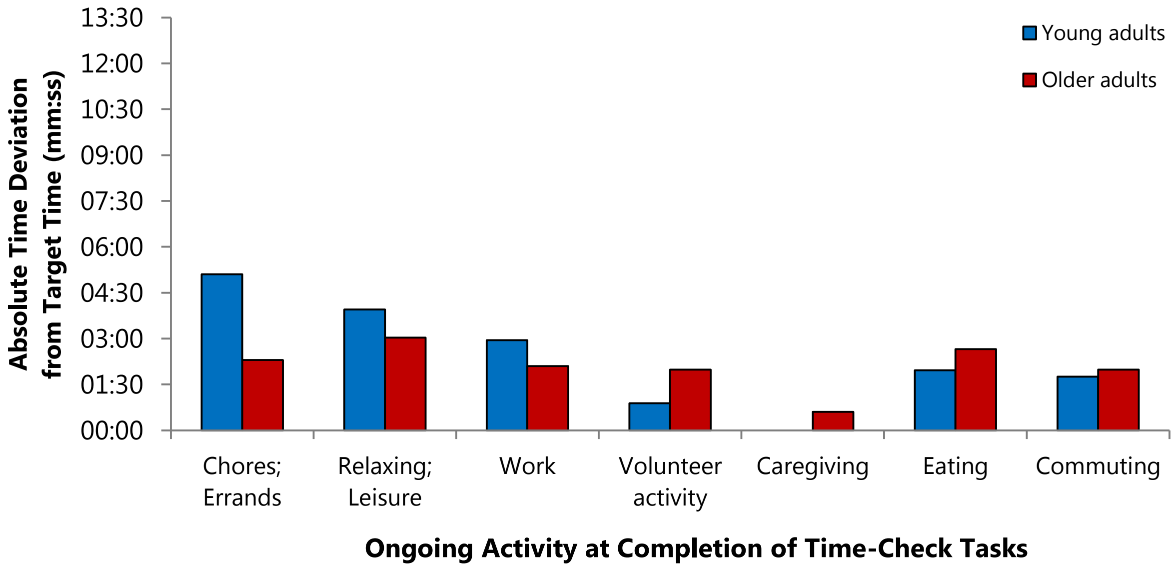


Figure D-2. Median absolute time deviations as a function of age group and the ongoing activity participants were engaged in prior to completion of the naturalistic time-check tasks. Immediately executed responses were excluded and individual response outliers were adjusted to a maximum response time of 30 min.

E. Research Portfolio Appendices

E.1 International Conferences

Sapega, S. E., Terrett, G., Bailey, P. E., & Rendell, P. G. (May 2014). *Capturing the context of prospective memory tasks in everyday life.* Poster presentation at the 4th International Conference on Prospective Memory. Naples, Italy.

Rendell, P. G., Rose, N. S., **Sapega, S. E.**, Terrett, G., & Bailey, P. E. (November 2014). *Aging and different prospective memory tasks in daily life: Event-based, short term time, time of day tasks.* Oral presentation at Psychonomics. Long Beach, California, USA.

Rendell, P. G., **Sapega, S. E.**, Terrett, G., Rose, N. S., Kliegel, M., & Henry, J. D. (December 2015). *Contrasting age-related prospective memory performance in laboratory and naturalistic settings.* Oral presentation at Memory Day: Memory and Skill across Time. Dunedin, New Zealand.

E.2 Additional Presentations and Awards

Sapega, S. E. (September 2012). *See it now, remember it later: Commit to your intentions.* ACU 3 Minute Thesis Competition. Sydney, Australia. [Awarded Second Place]

Sapega, S. E., Rendell, P. G., & Gleeson, J. (September 2012) *Right on time: Completing future intentions in everyday life.* Oral presentation at the 1st Inaugural School of Psychology Conference. Melbourne, Australia.

Sapega, S. E. (August 2013). *See it now, remember it later: Commit to your intentions.* ACU 3 Minute Thesis Competition. Melbourne, Australia. [Awarded Second Place & People's Choice Winner]

Sapega, S. E., Rendell, P. G., Terrett, G., Bailey, P. E., & Chan, V. (October 2013) *Finding the time to remember: Prospective memory in everyday life.* Oral presentation at the 2nd School of Psychology Conference. Melbourne, Australia.

Sapega, S. E., Rendell, P. G., & Terrett, G. (October 2014) *Using technology to examine everyday memory of younger and older adults.* Oral presentation at the 3rd School of Psychology Conference. Melbourne, Australia.

Sapega, S. E., Rendell, P. G., & Terrett, G. (April 2015) *Age-related differences in prospective memory: Naturalistic versus laboratory settings*. Oral presentation at the HDR Research Seminar, Australian Catholic University. Melbourne, Australia.