Prospective Memory in Amnestic Mild Cognitive Impairment

Submitted by

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Statement of Authorship

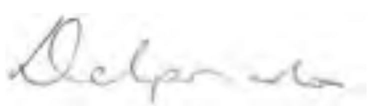
Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis submitted for the award of any other degree or diploma.

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

The thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

Chapters 2 and 4 of this thesis consist of work with joint authorship. In all instances, I am the primary author and have made the most substantial contribution to the work presented. Other authors have contributed as follows: Glynda Kinsella, Ben Ong, and Kerryn Pike (research supervision); David Ames, Elsdon Storey, Michael Saling, Linda Clare, Elizabeth Mullaly, and Elizabeth Rand (established research protocols for the larger research project from which the current studies drew participants and some cognitive measures).

Research procedures reported in this thesis were approved by the La Trobe University Human Ethics Committee (Project Number 08-079) and the relevant ethics committees for Austin Health, Barwon Health, Bayside Health, Eastern Health, Melbourne Health and St Vincent's Health.



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Thesis Format

This Doctor of Psychology in Clinical Neuropsychology research thesis represents 40% of the total clinical degree and is an original piece of work that makes a contribution to knowledge that is of direct relevance to the profession.

The thesis is presented using the alternative format that has been approved by La Trobe University, Melbourne, Victoria, Australia (Appendix A). In this format all or part of the thesis may be presented as a series of scientific manuscripts that have been submitted or accepted for publication in journals relevant to the area of research.

This thesis is presented along a central theme. It contains a review of the literature as a separate introduction, and a general discussion and conclusion that provides integration of the material. The two empirical chapters should stand alone and are presented in the required format by the peer review journal to which they have been submitted. The only modifications have been to incorporate the figures and tables into the bodies of the manuscripts. As each paper requires a separate introduction and discussion, there may be some repetition with the thesis' literature review and general discussion. Furthermore, because each of the papers has its own methods section, no generic methods section appears in the body of the thesis.

Publications and Presentations Associated with this Thesis

Some of the work presented in this thesis has been communicated in published form as declared below:

Journal publications

Delprado, J., Kinsella, G., Ong, B., Pike, K., Ames, D., Storey, E., Saling, M., Clare, L., Mullaly, E., & Rand, E. (in press). Clinical measures of prospective memory in amnestic mild cognitive impairment. *Journal of the International Neuropsychological Society*. doi: 10.1017/S135561771100172X

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Unpublished conference presentations

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Thesis Summary

A range of cognitive difficulties beyond retrospective memory are now associated with amnestic mild cognitive impairment (aMCI). Despite this, the contribution of prospective memory (PM) to the cognitive profile and diagnosis of aMCI has received little attention. In Chapter 2, the clinical and diagnostic utility of PM measures in aMCI was assessed. Individuals with aMCI (*n*=84) were compared to healthy older adults (*n*=84) on the Cambridge Prospective Memory Test (CAMPROMPT) and two brief, single-trial PM tasks. Participants with aMCI showed impairment on all PM measures. The importance of retrospective memory for PM functioning was confirmed, however, the PM measures contributed more to the diagnostic picture of aMCI than retrospective memory alone. Surprisingly, it was a brief PM task that better predicted aMCI compared to the more complex PM battery (CAMPROMPT). Each of the PM measures showed good discriminative ability with Receiver Operating Characteristic curve analyses providing cut-off scores. The results indicate that these measures may be useful screening tools for identifying aMCI. Following a pilot study (Chapter 3), Chapter 4, explored the relationship between PM and everyday functioning in an aMCI population by employing naturalistic measures of PM. Firstly, participants were asked to make telephone calls to the experimenter at specified times over two weeks in the context of their day-to-day lives. Individuals with aMCI performed significantly worse than the healthy older adults in remembering to complete phone calls. Secondly, using Marsh, Hicks, and Landau’s (1998) methodology of eliciting from participants their own PM tasks for the week, the aMCI group (*n*=21) completed significantly less of their PM tasks compared to the HOA group (*n*=24). Strategy use and reasons for failing to complete tasks were also investigated. In conclusion, assessing PM is clinically useful in an aMCI population, in relation to both diagnosis and describing everyday functioning.

Chapter 1. Prospective Memory in Amnestic Mild Cognitive Impairment

The overall aim of this research was to develop a more comprehensive understanding of prospective memory (PM) functioning in amnestic mild cognitive impairment (aMCI). Literature examining PM in this population has largely involved experimental measures with limited clinical application. This is important if the construct of PM is to form part of a diagnostic assessment and also to inform management strategies for people presenting with aMCI. This thesis will firstly discuss the background literature relating to PM, including the theoretical explanatory models of PM, followed by a discussion of aMCI and the relationship between PM and aMCI. Following this, the first study will employ clinically available, standardised measures of PM to examine the discriminative ability of PM for the diagnosis of aMCI. Furthermore, the cognitive skills underlying PM in aMCI will be explored. The second study will extend investigation of PM outside of the laboratory in order to depict the everyday PM functioning of healthy older adults and individuals with aMCI. This real-world information is important to establish the extent of challenges in PM in everyday life and the supports that people with aMCI might spontaneously put into place in response to PM difficulties.

Prospective Memory

Prospective memory (PM) refers to remembering to perform an intended act in the future (Einstein & McDaniel, 1990). PM tasks arise in a number of different situations of everyday life. For example, in the work environment PM might involve remembering to attend appointments and return emails. In the home environment, PM tasks may include remembering to turn off the stove or return a book to the library. PM deserves special consideration in the literature because of the important role it plays in the everyday functioning of an individual. The significance of PM for independent living has been clearly demonstrated in a range of populations including individuals with mild to severe head injuries (Fortin, Godbout, & Braun, 2003), HIV (Woods et al., 2008), Alzheimer's disease (Twamley, Ropacki, & Bondi, 2006), and in the elderly (Kidder, Park, Hertzog, & Morrell, 1997). Disruptions of PM may account for as much as half of self-reported memory failures (Smith, Della Sala, Logie, & Maylor, 2000) and, relative to other types of memory problems, PM difficulties generate the greatest frustration in the caregivers of those individuals with impaired memory (Smith et al., 2000). Furthermore, the importance of PM information over other types of information can be seen in the *intention superiority effect* (Freeman & Ellis, 2003), whereby individuals appear biased towards or can more easily access to-be-performed intentions, such as a PM task, as opposed to what has already been performed or material not intended for action.

Parameters of Prospective Memory

McDaniel and Einstein (2007), in a seminal book in the area of PM, set out the parameters for PM tasks as: (i) the execution of the intended action is not immediate as it occurs after a delay; (ii) the PM task is embedded in ongoing activity and the individual must identify PM cues that indicate it is the appropriate time to perform the PM task; (iii) the window for response initiation is constrained in that there is a specific time the task needs to be started as opposed to a task, for example, that can be performed at any time over a series of months; (iv) the time frame for response execution is limited so that a task which requires days or weeks to complete would not be considered a PM task and; (v) a conscious intention must be formed.

Manipulation of these PM task parameters allows for further exploration of the concept of PM. Firstly, variations in the time frames for delay between task formation and execution have been shown to have a significant impact on PM performance. Kvavilashvili

(1998) found that a 5 minute delay between instructions for the PM task and initiation of the ongoing activity had no influence on the PM performance of university students. Whereas others, also using an undergraduate population, have found PM impairment following a 3 minute delay between instructions and the task (Brandimonte & Passolunghi, 1994). In another study, when older adults had to delay their intended action by just 5 seconds, they forgot to perform the PM task about 50% of the time (McDaniel, Einstein, Stout, & Morgan, 2003). It appears, therefore, that older adult populations, in comparison to undergraduate students, may be particularly susceptible to these delays prior to task execution. Based on these findings, in order to optimise successful PM performance, it would be advantageous to perform an intended action as soon as it comes to mind rather than taking the chance of forgetting it over a delay.

Secondly, the ongoing task has also been investigated as to how it affects PM performance. An ongoing task with a high number of distractions decreases PM performance relative to a task with a low level of distractions (Knight, Titov, & Crawford, 2006). Furthermore, those who are already impaired when it comes to PM, such as those with a traumatic brain injury, are particularly susceptible to the increased distractions of an ongoing task (Knight et al., 2006). Congruence between the ongoing task and PM task can also influence PM performance. Marsh, Hicks, and Hancock (2000) found that when the ongoing task was semantically and structurally matched to the cue for the PM task, performance was better in comparison to when the ongoing task and PM cue were mismatched.

The third point to consider is that there is a constrained window of time to initiate execution of the PM task. Ellis (1988) made a distinction between *pulses,* which require execution within a short period of time such as a few minutes, and *steps,* which may be executed over a longer time period such as the space of a few hours. Their participants were more likely to use a memory aid for a pulse than for a step. However, different PM tasks were used for the pulse and step conditions and participants rated the pulse activities as more important than the step activities, which could account for the differential use of memory aids. Maylor (1990) adopted this approach with healthy older adults and employed the same task for each condition so that neither the step nor pulse could be considered more important. Overall performance was better in the step condition than in the pulse condition but performance in the two conditions became equivalent when the same cue or strategy was used. Therefore, PM performance appears to be better when a longer period is allowed for initiation of task execution, although this effect may be mediated by task complexity and strategy use.

The fourth parameter described by McDaniel and Einstein (2007) was that the time frame for task execution is limited, a factor that is not typically manipulated in the literature. And finally, they outlined that a conscious intention must be formed, however, in PM experiments this intention is often formed by the researcher rather than being generated by the individual. Studies investigating free recall have found a *generation effect* where individuals have demonstrated better memory for self-generated material than for material produced by others (see Bertsch, Pesta, Wiscott, & McDaniel, 2007 for a review). Nevertheless, the extension of this effect to the area of PM has not been as clear (Kinsella, Ong, & Tucker, 2009) and requires further exploration.

Dichotomous Models of Prospective Memory

The body of PM literature has historically considered the concept of PM in various dichotomous terms. For example, one way of categorising PM tasks is using the distinction between time-based and event-based tasks. In time-based PM the task needs to be performed at a specific time, such as taking medication at 8am, whereas for event-based PM the task may occur at a certain place or in conjunction with some other event, such as taking medication with breakfast. Performance has generally been found to be better for event-based tasks rather than time-based PM tasks (Groot, Wilson, Evans, & Watson, 2002). This is thought to be because time-based tasks load highly on self-initiated retrieval (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). Event-based PM, on the other hand, requires less strategic monitoring and intentions are retrieved more automatically because these tasks can be more easily associated with external cues such as conjunction cues, which refers to the opportunity to connect the PM task with other routine events in an individual's life (Maylor, 1990).

Another dichotomous distinction can be made between the prospective and retrospective components of a PM task. A critical aspect of success on a PM task is not only recall of the content of that task but also its retrieval at an appropriate moment for action. In this sense there are two components to a PM task: prospective, recognising when the opportunity arises, that something needs to be done; and retrospective, recalling the content of what needs to be done (Ellis & Kvavilashvili, 2000). Some researchers argue that PM literature should focus more purely on the PM component as opposed to retrospective memory, however, other researchers approach PM as referring to the complete event of prospective remembering (Ellis & Kvavilashvili, 2000) and this holistic definition will be adopted in this thesis.

A dichotomisation has also been made between focal and non-focal cue types. When an ongoing task is congruent with and encourages processing of the PM cue, this is termed a focal PM task, whereas in non-focal PM tasks the ongoing task does not direct attention to processing of the relevant PM cue (McDaniel, Shelton, Breneiser, Moynan, & Balota, 2011). Tasks involving focal cues allow for relatively spontaneous retrieval of the PM intention and in this way are similar to event-based PM tasks (Scullin, McDaniel, Shelton, & Lee, 2010). Non-focal PM tasks require more strategic, self-initiated allocation of attention for monitoring of the environment for the appropriate PM cue, which recruits similar cognitive processes as involved in time-based PM tasks (McDaniel et al., 2011).

Another method for categorising PM tasks is as habitual versus episodic. Habitual PM tasks are those in which the action is performed repeatedly and in a routine manner whereas episodic PM tasks are more likely to be one off (McDaniel & Einstein, 2007). Being a more regular occurrence, it might be expected that a habitual PM task would be easier than a more sporadic task, however, a new type of memory failure also becomes evident in habitual PM tasks. Typically PM deficits are from errors of omission or forgetting to perform the PM task, but there are also errors of repetition whereby the individual mistakenly performs the PM task again believing they had not done it before (Einstein, McDaniel, Smith, & Shaw, 1998). People might have difficulty monitoring their output which can lead to these errors of repetition (Marsh, Hicks, Cook, & Mayhorn, 2007; Marsh, Hicks, Hancock, & Munsayac, 2002). Although in these cases the PM task is performed, the repetition could still prove problematic as in the situation of taking multiple doses of medication.

Multifactorial Models of Prospective Memory

In contrast to the dichotomous models described, McDaniel and Einstein (2000) developed a multiprocess framework of PM focusing on the primary distinguishing feature of PM being that there is no explicit request for a memory search in order to retrieve the PM intention, in contrast to retrospective memory where there is an explicit request for retrieval of the previously presented material, rather it relies on the detection of an appropriate PM cue. The model posits that retrieval of a PM intention can occur as a result of two different processes that vary as a function of the characteristics of the PM task, target cue, ongoing task, and the individual. A summary of the processes identified by McDaniel and Einstein (2000) and McDaniel, Guynn, Einstein, and Breneiser (2004) are summarised in Figure 1.1.

The first process involves active, strategic monitoring of the environment for the presence of the target cue. These systematic attentional processes are typically activated when the association between the target cue and the intended action is weak. On the other hand, when the target cue is sufficiently associated with the intended action, then automatic and reflexive retrieval processes should occur. This model has since proved useful for the interpretation of findings from the PM literature (e.g., Raskin et al., 2011), nevertheless, this framework still lacks a degree of specificity and does not encompass all of the complexities of PM.

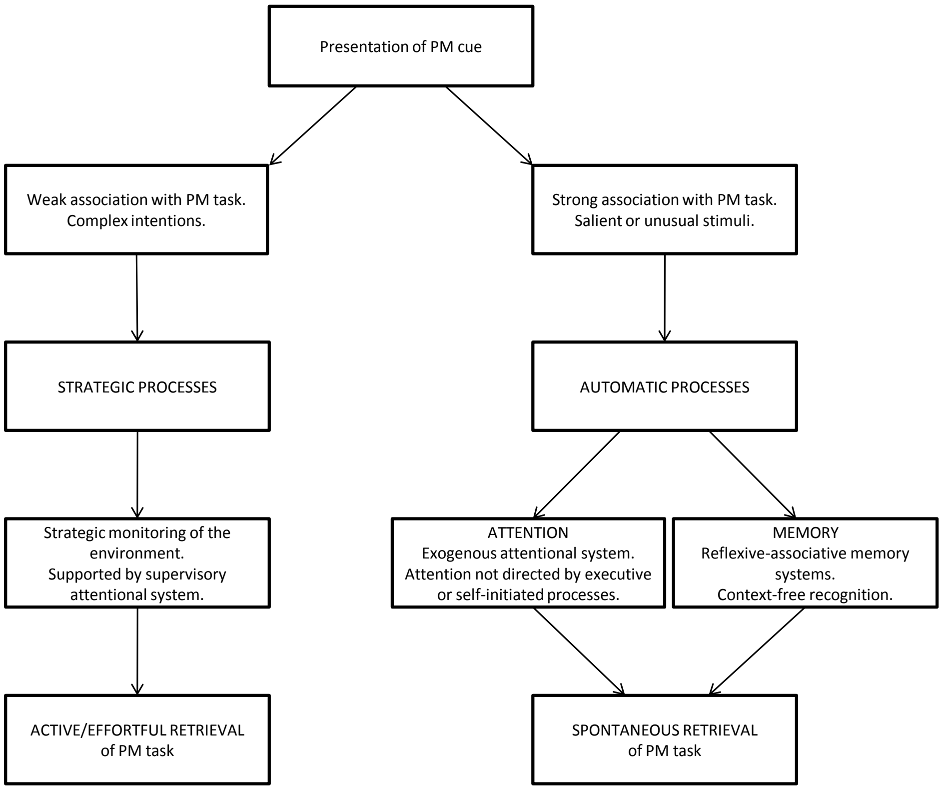

Figure 1.1. Diagrammatic representation of the processes associated with the multiprocess framework of prospective memory (PM) as described by McDaniel and Einstein (2000) and McDaniel, Guynn, Einstein, and Breneiser (2004).

Elaborating upon this idea, Kliegel, McDaniel, and Einstein (2000) developed a model of the distinct phases in complex prospective remembering, which can be used to investigate the processes underlying PM performance, how different populations approach these components of PM (e.g., Kliegel, Phillips, Lemke, & Kopp, 2005) and how PM develops across the lifespan (e.g., Kliegel, Mackinlay, & Jager, 2008). This model comprises four phases. The first phase involves the *intention formation* where the participant plans what task they need to perform and how they are going to do it. Second, *intention retention* refers to whether the participant remembers what they intended to do. Third, *intention initiation* requires the participant to initiate the task at the appropriate time and, finally, *intention execution* involves the participant actually following through with their intention.

Cognitive Processes and Cognitive Neuroscience Underlying Prospective Memory

There are a number of cognitive processes that have been recognised as contributing to PM performance. Reese and Cherry (2002) found that recognition memory was the strongest predictor of successful event-based PM, which may reflect the need for recognition of appropriate PM cues and can be linked to the automatic memory processes identified in McDaniel and Einstein's (2000) multiprocess framework, whereas working memory was only mildly related to the event-based PM task and there was no relationship with age and overall verbal abilities. Kliegel et al. (2005), on the other hand, found that working memory skills became more important specifically during the planning phases of PM intentions. Objective assessment of episodic memory has also been shown to be significantly related to PM although the relationship between PM and self-ratings of retrospective memory was quite weak (Salthouse, Berish, & Siedlech, 2004). Executive functioning including planning, self-initiation, and monitoring is another cognitive ability that has often been shown to be involved in PM (e.g., Groot et al., 2002; Salthouse et al., 2004). Martin, Kliegel, and McDaniel (2003), however, found that executive functioning did not predict performance on a single, simple PM task, but it did predict performance in more complex PM tasks. Again this reflects McDaniel and Einstein's (2000) framework in relation to the strategic, executive processes required for complex intentions. In summary, the primary cognitive correlates of PM include aspects of memory and executive functioning.

These cognitive factors are readily integrated into McDaniel and Einstein's (2000) multiprocess model of PM. The automatic retrieval processes are associated with memory, specifically the reflexive-associative memory subsystem (McDaniel & Einstein, 2011; McDaniel et al., 2004; Moscovitch, 1994). Strategic monitoring processes and the systematic allocation of attention, on the hand, is more closely related to frontal and executive skills (Burgess, Scott, & Frith, 2003; Simons, Scholvinck, Gilbert, Frith, & Burgess, 2006).

These same cognitive skills are also consistent with Kliegel et al.'s (2000) model of complex PM. Executive functioning, for example, has been shown to be particularly important during the intention formation, initiation, and execution stages of complex PM (Kliegel et al., 2008). Specifically, planning skills are required in the formation of an intention, whereas monitoring, inhibition and switching attention from the ongoing task are involved during the initiation of an intention and are also required when the PM task is executed (Kliegel, Martin, McDaniel, & Einstein, 2002). The retention phase of the PM task more clearly relies on retrospective memory (Kliegel et al., 2008).

The relationship of cognition to PM can also be explored through an analysis of the associated cognitive neuroscience. The contribution of executive functioning to PM has been highlighted by McDaniel, Glisky, Rubin, Guynn, and Routhieaux (1999) who found that in a sample of older adults, participants classified as high functioning on a composite measure assessing frontal lobe function achieved better event-based PM performance than low functioning frontal participants, but there was no significant difference in PM performance between participants who were classified as high and low functioning on a composite measure tapping medial temporal functioning. Their results provide early support for the theoretical position that frontal lobe processes such as executive functioning play a key role in PM. The activation of these frontal systems has also been shown in studies using positron emission tomography (PET). For example, Burgess, Quayle, and Frith (2001) found increased regional cerebral blood flow in frontal regions bilaterally and inferior parietal regions during experimental event-based PM measures. Similarly, a number of frontal regions were found to be active in the right hemisphere for time-based and left frontal regions active in event-based PM (Okuda et al., 2007). A functional magnetic resonance imaging (fMRI) study also found activation in the prefrontal cortex not only during the detection of a PM cue, but also during retrieval of the PM intention (Simons et al., 2006). The involvement of the temporal lobes during PM has also been evident (e.g., Poppenk, Moscovitch, McIntosh, Ozcelik, & Craik, 2010), which corroborates the relationship between memory systems and PM. More specifically, a reflexive-associative memory system, which is linked to mesial temporal structures such as the hippocampus and is the mechanism thought to be responsible for spontaneous retrieval processes in PM (McDaniel & Einstein, 2011; McDaniel et al., 2004). Therefore, it can be seen that these regions of the brain active during PM correlate to the cognitive processes also underlying PM.

In summary, there is emerging evidence to suggest that mesial temporal lobe structures are linked to the episodic memory demands of the retrospective component of PM and also to the reflexive-associative memory system that supports spontaneous retrieval of event-based or focal PM intentions. Frontal neural systems, on the other hand, are considered critical for executive skills linked to the strategic, systematic attention monitoring required by complex time-based or non-focal tasks.

Factors affecting Success and Failure on tasks of Prospective Memory

There are a number of different factors that can contribute to an individual successfully completing a PM task. For example, less education and lower social status have been found to substantially increase the risk of PM impairment (Huppert, Johnson, & Nickson, 2000). These socio-demographic factors are relevant to all individual differences in cognitive processes, but more noteworthy are the other factors that have been cited, related to the parameters of the PM task itself, which can be manipulated to improve subsequent PM performance.

Motivation and perceived importance of the PM task have been suggested to play a role in an individual's PM performance. Guajardo and Best (2000) examined PM in preschool aged children but found no consistent effects of including an incentive. However, in children with moderate but not severe traumatic brain injury resulting in impaired PM performance, monetary gain was found to improve event-based PM (McCauley et al., 2010). It is possible that PM becomes more effortful for children with cognitive impairments following head injury and under these circumstances an incentive may improve motivation to apply the additional effort required. In adults, Ellis (1988) found a positive relationship between the reported recollection of the intention and the personal importance of the intention. Kliegel, Martin, McDaniel, and Einstein (2001) varied perceived importance by informing one group of participants that the ongoing task was more important than the PM task, whilst another group was told the PM task was more important than the ongoing task. They found that PM task importance does improve PM performance for time-based but not event-based tasks. Jeong & Cranney (2009) used a naturalistic PM paradigm where university students were asked to send mobile phone text messages to the researchers at specified times and under either a low or high motivation condition (i.e., with or without the incentive of course credit). They found that whilst there was no difference in self-ratings for how motivated participants were between conditions, there was an observable improvement in PM performance in the high motivation condition. Therefore, whilst the exact relationship to specific PM outcomes remains somewhat unclear, motivation clearly plays a significant role in PM as a whole.

Building on the idea of motivation is the fact that PM often involves socially important tasks, such as remembering to do things for others. When the social relevance of a PM intention is manipulated, PM performance is better under pro-social conditions rather than standard circumstances (Brandimonte, Ferrante, Bianco, & Villani, 2010). Altgassen, Kliegel, Brandimonte, and Filippello (2010) found that varying social importance did not influence PM performance in young adults but older adults exhibited significantly better PM performance in the high social importance condition than in the standard condition. The important role PM plays in day-to-day social interactions, particularly for older adults, further emphasises the need to measure PM in everyday environments where social motivation naturally occurs and because it becomes more artificial within the context of the laboratory.

Memory strategy use can also improve PM performance. Kapur, Glisky, and Wilson (2004) describe a number of memory aids such as electronic organisers, alarms, and speech storage devices that can act as effective reminders and improve PM functioning. The use of strategies for everyday PM will often transform a self-initiated time-based PM task into a less demanding event-based PM task, for example, the use of a timer or alarm would act as an environmental cue (Marsh & Hicks, 1998). Spaced retrieval is another explicit memory strategy commonly used to enhance retrospective memory for specific material and can also be applied to remembering a PM intention. Research shows that PM performance of participants with Alzheimer’s disease benefited from training in spaced retrieval in addition to elaborated encoding of the PM task (Kinsella, Ong, Storey, Wallace, & Hester, 2007).

Measuring Prospective Memory: Laboratory vs. Naturalistic and Self-report

Phillips, Henry, and Martin (2008) describe a model of PM measurement where there is an increasing degree of ecological validity across each level. Table 1.1 represents the different methods of measuring PM with ecological validity increasing as the table progresses, however, often this also relates to a decrease in experimental control. This pervasive issue regarding the difficulty in maintaining a balance between ecological validity and experimental control will subsequently be discussed in further detail. Phillips and colleagues (2008) describe several aspects of a PM measure. Firstly, with regards to the setting, PM tasks may be conducted within a naturalistic, everyday setting, or within the laboratory. Alternatively, a complex or virtual environment might simulate a naturalistic setting within the laboratory. Secondly, *natural* tasks occur in the context of everyday life regardless of experimenter involvement, whereas *artificial* tasks are instigated by the experimenter. Furthermore, *novel* tasks tend to be abstract, whereas the content and task demands associated with *familiar* tasks are likely to have been previously encountered in everyday life. These dimensions of PM tasks need to be carefully accounted for in evaluation of PM performance in order to optimise the ecological validity of a measure.

Table 1.1

Measurement and ecological validity in prospective memory

	Type of Measure	Setting	Task Description		Task Example
←Increasing ecological validity / Increasing experimental control →	1. Laboratory environment, artificial task	Laboratory	Artificial [a]	Novel [c]	Lexical decision task
	2. Laboratory environment, realistic task	Laboratory	Artificial	Familiar [d]	Remind experimenter to carry out action
	3. Complex environment, outside everyday experience	Complex real or virtual environment	Artificial	Familiar	Virtual shopping experience
				Novel	Signal presence of particular item
	4. Naturalistic environment, experimental task	Everyday life	Artificial	Familiar	Making telephone calls
				Novel	Time-logging in an electronic organiser
	5. Naturalistic environment, part of everyday experience	Everyday life	Natural [b]	Familiar	Taking medication

Note: Adapted from Phillips, Henry, and Martin (2008), p.174.
[a] Artificial tasks are instigated by the experimenter.
[b] Natural tasks would occur in everyday life without the interference of the experimenter.
[c] Novel tasks tend to be abstract and not previously encountered in everyday life.
[d] Familiar tasks are likely to have been encountered in everyday life.

The classic method for measuring PM performance within a laboratory setting involves a PM task embedded in an ongoing task. This is the basis of the dual-task paradigm devised by Einstein and McDaniel (1990) which is designed to mimic real life PM in that a PM cue occurs whilst a person is actively engaged in an ongoing activity. Einstein et al. (1995) used this model for a computer based task looking at time- and event-based PM. The ongoing activity was a continuous memory span task presented on a computer. The time-based PM task was then to press a computer key every 10 minutes and for the event-based PM task, participants were asked to press a response key whenever an animal word, for example, occurred during the continuous memory span task. Similarly, Einstein et al. (1998) used a computer key pressing task to develop a laboratory-based habitual PM task. Numerous investigations into PM have since been developed from these methodologies, particularly in the area of healthy ageing, which will be examined later in more detail.

Investigating everyday memory abilities in the laboratory has been a contentious issue and it has been suggested that laboratory-based tasks may have some limitations in reflecting real-world PM performance. Neisser (1978) argued that memory research conducted under controlled laboratory conditions has produced no important knowledge because of its limited ecological validity and that investigators should turn to uncontrolled, naturalistic observation outside the laboratory. Although the psychometric properties of many neuropsychological tests are acceptable, the relationship between these tests and the everyday functioning of the individual is lacking (Sbordone, 1996), which supports Neisser's (1978) position. Banaji and Crowder (1989) on the other hand, argued for the importance of experimental control in producing knowledge that can be generalised. In continuing the debate, Roediger (1991) emphasises a compromise between the two, which is evident in the PM literature by incorporating naturalistic stimuli within the laboratory. Examples of methodologies incorporating the naturalistic into the laboratory include a video-based simulated shopping task (Farrimond, Knight, & Titov, 2006; Knight et al., 2006), a video-based simulated street scene (McDermott & Knight, 2004), a board game representing a "virtual week" (Rendell & Craik, 2000), a story reading task (Kvavilashvili, 1998) and a computer-based simulation of cooking breakfast (Craik & Bialystok, 2006).

Naturalistic PM performance is a difficult entity to capture as even these laboratory-based PM tasks, which appear to generalise to real life, are still largely experimenter introduced. Furthermore, whilst these studies have employed naturalistic stimuli, they are not performed in a naturalistic setting and participants are often unable to use their everyday memory strategies for performing PM tasks. As a result, some PM paradigms have asked participants to perform PM tasks within their usual environments and in the context of their day-to-day lives, such as by getting them to post letters to the experimenter or phoning the experimenter at certain times (e.g., Troyer, 2001) or more recently with GPS technology recording both time and location information associated with PM (Sellen, Louie, Harris, & Wilkins, 1997). Marsh, Hicks, and Landau (1998) developed a new paradigm whereby participants described their own PM tasks for the week ahead and at the end of the week their success or failure at the PM tasks and the reasons behind their performance were explored. Naturalistic studies of everyday memory performance like this have often been criticised for their lack of control over participants' use of external aids or strategies (Roediger, 1991). Whilst allowing participants to use these strategies sacrifices some level of experimental control and instead relies upon aspects of self-report, it is still possible to get some degree of objective measurement outside of the laboratory.

PM can also be measured through self-report questionnaires. Kliegel and Jager (2006) examined the Prospective and Retrospective Memory Questionnaire (PRMQ) and its relationship to actual PM performance on standard laboratory time-based and event-based PM tasks in a healthy adult population. They found that PM performance was predicted by the PM subscales of the PRMQ but not by the retrospective memory subscales. However, it was unclear whether this finding was particular to PM; it was not reported whether the retrospective memory subscales of the PRMQ in turn predicted actual retrospective memory performances. Hannon, Adams, Harrington, Fries-Dias, and Gipson (1995) also utilised the PM component of the questionnaire and found that PRMQ performance was strongly related to PM performance on laboratory PM tasks and a relationship was also found between the

PRMQ and naturalistic post-in PM tasks. These studies indicate that questionnaire measures of PM have the potential to be valid indicators of actual PM performance. Memory questionnaires can also provide information about how other factors influence PM performance. For example, McDonald-Miszczak, Gould, and Tychynski (1999) used the Metamemory in Adulthood Questionnaire (MIA) and found that memory self-efficacy significantly influenced PM but not retrospective memory.

Despite these findings, there are also many difficulties when relying on self-report for the acquisition of data. Uttl and Kibreab (2011) employed three commonly used PM questionnaires (including PRMQ) and found that whilst these measures exhibited good reliability, there was poor convergent and divergent validity of PM self-reports with objective measures of PM. Similarly, whilst laboratory-based measures of PM and memory correlated with each other in predictable ways, and self-report rating scales correlated with one another, few experimental measures correlated with rating scale measures (Gibson, Macan, Potter, & Cunningham, 2010). This suggests that there is little overlap between objective measures and self-report and as such self-report measures should not solely be relied upon in lieu of experimental data. Furthermore, a substantial proportion of variability in PM self-reports were accounted for by verbal intelligence, personality, busyness, and use of memory strategies and aids (Uttl & Kibreab, 2011). Therefore, there are significant discrepancies in the reported validity of these self-report measures which affects the applicability of questionnaire studies but also naturalistic studies where there is limited objective measurement. Nevertheless, it is important to note that these questionnaires ask participants to report and rate their overall PM performance as a general concept. The reliability and validity of participants self-reports regarding discrete PM occasions they have experienced is yet to be established.

Prospective Memory and Ageing

Prospective memory performance in older adults is a particularly important area of research largely because we live in an ageing society and PM is crucial for maintaining independence in performing everyday activities, particularly in the elderly (Kidder et al., 1997). The PM and ageing literature is also noteworthy because it demonstrates the important distinction between the naturalistic and laboratory-based measurements of PM as older adults perform differently on PM tasks depending on whether they are in a naturalistic or laboratory setting. The *age-PM paradox* refers to how healthy older adults show impairments compared to younger adults on laboratory-based measures of PM and yet outperform their younger counterparts on naturalistic PM measures (Rendell & Thomson, 1999).

In the laboratory, an early influential study by Einstein et al. (1995) found an age-related decline in PM performance on time-based tasks but not event-based tasks. However, subsequent studies have found that event-based PM performance is also strongly and linearly related to chronological age (Cherry et al., 2001; Huppert et al., 2000), with older people tending to perform worse on tasks of PM than their younger counterparts. Furthermore, a meta-analysis compiling numerous PM experiments found that overall there is an age-related decline on both time- and event-based tasks in the laboratory (Henry, MacLeod, Phillips, & Crawford, 2004). In another study of habitual PM in the laboratory it was also found that age contributed to both omission and repetition errors (Einstein et al., 1998). Even some of the laboratory-based studies using naturalistic stimuli have found age related decrements in PM performance (Craik & Bialystok, 2006; Farrimond et al., 2006; McDermott & Knight, 2004).

In contrast, naturalistic studies have found no age deficits or in some instances age superiority in PM performance (Henry et al., 2004; Rendell & Craik, 2000). Rendell and Thomson (1999) specifically explored this concept by requiring participants to perform both a naturalistic PM task during their normal week and a laboratory-based PM task. Their study confirmed the paradoxical effect with the older adults consistently superior to the young adults on all the naturalistic PM tasks whilst the same participants showed a significant age related decline on retrospective memory tasks and on time- and event-based laboratory PM tasks. It has been suggested that older adults are able to compensate for their cognitive deficits in everyday memory by employing various memory strategies or cues and that motivation differs across settings for younger and older adults (Maylor, 1990). These naturalistic studies are often criticised for their lack of control over participants’ use of external aids or strategies (Roediger, 1991). However, laboratory-based studies have indicated that external reminders were equally beneficial to both older and younger adults (Henry et al., in press). Furthermore, even when the use of external aids is restricted, age benefits have still been found on naturalistic PM tasks (d'Ydewalle, Bouckaert, & Brunfaut, 2001). Therefore, naturalistic PM research can be seen to add important information to the PM literature.

One limitation of the current research with older adults is that populations for experiments are typically healthy older adults who volunteer and who are likely to be very high functioning. More research needs to be done on other populations of the ageing community, such as older adults with memory difficulties. For example, mild cognitive impairment is a condition which is becoming increasingly more common in the ageing community and warrants further attention.

Mild Cognitive Impairment

Mild cognitive impairment (MCI) refers to memory decline beyond age expectations but in the context of relatively preserved general cognition and functioning (Petersen, 2003). There are several subtypes of MCI, the most common of which is amnestic mild cognitive impairment (aMCI; Lonie, Herrmann, Donaghey, & Ebmeier, 2008). Individuals with aMCI have a high risk of progression to Alzheimer's disease (AD) (Petersen et al., 2009) with an annual conversion rate of 5% to 12%, in comparison to 1% to 2% of cognitively healthy older adults (Mitchell & Shiri-Feshki, 2009). Indeed, aMCI is sometimes considered to be a precursor to AD (Petersen et al., 1999). The early detection of AD, or those at risk of developing AD, is important in order to allow for care planning and intervention, especially considering that optimal benefits from cognitive interventions are achieved when the individual has adequate residual function to be actively involved in the intervention, during the earliest phases of the disease (e.g., Kinsella et al., 2009).

A workgroup developed by the National Institute on Aging and the Alzheimer's Association (Albert et al., 2011) have refined the clinical diagnostic criteria for aMCI originally described by Petersen and colleagues (1999). The core criteria include: (i) a cognitive concern reflecting a change in cognition reported by the patient, informant, or clinician; (ii) objective cognitive impairment for age and education, particularly in the memory domain; (iii) essentially intact activities of daily living; and (iv) does not meet criteria for clinical dementia.

Cognitive Processes Underlying Amnestic Mild Cognitive Impairment

People with aMCI exhibit significant memory deficits but limited impairments in other domains such as language and visuospatial skills (Petersen, 2004). Perri, Serra, Carlesimo, and Caltagirone (2007) documented a memory profile in aMCI subjects characterised by preserved short-term and implicit memory and extensive impairment of episodic long-term memory. However, Lonie et al. (2008) identified some other common areas of difficulties. They found that the majority of their aMCI subjects did not have an isolated impairment of episodic memory function but rather exhibited deficits in one or more additional domains of cognition, most commonly that of semantic memory function, followed by attention and executive function. Moreover, they also found preserved performance on measures of visuospatial function and processing speed, where aMCI subjects matched controls. Therefore, the concept of aMCI as an isolated memory impairment has been developed to recognise that preclinical memory deficits can appear in the context of additional executive functioning impairment (Albert et al., 2011), skills which are also critical for effective PM performance (e.g., Salthouse et al., 2004).

As well as a distinctive cognitive profile, aMCI has also been recognised as having distinct organic processes underlying the condition. In fact, although not essential, latest diagnostic criteria indicates the contribution of biological markers based on imaging and cerebrospinal fluid measures in the diagnosis of aMCI (Albert et al., 2011). Furthermore, individuals with aMCI have demonstrated neuropathology in mesial temporal lobe structures, particularly entorhinal cortex and the hippocampus (Pennanen et al., 2004; Tapiola et al., 2008), the same structures linked to the reflexive-associative memory system that supports spontaneous retrieval of event-based PM intentions (McDaniel & Einstein, 2011; McDaniel et al., 2004) and the episodic memory demands of the retrospective PM component (Goldstein et al., 2009). Frontal system impairment has also been implicated in aMCI (Brandt et al., 2009; Kume et al., 2011); a neural system considered critical for strategic, systematic attention monitoring required by time-based tasks (Burgess et al., 2003; Simons et al., 2006). Therefore, the multiple areas of cognitive impairment and neuropathology characteristic of aMCI indicate the potential for these individuals to struggle with different types and components of PM.

Prospective Memory and Mild Cognitive Impairment

The cognitive profile and neuropathology of individuals with aMCI clearly indicate that they may be susceptible to difficulties with PM. However, another feature of individuals with aMCI is that they are relatively independent with regards to their activities of daily living (Lonie et al., 2008). Given the important role PM plays in maintaining functional independence (Kidder et al., 1997), it is possible that PM might not pose such a problem for individuals with aMCI. On the other hand, significant PM deficits can even occur in the face of an otherwise intact neuropsychological profile (West, McNerney, & Krauss, 2007). Therefore, it would be useful to explore PM in aMCI because, on a theoretical basis, whether these individuals have intact or impaired PM does not seem to be a straightforward matter.

Despite the need for this research, the performance of individuals with aMCI on tasks of PM has only recently received increasing consideration. Table 1.2 represents a summary of the literature to date examining PM in aMCI. In an early study, Kazui and colleagues (2005) examined PM in this population and found impaired performance on an event-based task relative to healthy older adults, although those with aMCI did not perform as poorly as the participants with Alzheimer's disease. However, one limitation of their study was that it was hospital-based and the participants had quite significantly impaired cognition. Troyer and Murphy (2007) further investigated the distinction between performance on time-based and event-based PM tasks of people with aMCI and found that, whilst those with aMCI were also impaired on event-based PM as previously established (Kazui et al., 2005), performance on time-based PM tasks was particularly sensitive to the early cognitive decline seen in aMCI. Subsequent studies have also focused on time- and event-based performances. Costa and colleagues (2010) reported that individuals with aMCI were differentially impaired on time-based as opposed to event-based PM, which was thought to be a result of frontal involvement and the higher executive demands of time-based PM. Other studies, however, have reported a more generalised deficit in both time- and event-based PM (Karantzoulis, Troyer, & Rich, 2009; Thompson, Henry, Rendell, Withall, & Brodaty, 2010). Findings of global PM impairment in aMCI are compatible with their cognitive profile (i.e., impairments in memory and executive functioning) and underlying neuropathology (i.e., mesial temporal and frontal systems), which would compromise aspects of both time and event PM.

These studies have largely been limited to laboratory-based stimuli, which the ageing literature has shown does not necessarily reflect everyday PM performance. Karantzoulis et al. (2009), in addition to finding that their aMCI sample was impaired on laboratory-based PM tasks, also reported that significantly fewer individuals with aMCI than controls correctly executed a single naturalistic PM task, to telephone the researcher, after a 24-hour delay. Another study has used a time-logging PM task where participants were asked to turn on a handheld electronic organiser once per day for 2 days at a predetermined time (Thompson, Henry, Withall, Rendell, & Brodaty, 2011). They found that whilst their dementia group exhibited significant deficits on this task, the (mixed) MCI group performed comparably to the healthy controls. Therefore, whilst individuals with aMCI show clear PM impairments within a laboratory setting, the difficulties they might experience in the context of their day-to-day lives remains unclear.

Table 1.2

Summary of studies investigating prospective memory in mild cognitive impairment

Authors	**Participants**	**MCI type (subtype)**	**PM type**	**PM task**	**Task setting**	**Findings**
Kazui et al., 2005	48 controls 24 aMCI 48 AD	Amnestic (unknown)	Event	RBMT	Laboratory (familiar)	aMCI impaired compared to controls. PM did not differentiate groups.
Troyer & Murphy, 2007	42 controls 45 aMCI 24 AD	Amnestic (single-domain)	Time Event	Experimental	Laboratory (novel)	aMCI impaired compared to controls for all PM. Differentially impaired on time vs. event PM.
Blanco-Campal et al., 2009	21 controls 19 MCI-AD	Amnestic (unknown)	Event	Experimental	Laboratory (novel)	Event PM superior to traditional RM test in discriminating MCI-AD from controls.
Eschen et al., 2009	71 controls 27 MCI 9 mild AD	Amnestic (unknown)	-	PRMQ	Self-report	aMCI group not distinguished from controls by level of subjective PM or RM complaints.
Karantzoulis, Troyer & Rich, 2009	27 controls 27 aMCI	Amnestic (single-domain)	Time Event	MIST	Laboratory (familiar) & one naturalistic task	aMCI impaired compared to controls for all PM. Trend for greater difficulty on the time vs. event PM.
Schmitter-Edgecombe et al., 2009	42 controls 27 aMCI 15 non-aMCI	Amnestic Non-amnestic (unknown)	Event	Experimental	Laboratory (familiar)	aMCI and non-aMCI impaired compared to controls.

Costa et al., 2010	20 controls 10 aMCI 10 non-aMCI	Amnestic Non-amnestic	Time Event	Experimental	Laboratory (familiar)	MCI (combined aMCI and non-aMCI) impaired compared to controls. Differentially impaired on prospective vs. retrospective PM component.
Thompson et al., 2010	53 controls 48 MCI 39 early dementia	Amnestic Non-amnestic (single- & multi-domain)	Time Event	Virtual Week	Laboratory (familiar)	MCI impaired compared to controls for all PM.
Costa et al., 2011	24 controls 24 aMCI	Amnestic (single- & multi-domain)	Event	Experimental	Laboratory (artificial)	aMCI impaired compared to controls for all PM. Executive demand of ongoing task did not affect aMCI PM performance.
Thompson et al., 2011	45 controls 31 MCI 22 dementia	Amnestic (unknown)	Time	Experimental	Naturalistic (novel)	Dementia group impaired compared to controls and MCI. No difference between MCI and control groups.

Note: MCI = mild cognitive impairment; AD = Alzheimer’s Disease; PM = prospective memory; RM = retrospective memory; EF = executive functions; RBMT = Rivermead Behavioural Memory Test; PRMQ = Prospective and Retrospective Memory Questionnaire; MIST = Memory for Intentions Screening Test.

Rationale and Aims of the Current Study

Research to date indicates that PM is a critical feature of everyday functioning and as such deserves attention in the literature. Furthermore, research into healthy ageing has revealed that healthy older adults appear to have deficits in PM within a laboratory context but are able to overcome these difficulties within a naturalistic setting, again emphasising the importance of investigating everyday PM performance as laboratory-based measures will not necessarily be an accurate reflection of real-world performance. Individuals with aMCI lie somewhere along a continuum from healthy ageing to dementia and, as a group at risk of progression to Alzheimer's disease, early identification of aMCI is crucial for efficient management and intervention. Individuals with aMCI have the potential to exhibit deficits in PM given the nexus between their cognitive impairments and underlying neuropathology with the cognitive skills and neural regions recruited in PM tasks. Nonetheless, their performance on PM tasks has rarely been explored, with the current literature focusing on the theoretical basis for their PM presentation as opposed to how PM is relevant to this population clinically and diagnostically. Furthermore, if the aim is to describe the presentation of aMCI and identify ways to improve their day-to-day functioning, then it is important to investigate performance on naturalistic PM tasks, especially given the evidence from ageing research, which indicates that laboratory measures of PM may not accurately represent an individual's everyday PM capabilities. Therefore, the overall aim of this current research was to develop a clearer analysis of PM functioning in aMCI by extending investigation out of the laboratory and by adopting methods of PM measurement that have relance to clinical assessment and also to real world performance.

The aim in Study 1, presented in Chapter 2, was to investigate PM in a sample of aMCI participants by using clinical measures rather than laboratory defined measures. This was considered important if measurement of PM performance is to become a routine part of neuropsychological assessment of pre-clinical AD. The first aim of this study was to explore whether individuals with aMCI would demonstrate pervasive difficulty on both time- and event-based PM tasks, which would correspond with their cognitive deficits in both memory and executive functioning. The specific cognitive processes associated with PM function were explored by investigating which measures of retrospective memory and executive attention predicted PM performance. Finally, a comprehensive PM battery was compared to two simple, single-trial PM measures to evaluate their relative ability to predict and discriminate aMCI and healthy ageing. It was expected that the more complex, standardised PM battery would have more discriminating power than two single-trial tasks. In summary, this study provided information about the clinical and diagnostic utility of these standardised measures in aMCI and explored the specific cognitive skills associated with their performance.

The second study aimed to move further along Phillips et al.'s (2008) scale of PM measurement towards naturalistic measures of PM. Whilst there have been some studies that have used experimenter introduced naturalistic tasks (e.g., Karantzoulis et al., 2009; Thompson et al., 2011), there is yet to be an examination of self-generated PM in aMCI. This study adopted the methodology of Marsh and colleagues (1998), which had previously been used successfully with university undergraduate samples. Nevertheless, it was firstly necessary to determine whether the methodology could be used with participants with aMCI. A pilot study using this approach to measure self-generated PM is presented in Chapter 3 to develop the methodology for this population and to explore whether individuals with aMCI, as well as healthy older adults, could adequately fulfil the requirements of self-generated PM tasks.

Chapter 4 describes the two experiments that comprise Study 2. The first experiment employed a familiar, naturalistic, but experimenter-introduced PM task in which participants were asked to make a series of telephone calls at predetermined times to the researcher. Given that those with aMCI are described as relatively independent in their day-to-day functioning and they would have the opportunity to employ whichever strategies they chose, it was of interest to evaluate whether under these conditions individuals with aMCI would overcome observed PM deficits present under laboratory conditions. Furthermore, as with Study 1, in this experiment the cognitive correlates of PM were explored, but this time in relation to the naturalistic PM measure. To further extend the ecological validity of investigation of PM in aMCI, experiment two investigated PM in an everyday setting but using participants' own, self-generated PM tasks and explored not only their success rates but reasons for non-completion and strategy use.

Finally, Chapter 5 presents a discussion and integration of the combined findings of these studies. Whilst the theoretical implications of these findings are evaluated and discussed, specific focus is placed on the clinical issues raised by the study findings. Methodological issues, particularly with regard to the challenge of optimising ecological validity whilst maintaining experimental control, are also considered and suggestions made for the future direction of clinical research in PM and aMCI.

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Chapter 2. Clinical Measures of Prospective Memory in Amnestic Mild Cognitive Impairment

Clinical Measures of Prospective Memory in Amnestic Mild Cognitive Impairment

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Abstract

Recent research has established that individuals with amnestic mild cognitive impairment (aMCI) have impaired prospective memory (PM), however, findings regarding differential deficits on time-based versus event-based PM have been less clear. Furthermore, the diagnostic utility of PM measures has received scant attention. Healthy older adults (*n* = 84) and individuals with aMCI (*n* = 84) were compared on the Cambridge Prospective Memory Test (CAMPROMPT) and two single-trial event-based PM tasks. The aMCI participants showed global impairment on all PM measures. Measures of retrospective memory and complex attention predicted both time and event PM performance for the aMCI group. Each of the PM measures was useful for discriminating aMCI from healthy older adults and the time- and event-based scales of the CAMPROMPT were equivalent in their discriminative ability. Surprisingly, the brief PM tasks were as good as more comprehensive measures of PM (CAMPROMPT) at predicting aMCI. Results indicate that single-trial PM measures, easily integrated into clinical practice, may be useful screening tools for identifying aMCI. As PM requires retrospective memory skills along with complex attention and executive skills, the interaction between these skills may explain the global PM deficits in aMCI and the good discriminative ability of PM for diagnosing aMCI.

Keywords: Memory disorder, Neuropsychological tests, Aged, Dementia, Early detection, Diagnosis

Clinical Measures of Prospective Memory in Amnestic Mild Cognitive Impairment

Individuals with amnestic mild cognitive impairment (aMCI) have a high risk of progression to dementia of the Alzheimer's type (Petersen, 2009).Whilst exact figures vary, an annual conversion rate of 5% to 12%, as compared with 1% to 2% of cognitively healthy older adults, has been reported (Mitchell & Shiri-Feshki, 2009). Although initially conceptualised as a purely amnestic disorder, with relative preservation of other cognitive domains and intact activities of daily living (Petersen et al., 1999), recent research into aMCI has demonstrated considerably more variation in cognitive impairment (Lonie, Herrmann, Donaghey, & Ebmeier, 2008). Established episodic memory impairment within this population may interact with newly acknowledged, more subtle, deficits in executive attention to impact on an aspect of memory that requires both of these cognitive processes, namely, prospective memory.

Prospective memory (PM) refers to remembering to perform an intended action in the future (Einstein & McDaniel, 1990). PM comprises a retrospective component (remembering what to do) and a prospective component (remembering when to act; Ellis & Kvavilashvili, 2000). Time-based PM tasks are executed at specific times, such as remembering to telephone someone at 4.30pm, and require self-initiated strategic monitoring of the environment to recognise the appropriate time to act (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000). Event-based tasks are executed in conjunction with another event, such as passing on a message the next time you see a friend, which allows for spontaneous retrieval of the PM task (McDaniel & Einstein, 2011; McDaniel, Guynn, Einstein, & Breneiser, 2004). This early binary approach of categorising PM (i.e., time vs. event) has been developed further by several research groups (e.g., Kliegel, McDaniel, & Einstein, 2000; McDaniel & Einstein, 2000; Smith & Bayen, 2004) to provide a more comprehensive model of PM which requires multiple processes including: planning the intended action; retention; monitoring and identification of focal or non-focal cues; inhibition of the ongoing activity; timely initiation and accurate execution of an intention. Furthermore, the complexity of the PM task may affect the cognitive resources required. Martin and colleagues (2003) found that executive functioning predicted performance on complex PM tasks but not on a simple PM task; and Kliegel, Jager, and Phillips (2008) reported that PM was more challenging if the cue for PM was peripheral (i.e., non-focal) to the ongoing activity, as compared to a task in which the cue for PM was embedded within an ongoing task (i.e., focal cue). These findings emphasise the importance of considering the method of measuring PM as cognitive processes recruited will vary according to task demands. Nevertheless, the broad distinction of time-based vs. event-based PM has provided a useful guideline for distinguishing profiles of performance in the clinical measurement of PM. For example, in other clinical populations, a time-event distinction has been useful in identifying differential impairment of time-based PM in Parkinson's disease (e.g., Raskin et al., 2011) or global time and event PM deficits in schizophrenia (e.g., Wang et al., 2009) and HIV (e.g., Carey, Woods, Rippeth, Heaton, & Grant, 2006).

Individuals with aMCI have demonstrated neuropathology in mesial temporal lobe structures, particularly entorhinal cortex and the hippocampus (Pennanen et al., 2004; Tapiola et al., 2008), the same structures linked to the reflexive-associative memory system that supports spontaneous retrieval of event-based PM intentions (McDaniel & Einstein, 2011; McDaniel et al., 2004) and the episodic memory demands of the retrospective PM component (Goldstein et al., 2009). Frontal system impairment has also been implicated in aMCI (Brandt et al., 2009; Kume et al., 2011); a neural system considered critical for strategic, systematic attention monitoring required by time-based tasks (Burgess, Scott, & Frith, 2003; Simons, Scholvinck, Gilbert, Frith, & Burgess, 2006). Therefore, individuals with aMCI have the potential to struggle with different components and types of PM due to multiple areas of impairment.

Costa and colleagues (2010) reported that individuals with aMCI were differentially impaired on time-based as opposed to event-based PM, which was thought to be a result of frontal involvement and the higher executive demands of time-based PM. However, McDaniel, Shelton, Breneiser, Moynan, and Balota (2011) manipulated the demands of an event-based task and found that, in the very earliest stages of dementia, focal PM (associated with more automatic retrieval processes) was differentially impaired compared to nonfocal PM (associated with strategic attentional demands). The suggested reason for this discrepancy was that the spontaneous associative retrieval processes relied on in focal, event-based PM tasks were compromised, related to early known changes in the mesial temporal systems. Other studies using aMCI populations have reported a more generalised deficit in both time- and event-based PM (Karantzoulis, Troyer, & Rich, 2009; Thompson, Henry, Rendell, Withall, & Brodaty, 2010). These different findings may reflect the varying methodologies used across studies to index time- and event-based PM, the complexity of tasks and saliency of cues. Nonetheless, the findings of global PM impairment in aMCI are compatible with proposed underlying neuropathology (i.e., mesial temporal system and frontal circuits) and observed cognitive deficits (episodic and associative memory impairment as well as executive attention deficits) which have the potential to undermine both time- and event-based PM tasks.

While impairments in multiple areas of cognition are now considered important in the diagnosis of aMCI (Albert et al., 2011; Brandt et al., 2009; Lonie et al., 2008), the area of PM remains under-utilised diagnostically. One reason may relate to the limited availability of appropriate tests to systematically measure the construct in clinical practice. The Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn, & Baddeley, 1991), was an early memory battery that included PM subtests. However, the PM subtests were simple, single-trial, event-based tasks. There is an inherent difficulty in employing single probes of PM with a limited scale, as it may lessen the sensitivity and reliability of the measure. Nevertheless, a number of researchers have successfully adapted the RBMT PM protocol. For example, Kinsella and colleagues (2009) asked participants to remember to request an appointment card at the end of their assessments and combined this with another easily implemented single-trial PM task from Huppert, Johnson, and Nickson (2000) in which participants needed to remember to seal and initial an envelope, unprompted, after being dictated an address. Kinsella and colleagues (2009) found these brief PM tasks to be useful in measuring PM and assessing response to intervention in an aMCI population.

More recent developments in standardised measurement of PM for use in clinical settings have included the Memory for Intentions Screening Test (MIST; Raskin, 2009), which incorporates time- and event-based naturalistic PM tasks and allows for the assessment of error types. Karantzoulis, Troyer, and Rich (2009) employed the MIST in individuals with aMCI and found that they performed more poorly than healthy controls. Another standardised PM measure available for clinical use is the Cambridge Assessment of Prospective Memory (CAMPROMPT; Wilson et al., 2005). The CAMPROMPT comprises a battery of naturalistic time- and event-based PM tasks and, to increase everyday relevance, participants are allowed to implement strategies, including taking notes. In clinical practice, the ecological validity of a measure is crucial for application to a client’s day-to-day functioning. With regards to PM, permitting the use of external strategies is one way to reflect real life demands, and the CAMPROMPT is one of the few measures that allow strategies as part of the standardised administration. The CAMPROMPT has proved useful in the traumatic brain injury literature (e.g., Fleming et al., 2008; Groot, Wilson, Evans, & Watson, 2002) but to date there have been no reports of its utility with individuals with dementia or aMCI.

The general objective of this study was to extend previous research exploring PM in aMCI, which has been largely based on experimental measures, by evaluating performance on a standardised, clinical assessment of PM that allows comparison of time- and event-based PM performance. We expected that individuals with aMCI, compared with healthy older adults, would demonstrate pervasive difficulty in both time- and event-based PM tasks, reflecting the characteristic significant impairment of episodic memory in aMCI (Albert et al., 2011) and the frequent compromise of the executive attention component of working memory (Brandt et al., 2009; Lonie et al., 2008). This study further explored the cognitive processes associated with PM by investigating the contribution of retrospective memory and executive attention in predicting PM performance. We expected that the reflexive-associative memory system indexed by retrospective memory skills would be sufficiently predictive of simple event-based PM when cues for action were strongly present; whereas, executive attention of working memory would additionally contribute to the more complex, time-based PM tasks, which are considered to rely heavily on strategic attention monitoring (McDaniel & Einstein, 2011). Finally, we compared performance on the two scales (time; event) of the PM battery with two simple, single-trial PM measures to evaluate their relative ability to predict and discriminate aMCI and healthy ageing. We expected the more complex, standardised PM battery to have more discriminating power than the two single-trial tasks. Furthermore, given that both time- and event- based tasks target cognitive skills impaired in aMCI, it was expected that both scales would be effective in discriminating aMCI from healthy older adults.

Method

Participants

Participants were part of a larger study investigating the effects of a memory training program. Assessments for the present study were administered prior to the implementation of any interventions. Ethics approval was obtained from La Trobe University and participating health services. All participants provided written informed consent. Participants comprised 136 healthy older adults (HOA) and 113 individuals with aMCI. To ensure equivalent groups, cases were selected to be matched in terms of age (within 4 years), education (within 3 years) and gender. The final HOA and aMCI groups each included 84 participants.

The aMCI participants were referred from Cognitive Dementia and Memory Services (memory clinics) and experienced aged care specialists throughout Melbourne and selected regional centres, and had been diagnosed through multidisciplinary diagnostic consensus (i.e., neurological, psychiatric, radiological, neuropsychological, and functional assessment) and satisfied Petersen's revised aMCI criteria (Petersen, 2004). This diagnosis was then confirmed using the following inclusion criteria: (a) subjective memory complaint (i.e., sought professional investigation or assessment due to concern about memory performance); (b) objective memory impairment evidenced by performance more than 1.5 *SD* below age-appropriate normative data on at least one of the four memory screening measures of delayed recall: Hopkins Verbal Learning Test – Revised (HVLT-R; Brandt, 1991); Logical Memory subtest from the Wechsler Memory Scale Third Edition (Wechsler, 1997b); Verbal Paired Associates subtest from the Wechsler Memory Scale Fourth Edition (Wechsler, 2009); and Rey Complex Figure Test (RCFT; Meyers & Meyers, 1995);[1] (c) absence of, or very mild impact of impairment in basic activities of daily life as determined by a Clinical Dementia Rating (CDR; Morris, 1993) score of no greater than 0.5; and on the Alzheimer's Disease Functional Assessment and Change Scale (ADFACS; Mohs et al., 2001), a score of 0 (independent) on the basic (personal) activities of daily living (ADL) scale, or scoring 1 (occasional assistance) on no more than two of the six items; (d) absence of dementia using NINCDS-ADRDA criteria (McKhann et al., 1984). Given that the aMCI participants were recruited from clinical services, where a diagnosis of aMCI had already been made based on

[1] Actually, 64% of the aMCI sample performed more than 1.5 *SD* below age-appropriate normative data on *two* or more of the four memory measures used.

multi-disciplinary clinical judgement and consensus, it was considered appropriate that aMCI participants only required impaired performance on one of the memory screening measures in this study (Petersen & Morris, 2005).

Healthy older adult participants were recruited via local community centres. Inclusion criteria for the HOA group were: (a) absence of a subjective memory complaint (i.e., had not sought professional investigation or assessment due to concern about memory performance); (b) performance at 1.5 *SD* or above age-appropriate norms on each of the four screening measures of delayed memory (HVLT-R, Logical Memory, Verbal Paired Associates, and RCFT) [2]; (c) absence of impairment in basic activities of daily life as determined by a CDR score of 0; and on the ADFACS, a score of 0 (independent) on the basic (personal) ADL scale, or scoring 1 (occasional assistance) on no more than two of the six items.

Further inclusion criteria for both groups included being over 60 years of age, living in the community, and at least seven years of education. Fluency in English and adequate vision and hearing were required. Exclusion criteria were: diagnosis of any significant medical condition that might affect cognition; history of psychiatric or learning disorders; and presence of acute anxiety or depression. General inclusion and exclusion criteria were assessed in questionnaire format and clinical interview.

Demographic features of the participants are shown in Table 2.1. The aMCI and HOA groups did not differ in age (p = .93), education (p = .45), gender (p = 1.00), or predicted premorbid intelligence (p = .61), according to the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). As expected, the Mini-Mental Status Examination (MMSE; Folstein, Folstein, & McHugh, 1975), used to assess current cognitive status, differentiated the groups ($p < .001$).

[2] If only one of the memory scores was below criterion, an alternate version was administered and, if subsequent delayed recall performance fell within 1.5 *SD* of the mean, the participant was still included as a HOA. Following administration of an alternate-form memory test, nine HOA participants remained included and two were excluded. This criterion was used given that in healthy populations of older people, a single low score is not uncommon in an otherwise normal cognitive profile across multiple tests (de Rotrou et al., 2005).

Table 2.1

Summary statistics for the aMCI and HOA groups

	HOA			aMCI		
	n	*M*	*SD*	*n*	*M*	*SD*
Demographic characteristics						
Age (years)	84	74.77	6.95	84	74.87	6.71
Education (years)	84	13.30	2.97	84	12.96	2.85
Gender (% male)	84	44		84	44	
MMSE **	84	28.86	0.93	84	27.18	1.79
WTAR predicted IQ	84	108.80	8.17	83	109.40	6.74
Standardised PM Measure						
CAMPROMPT Time-based scale**	84	10.40	4.26	84	6.14	4.76
CAMPROMPT Event-based scale**	84	11.24	3.94	84	7.15	4.63
Single-trial PM Measures						
Prompt card (total)**	84	1.30	.82	84	0.42	0.73
Envelope (PM component)**	84	1.90	0.33	83	1.11	0.78
Envelope (RM component)**	84	1.67	0.57	83	0.87	0.79
Cognitive functioning						
CVLT-II (long delay) **	84	10.56	2.91	84	3.63	3.34
WAIS-III Digit Span backwards	83	6.80	2.24	83	6.27	1.75
DKEFS Letter fluency	82	39.07	12.18	82	37.55	11.39
DKEFS Category fluency	81	38.04	8.00	83	31.73	7.03
DKEFS Switching fluency	82	12.82	3.06	83	10.24	2.76
TMT B-A [a] **	80	55.00	39.33	82	88.50	76.25
TEA dual-task [a] *	80	1.18	2.18	81	1.91	3.02

Note. MMSE = Mini-Mental Status Examination; WTAR = Wechsler Test of Adult Reading; CAMPROMPT = Cambridge Prospective Memory Test; PM = prospective memory; RM = retrospective memory; CVLT-II = California Verbal Learning Test – Version II; WAIS-III = Wechsler Adult Intelligence Scale Third Edition; DKEFS = Delis-Kaplan Executive Function System; TMT B-A = Trail Making Test Part B less Part A; TEA = Test of Everyday Attention.

[a] Median and interquartile range values of raw (untransformed) variables are presented in this table. Analyses were performed on the square root transformed TMT B-A means (HOA: M = 8.10, SD = 2.27; aMCI: M = 10.15, SD = 3.09), and on the log transformed TEA dual task means (HOA: M = 1.52, SD = 0.41; aMCI: M = 1.68, SD = 0.50).

* Significant value ($p < .01$); ** Significant value ($p < .001$).

Measures

As part of the larger intervention study, participants underwent extensive screening and baseline assessments; only the measures relevant for the present study are described in this paper.

Standardised PM measure: CAMPROMPT. The Cambridge Prospective Memory Test (Wilson et al., 2005) was used as a standardised measure of complex PM. The 25-minute test is comprised of three time-based and three event-based (one focal and two non-focal) PM items embedded within a series of attention-demanding puzzles that serve as the ongoing task. For example, ‘when there are seven minutes left, remind me not to forget my keys’ and ‘when you come to a quiz question about [television show], give me this book’. Participants are allowed to use external strategies, including taking notes, and are provided with a pen and paper (in this study, recorded dichotomously, i.e., made notes, did not make notes). A digital countdown timer and analogue clock are used. Each item is scored between 0 and 6, therefore each scale (time; event) total is 18 and the maximum score for the test as a whole is 36, with higher scores reflecting better performance. The CAMPROMPT has a very high inter-rater reliability of 0.998 (Pearson) and moderate test-retest reliability of 0.64 (Kendall's Tau-b; Wilson et al., 2005). In the current study, the CAMPROMPT showed moderate inter-item reliability, with a Cronbach alpha coefficient of 0.75, indicating good internal consistency.

Single-trial PM measures: Prompt card and envelope tasks. The first single-trial PM measure was the *prompt card* task, as used by Kinsella et al. (2009), adapted from a similar task in the RBMT (Wilson et al., 1991). During the assessment session, a prompt card was prepared listing a set of appointment times (associated with subsequent research procedures for the larger study protocol). The participant was requested to remind the assessor at the end of the testing session to provide the prompt card. A score of 2 was given if the participant spontaneously requested the card within 15 seconds of testing completion, 1 point if the request was made late or required prompting (i.e., was there something else you had to do?), and 0 if the participant could not remember the instructions.

The *envelope* task was the second single-trial PM measure (Huppert et al., 2000; Kinsella et al., 2009). Participants were instructed that later during the assessment the examiner would dictate a name and address to write on an envelope. When this happened, they were asked to remember to seal the envelope and write their initials on the back. After a 20 minute delay the envelope was presented and the address dictated. Participants could receive a total of 4 points for this task: 2 points for the prospective component and 2 points for the retrospective component. For the prospective component, the participant needed to remember to do something after addressing the envelope. They received 2 points if this was within 15 seconds of the address being dictated, 1 point if it was done late or required a prompt, and 0 if no action was performed. For the retrospective component, 2 points were awarded if the envelope was both sealed and initialled on the back, 1 point if only one of these tasks were performed, and 0 if the wrong or no action was performed.

Cognitive functioning. The long delay, free recall trial of the Californian Verbal Learning Test – Second Edition (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000) was used as a measure of retrospective memory. The backwards trial of the Wechsler Adult Intelligence Scale Third Edition (WAIS-III; Wechsler, 1997a) Digit Span subtest was used to assess working memory. To address executive attention of working memory, the verbal fluency trials (letter, category, switching) from the Delis-Kaplan Executive Function System (DKEFS; Delis, Kaplan, & Kramer, 2001) were used as these tasks reflect Baddeley’s (2001) episodic buffer component of executive functioning (requiring attention monitoring and manipulation, and strategic access to long-term memory). Furthermore, the derived score subtracting Part A from Part B of the Trail Making Test (TMT B-A; Hester, Kinsella, Ong, & McGregor, 2005; Reitan & Wolfson, 1985) was used as it isolates the ability to switch attention, independent of manual dexterity (Corrigan & Hinkeldey, 1987). Larger B-A scores reflect increased difficulty with switching attention. The ability to divide attention was assessed using the dual-task decrement component of the Telephone Search While Counting subtest from the Test of Everyday Attention (TEA dual-task; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994).

Statistical Analyses

Two variables exhibited significant skew and kurtosis (TMT B-A; TEA dual-task). Following square root (TMT B-A^{SQRT}) and natural logarithmic (TEA dual-task^{LN}) transformations, data conformed more closely to assumptions of normality. To aid interpretation, the median and interquartile ranges of the original, untransformed variables are reported in Table 2.1.

Group differences with respect to the CAMPROMPT (time- and event-based scales) and envelope task (prospective and retrospective components) were assessed using mixed-model analyses of variance (ANOVAs). A chi-square test was used to compare the groups on note-taking during the CAMPROMPT. For the prompt card task, a univariate ANOVA was used to compare groups. Effect size is reported as η_p^2 where .01 is a small effect, .06 is a medium effect, and .14 a large effect (Cohen, 1988).

A one-way between-groups multivariate analysis of variance (MANOVA) was performed to investigate group differences on the seven measures of cognitive functioning. When the results for the dependent variables were considered separately, a Bonferroni adjusted alpha level of .007 was used, rather than .05. The relationship between the measures of cognitive functioning and PM was first investigated using Pearson product-moment correlation coefficients. Follow-up multiple regression analyses were conducted separately for each group using the variables that significantly correlate with PM to predict performance for CAMPROMPT time- and event-based scales. Due to the difficulty conducting multiple regression analyses on measures with a limited scale, the single-trial PM measures were not used.

To address the final aim, a logistic regression was undertaken using the PM measures (CAMPROMPT time and event scales, prompt card, and envelope tasks) and the traditional retrospective memory measure (CVLT-II, delayed free recall) to predict group membership (aMCI or HOA). The envelope task total score was used to reduce the number of analyses undertaken. To further explore the diagnostic accuracy of these measures for aMCI, a receiver operating characteristic (ROC) analysis was conducted. Using Hanley and McNeil's (1983) method, the areas under the curves (AUCs) were compared.

Results

Prospective Memory Functioning

Standardised PM measure: CAMPROMPT. The means and standard deviations for all PM measures are presented in Table 2.1. Comparison of performance on the CAMPROMPT showed that the HOA group performed significantly better than the aMCI group, $F(1,166) = 51.82$, $p < .001$, with large effect size, $\eta_p^2 = .24$. There was also a significant main effect for subscale, $F(1,166) = 6.70$, $p = .01$; with small effect size, $\eta_p^2 = .04$. Performance for both groups was better for the event-based as opposed to the time-based scale of the CAMPROMPT. The interaction effect was not significant, $F(1,166) = 0.06$, $p = .80$, $\eta_p^2 < .001$. The aMCI and HOA groups did not differ in the number of participants that chose to use notes during the CAMPROMPT, 49% and 61% respectively, $\chi^2(1, N = 162) = 2.54$, $p = .11$, $\phi = .13$.

Single-trial PM measures: Prompt card and envelope tasks. The HOA participants performed significantly better than the aMCI group on the prompt card task, $F(1,162) = 53.28$, $p < .001$; with large effect, $\eta_p^2 = .25$.

On the envelope task, participants with aMCI again performed more poorly than the HOA participants, $F(1,165) = 85.74$, $p < .001$, with large effect size, $\eta_p^2 = .34$. There was also a significant main effect for task component, $F(1,165) = 22.45$, $p < .001$, $\eta_p^2 = .12$; both groups performed better on the prospective rather than the retrospective component of the task. There was no interaction effect, $F(1,165) = 0.001$, $p = .98$, $\eta_p^2 < .001$.

Cognitive Predictors of Prospective Memory

The means and standard deviations for the cognitive variables are presented in Table 2.1. There was a statistically significant difference between the aMCI and HOA groups on the combined cognitive variables, $F(7,146) = 29.86$, $p < .001$, $\eta_p^2 = .59$. Considering the dependent variables separately, HOA participants performed significantly better than the aMCI group on the CVLT-II delayed free recall, $F(1,152) = 180.78$, $p < .001$, $\eta_p^2 = .54$; category fluency, $F(1,152) = 23.83$, $p < .001$, $\eta_p^2 = .14$; switching fluency, $F(1,152) = 33.18$, $p < .001$, $\eta_p^2 = .18$; and TMT B-A^{SQRT}, $F(1,152) = 20.93$, $p < .001$, $\eta_p^2 = .12$. The groups did not significantly differ on digit span backwards, $F(1,152) = 3.15$, $p = .08$, $\eta_p^2 = .02$; letter fluency, $F(1,152) = 0.66$, $p = .42$, $\eta_p^2 = .004$; or the TEA dual-task^{LN}, $F(1,152) = 5.18$, $p = .02$, $\eta_p^2 = .03$.

A correlation was conducted between the time- and event-based scales of the CAMPROMPT and the seven cognitive variables. For the aMCI group, CVLT-II delayed free recall ($r = .33$), DKEFS Switching fluency ($r = .23$) and TMT B-A^{SQRT} ($r = -.32$) significantly correlated with CAMPROMPT time-based performance. CVLT-II delayed free recall ($r = .36$) and TMT B-A^{SQRT} ($r = -.30$) also significantly correlated with the CAMPROMPT event scale. Digit span backwards ($r = .22$) was the only significant variable for the HOA group, moderately correlating with the CAMPROMPT event scale.

A multiple regression was performed for the time- and event-based CAMPROMPT scores for each group using variables that significantly correlated with PM (see Table 2.2).

CVLT-II delayed free recall and TMT B-A^{SQRT} were unique predictors of performance on both scales (time; event) of the CAMPROMPT for the aMCI group. For the HOA group, none of the cognitive variables significantly predicted CAMPROMPT performance. The combined cognitive variables accounted for only 6-7% of variance in performance on either scale of the CAMPROMPT for the HOA group but 19-22% for the aMCI group.

Table 2.2

Predictors of time- and event-based PM performance for aMCI (n=82) and HOA group (n=80)[a]

	CAMPROMPT Time				CAMPROMPT Event			
	HOA		aMCI		HOA		aMCI	
Predictors	R^2	β	R^2	β	R^2	β	R^2	β
CVLT-II		.03		.24*		.02		.34**
WAIS-III Digit Span backward		.16		.03		.18		-.17
DKEFS Switching fluency		.10		.11		.10		.05
TMT B-A^{SQRT}		-.08		-.25*		-.04		-.31**
Overall Model	.07		.19**		.06		.22**	

Note. CAMPROMPT = Cambridge Prospective Memory Test; CVLT-II = California Verbal Learning Test – Version II, delayed free recall; WAIS-III = Wechsler Adult Intelligence Scale Third Edition; DKEFS = Delis-Kaplan Executive Function System; TMT B-A = Trail Making Test Part B less Part A; SQRT = square root transform.

[a] Smaller *n* due to missing values.

* Significant value ($p < .05$); ** Significant value ($p < .01$).

Predictive and Discriminative Ability of Prospective Memory Measures

The combined PM and retrospective memory predictors reliably distinguished between the aMCI and HOA groups, $\chi^2(5, N = 163) = 132.39$, $p < .001$. Specifically, the significant individual predictors were the CVLT-II delayed free recall, Wald Statistic = 27.61, $p < .001$, odds ratio = 1.69, and the envelope task (total score), Wald Statistic = 4.58, *p*

= .03, odds ratio = 1.93. Overall prediction success for the total model improved from 50.9% to 87.1% with the inclusion of the retrospective memory and PM measures.

ROC analysis was significant for the retrospective memory and each of the PM measures (see Table 2.3). The ROC curves are presented in Figure 2.1. Comparison of the AUCs found that all measures were strong, although the CVLT-II delayed free recall was significantly better than the PM measures, which were not significantly different from one another. Cut-off scores and associated sensitivity, specificity, and likelihood ratios are presented in Table 2.3.

Table 2.3

Summary of the ROC analyses with cut-off scores for aMCI (n=80) vs. HOA group (n=83)[a]

	AUC	95% CI	Cut-off score	Sensitivity	Specificity	LR+	LR-
Retrospective							
CVLT-II	.93*	[.90,.97]	<8	88%	84%	5.50	0.14
Prospective							
CAMPROMPT Time	.76*	[.69,.83]	<9	69%	69%	2.20	0.45
CAMPROMPT Event	.76*	[.68,.83]	<10	73%	70%	2.41	0.39
Prompt card task	.77*	[.69,.84]	<1	78%	73%	2.89	0.30
Envelope task	.85*	[.76,.89]	<3	66%	81%	3.47	0.42

Note. AUC = area under the curve; LR+ = likelihood ratio positive; LR- = likelihood ratio negative; CVLT-II = California Verbal Learning Test – Version II, delayed free recall; CAMPROMPT = Cambridge Prospective Memory Test (total score).

[a] Smaller *n* due to missing values.

* Significant value ($p < .001$).

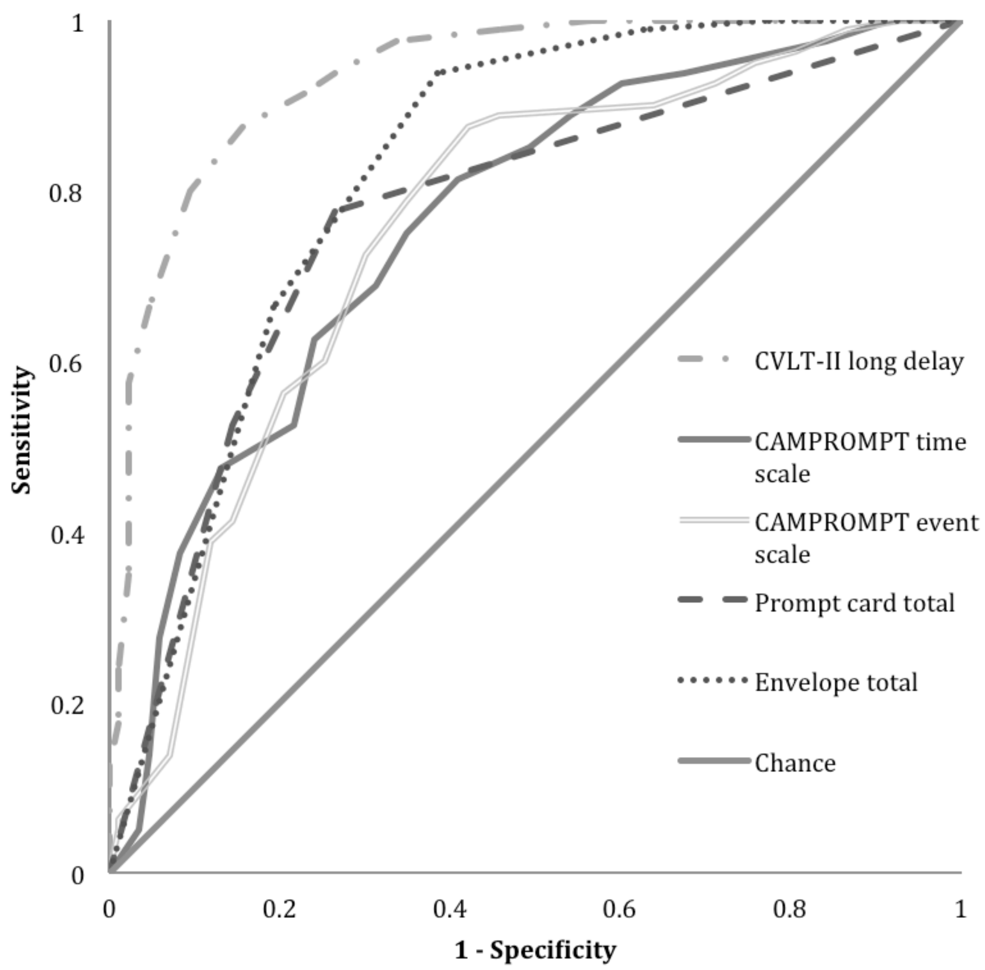

Figure 2.1. Receiver operating characteristic (ROC) curves for a retrospective memory measure and four prospective memory measures as diagnostic indicators of amnestic mild cognitive impairment.

Discussion

The main focus of the study was to assess the utility of clinical measures of PM in the assessment of aMCI. As expected, individuals with aMCI were impaired on both the time- and event-based scales of a comprehensive PM test battery (CAMPROMPT) when compared with healthy older adults. Both the aMCI and the HOA participants demonstrated greater difficulty with the time-based rather than event-based tasks which is consistent with previous research (e.g., Groot et al., 2002) and the assumption that time-based PM is generally more difficult due to higher executive demands. However, in addition to group differences on the time-based tasks, it was notable that the aMCI group were also impaired on the event-based tasks as compared to the HOA group. This should not be unexpected as effective event-based PM is considered reliant on automatic associative retrieval skills which are compromised in aMCI (McDaniel et al., 2011). This impairment on event-based tasks as well as time-based tasks (Karantzoulis et al., 2009; Thompson et al., 2010) may characterise the PM profile that discriminates aMCI from normal cognitive ageing, where the typical profile is differential impairment on time-based tasks reflective of diminishing cognitive resources for effective attention allocation in healthy ageing (Einstein & McDaniel, 2005). This finding also supports the concept of widespread cognitive impairment in aMCI with deficits not only in episodic memory but also aspects of the executive attention component of working memory (Lonie et al., 2008), compounding deficits that can impair multiple processes operating in both time- and event-based PM.

As well as the CAMPROMPT, the aMCI group was compared to healthy older adults on two single-trial event-based PM tasks, both of which confirmed the global impairment of PM in individuals with aMCI, regardless of the complexity of the task. Although the envelope task is a simple single-trial task, the scoring allowed for a comparison of prospective and retrospective performance. Interestingly, our findings that both groups demonstrated greater difficulty with the retrospective component of PM contradict those of Costa et al. (2010) whose participants struggled more with the prospective component. This may be due to their sample including individuals with non-amnestic, dysexecutive MCI, a group that would be expected to have greater difficulty with the executive demands of the prospective component of PM, whereas our sample was entirely aMCI. Exploring these potential differences between MCI subtypes is an area for future development.

The cognitive processes associated with PM were also explored by investigating the contribution of retrospective memory and executive attention in predicting PM performance. Somewhat contrary to expectations, the same pattern of cognitive skills predicted both time- and event-based PM performance in the aMCI group. This may reflect the compounding deficits in aMCI affecting all aspects of PM. The significant cognitive predictors are congruous with a general model of PM based on a retrieval memory measure and a measure that isolates the individual's ability to shift and allocate attention (executive attention), which reflects the process in PM whereby an individual needs to continuously redirect attention from the ongoing task to monitor the environment for the appropriate cue and finally disengage attention from the ongoing task for execution of the PM intention (McDaniel & Einstein, 2000). The fact that the time- and event-based tasks in this study appear to employ similar cognitive resources (i.e., both retrospective memory and executive attention), which are impaired in aMCI, may further explain how these individuals were globally and comparably impaired on both time and event PM. This is in contrast to individuals with Parkinson's disease, who also have noted deficits in subcortically-mediated memory and executive functions but exhibit differential time-based PM deficits (Raskin et al., 2011). This may relate to the memory difficulties in Parkinson's disease being linked to their frontal pathology (Braak, Ghebremedhin, Rub, Bratzke, & Del Tredici, 2004), whereas in aMCI there are also underlying deficits in mesial temporal networks (Tapiola et al., 2008). For healthy older adult populations, on the other hand, it appears that non-cognitive factors may be playing more of a role in their PM performance in this study.

Finally, the CAMPROMPT and the single-trial PM measures were directly compared against a retrospective memory measure to determine their relative capacity in discriminating the aMCI group from the HOA group. The retrospective memory measure was found to have the highest discriminative power; however, this is not unexpected given that the retrospective measure used to predict group membership was very similar to one of the screening measures that were used to diagnose the aMCI group (i.e., two different word list learning tasks). Therefore, the apparent superiority of a traditional retrospective memory measure over PM measures should not be over-interpreted. All four PM measures showed good discriminatory ability. As expected, both the time and event scales of the CAMPROMPT were equivalent in their ability to discriminate aMCI from HOA. Surprisingly, the brief, single-trial tasks were as effective as the more complex PM battery, CAMPROMPT, in identifying aMCI group membership. Given that these tasks are quick and easy to administer, these results have significant practical implications. For example, these tasks might be used as screening tools in clinical assessment to indicate the possibility of aMCI and the need for more comprehensive neuropsychological follow-up. However, for all of the PM measures, the cut-off scores provided in this paper should be used with caution as PM performance has been shown to be affected by age (Henry, MacLeod, Phillips, & Crawford, 2004; Wilson et al., 2005), which is not taken into account by the study analyses in generating the cut-off scores. Although the CAMPROMPT does provide preliminary age- and IQ-adjusted normative data (Wilson et al., 2005), the sample size for the 70-year + age group is very limited. Further studies using large populations will be needed to broaden the utility of these PM measures in clinical assessment.

One limitation of much of the research regarding PM, including the current study, is that a simple distinction between time- and event-based PM does not encompass the potential complexity of PM performance in everyday life. Indeed, the above findings indicated that similar cognitive skills were recruited during CAMPROMPT time- and event-based performance, which did not fit with our expectations derived from the prior literature. Furthermore, the aMCI were comparably impaired on the time- and event-based PM tasks and these tasks were equivalent in their diagnostic ability. This may indicate that the

CAMPROMPT scales are not adequately differentiating between the different types of PM. Experimental studies are contributing to the understanding of PM by evaluating the significance of different types of monitoring involved in a PM task (e.g., strategic vs. spontaneous; McDaniel & Einstein, 2000) and the types of cues provided (e.g., focal vs. nonfocal; Einstein & McDaniel, 2005). As the theoretical model of PM increases in complexity and the contribution of cognitive and non-cognitive factors are integrated into the model, clinical measures will need to reflect these developments. For example, the CAMPROMPT allows the use of notes during the task, thereby simulating the naturalistic environment in a way that few other neuropsychological measures permit. In this study, a record was made of whether or not participants took notes; however, the quality of their notes and the extent to which they referred to their notes was not documented. In future, this would be a valuable area to measure, not only to improve experimental control, but also to guide potential interventions.

Further to methodological limitations of this study, we have presented the CAMPROMPT as a more complex assessment of PM functioning in the context of comparison to single-trial measures. In fact, the CAMPROMPT is still limited in the number of PM trials it includes. Therefore the reduced reliability associated with limited PM tasks (Kelemen, Weinberg, Alford, Mulvey, & Kaeochinda, 2006) remains an issue for all the PM measures in this study. Similarly, with regard to the scoring systems for each of the measures used, they are to some extent arbitrary and do not necessarily reflect the theoretical constructs of concern in the PM literature. Nevertheless, these measures in their current form, with standardised administration (as would be employed in a clinical setting) have still proven to be useful within this population.

In summary, although PM performance is not typically considered in the assessment of aMCI, these findings suggest that even simple measures of PM, which can easily be integrated into clinical practice, can provide additional information to the diagnosis of aMCI. Both time and event PM appear to incorporate retrospective memory retrieval skills as well as complex attention and executive abilities. The interaction between these skills may explain the global time- and event-based impairments in PM exhibited by individuals with aMCI and the good discriminative ability of these measures for diagnosing aMCI.

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Chapter 3. Naturalistic Prospective Memory in Amnestic Mild Cognitive Impairment: A Pilot Study

Investigations of prospective memory (PM) in amnestic mild cognitive impairment (aMCI) have largely been conducted within a laboratory setting (Blanco-Campal, Coen, Lawlor, Walsh, & Burke, 2009; Costa et al., 2010; Costa et al., 2011; Karantzoulis, Troyer, & Rich, 2009; Kazui et al., 2005; Schmitter-Edgecombe, Woo, & Greeley, 2009; Thompson, Henry, Rendell, Withall, & Brodaty, 2010; Troyer & Murphy, 2007). This was the approach adopted in the previous chapter and individuals with aMCI demonstrated significant impairment on clinically accessible, artificial but familiar tasks that were laboratory-based. The practical applications of these measures were evident in their diagnostic utility for discriminating this at-risk population from healthy older adults. However, the application of these results to everyday functioning is limited and it is important to step outside the laboratory towards naturalistic measures of PM in order to improve ecological validity and address issues such as motivation and strategy use, which play important roles in PM functioning in day-to-day life (Jeong & Cranney, 2009; Kapur, Glisky, & Wilson, 2004).

Few studies have explored naturalistic PM in aMCI (Karantzoulis et al., 2009; Maylor, 1996; Thompson, Henry, Withall, Rendell, & Brodaty, 2011) and these have relied on experimenter introduced PM tasks. Protocols for using experimenter introduced PM tasks conducted within an everyday setting have been well established (Phillips, Henry, & Martin, 2008). Time-logging tasks are the most common approach, typically achieved by requesting participants to make telephone calls at scheduled times, either on a single occasion (as employed by Karantzoulis et al., 2009) or multiple times (e.g., Fish et al., 2007). Alternatively, Thompson and colleagues (2011) asked participants to turn on handheld electronic organisers at pre-determined times. These experimenter introduced PM tasks are still somewhat artificial, despite the fact they are familiar and occur in a naturalistic setting. The assessment of natural, self-generated PM tasks has received less attention because of the difficulty in obtaining sufficient experimental control.

Marsh, Hicks, and Landau’s (1998) methodology represented a major advancement in the ecological validity of PM assessment by employing participants’ own, self-generated PM tasks in the context of their day-to-day functioning. University undergraduates were asked to describe their own PM tasks for the week ahead and at the end of the week their success or failure at the PM tasks and the reasons behind their performance were explored. Their young adult sample had relatively high levels of successful task completion, at around 75%, and low levels of self-reported forgetting, around 3-4%. Instead, reprioritisation and rescheduling were the reasons behind most of their PM failures. Beavis (2001), in an unpublished doctoral thesis, adopted this approach with healthy younger and older adults and reported that overall PM does not appear to decline with age in high functioning older adults when using this approach. Their older adults also reported high success rates, around 88%, and similar levels of forgetting, reprioritisation and cancellation of their PM tasks.

Whilst experimenter introduced protocols of naturalistic PM have been tried and tested, the methodology of Marsh and colleagues (1998) does not appear to have been used with cognitively impaired individuals. As a result, a pilot study was conducted to explore whether individuals with aMCI as well as healthy older adults (HOA) could adequately fulfil the requirements of the task of self-generated PM.

Method

Procedure

The methodology was based on Marsh and colleagues (1998), as it was adapted by Beavis (2001), where participants were requested to generate a to-do list for the week. Furthermore, strategy use associated with their self-generated tasks was more specifically addressed in this study, which was lacking from Beavis' (2001) research and only explored in a general manner by Marsh et al. (1998), who categorised participants as either recorders (those who habitually used a diary or some other written list to keep track of their intentions and obligations) or non-recorders.

With regards to the period of measurement, Marsh and colleagues (1998) assessed their participants in two sessions conducted one week apart. The present study was intended to be conducted across a 12-day period (participants generating two weekly to-do lists, each week consisting of six days), however, only one week, a 6-day period, was used for the pilot study.

Participants generated their own PM tasks for the week by following the instruction sheet and record form in Appendix B. In summary, participants were provided with a series of categories and examples of tasks (appointments, things to arrange, things to do around the house, things to communicate, regular things, and other things) on the record sheet to prompt task generation. They were also told they could refer to their diary or calendar to remind them of what they had to do for the week. Participants were then asked to rate on a 7-point Likert scale how important it was that each task was completed that week. Participants were told to carry out their week as normal, and use their usual methods for carrying out their to-do lists. At the end of the week, participants were asked to review their form and indicate whether each task had been successfully completed and if not, why not? Initial categories of reasons for non-completion included: forgetting; reprioritisation (i.e., the participant decided that it was no longer appropriate or important to complete the task that week); cancellation of the task by someone else; other circumstances made it impossible to complete the task (e.g., weather); and other. Regardless of whether participants had successfully completed the task or not, for each task they were asked to report what strategy they had used to help them remember. Strategy options included: no explicit strategy; written in a diary or calendar; written down on a note, post-it etc.; relying on habit; pairing with another task; relying on a reminder from someone else; and other.

A number of administration issues became apparent in the course of the pilot study and likely contributed to the difficulty with task generation exhibited by the aMCI group. As a result, the administration procedure was adjusted on several occasions. Firstly, as described above and in Appendix B, a written form was used that participants were intended to complete themselves. Almost immediately it was evident that participants were confused or overwhelmed by this process. Consequently, whilst the procedure remained the same, the instructions and form were administered orally so that participants were not presented with too much information at one time. Nevertheless, difficulties remained in participants' generating sufficient tasks for the week. Therefore, a more detailed administration procedure was devised (Appendix C), which involved providing participants with a rationale for the task, an explanation of time- and event-based PM and describing several examples of these types of tasks. Participants continued to be overwhelmed by this approach. Finally, a simplified but structured method was adopted where the provision of examples, one by one, was the primary means for generating tasks and participants were prompted for their own tasks after each example (Appendix D). This approach appeared to be the most successful in obtaining tasks from participants, particularly with the aMCI group. Examples of PM tasks generated by participants are listed in Appendix E.

Participants

Inclusion and exclusion criteria were the same as for the larger study (see Chapter 2). Initially 32 participants were recruited for the pilot study.[3] Of those, 12 participants (9 aMCI, 3 HOA) were either unable to generate any PM tasks or did not understand the task concepts and instructions. The remaining participants consisted of 9 individuals with aMCI and 11 HOA.

Demographic characteristics of these participants are shown in Table 3.1. The aMCI and control groups did not differ in age (p = .62), education (p = .11), gender (p = .41), predicted premorbid intelligence (p = .22), or MMSE score (p = .18).

Table 3.1

Summary statistics for the aMCI (n=9) and HOA (n=11) groups

	HOA		aMCI	
	M	*SD*	*M*	*SD*
Demographic characteristics				
Age (years)	72.82	7.88	74.44	5.98
Education (years)	15.09	2.12	13.33	2.55
Gender (% male)	9.10		22.22	
MMSE	28.73	1.19	27.78	1.86
WTAR predicted IQ	114	3.10	111	7.00

Note. MMSE = Mini-Mental Status Examination; WTAR = Wechsler Test of Adult Reading.

Statistical Analyses

Given the small sample size, this pilot study was low in power and, while p values are provided, more emphasis is placed on effect sizes in these circumstances. Effect size is

[1] There is overlap between the participants used in this pilot study and those presented in Chapter 2. However, the measures and demands of study 1 did not confound the results of the pilot study, and vice versa.

reported as η_p^2 where .01, .06, and .14 correspond to small, medium, and large effect sizes respectively (Cohen, 1988).

The majority of measures conformed to assumptions of normality. A few (mostly relating to strategies used) were positively skewed, however, given this was a pilot study, it was deemed appropriate to use these variables untransformed for preliminary analyses to explore the practicalities of employing this methodology. A series of one-way ANOVAs were used to compare the overall number of to-do list tasks generated, the proportion of time-based tasks generated, average ratings of task importance, and finally the percentage of tasks successfully completed between the aMCI and HOA groups.

Considering the reasons for non-completion, to minimise the number of variables analysed, a combined *cancellation* variable was created for whether the task was cancelled by another person or by external circumstances as there were few responses in either category. Furthermore, all participants elected one of the primary reasons for non-completion; the *other* category was not used. A multivariate analysis of variance (MANOVA) was conducted to compare the aMCI and HOA groups on the three reasons for non-completion (forgetting; reprioritisation; cancellation). Following this, a Bonferroni-adjusted error rate of .02 (i.e., $\alpha/3$) was used to assess univariate results of the three dependent variables. With regards to the strategy categories, a combined *written* variable was generated which incorporated diary use with any other notes or written materials as participants did not tend to distinguish between the different types of written strategies when reporting their strategy use. Again, the *other* category was not used. A MANOVA was conducted to compare strategy use (written; habit; pairing with another task; reminder from someone else; none) between groups. A Bonferroni-adjusted error rate of .01 (i.e., $\alpha/5$) was used.

Results

The means and standard deviations for measures associated with the to-do list task are presented in Table 3.2. Overall, the HOA group generated more PM tasks for their to-do lists than the aMCI group, $F(1,19) = 4.96$, $p = .04$, $\eta_p^2 = .22$. However, the groups did generate similar proportions of time-based versus event-based PM tasks, $F(1,19) = 0.66$, $p = .43$, $\eta_p^2 =.04$. Ratings of task importance were not significantly different between groups, $F(1,19) = 0.64$, $p = .43$, $\eta_p^2 = .04$. There was no significant difference in self-reported overall success rate between the groups, $F(1,19) = 0.61$, $p = .45$, $\eta_p^2 = .03$.

Table 3.2

Experiment 2: Summary statistics for the HOA (n=11) and aMCI (n=9) groups

	HOA		aMCI	
	M	*SD*	*M*	*SD*
To-do list Measures				
Tasks generated (total) *	10.82	4.12	6.67	4.18
Tasks generated (% time-based tasks)	41.13	22.07	50.69	30.73
Importance	5.78	0.34	5.63	0.51
Success (% completed)	91.54	7.09	87.25	16.63

Note. MMSE = Mini-Mental Status Examination; WTAR = Wechsler Test of Adult Reading.

[a] For the HOA group, $n = 21$ due to missing values.

* Significant value ($p < .05$); ** Significant value ($p < .01$); *** Significant value ($p < .001$).

There were no significant differences between the aMCI and HOA groups on the combined reasons for non-completion, $F(3,16) = 1.31$, $p = .31$, $\eta_p^2 = .20$. When the dependent variables were considered separately, the groups were not different in terms of reported forgetting, $F(1,19) = 1.26$, $p = .28$, $\eta_p^2 = .07$, reprioritisation, $F(1,19) = 0.64$, $p = .43$, $\eta_p^2 = .04$; or cancellation of tasks, $F(1,19) = 2.67$, $p = .12$, $\eta_p^2 = .13$. Figure 3.1 represents a comparison of the success rates and reasons for non-completion between the two groups.

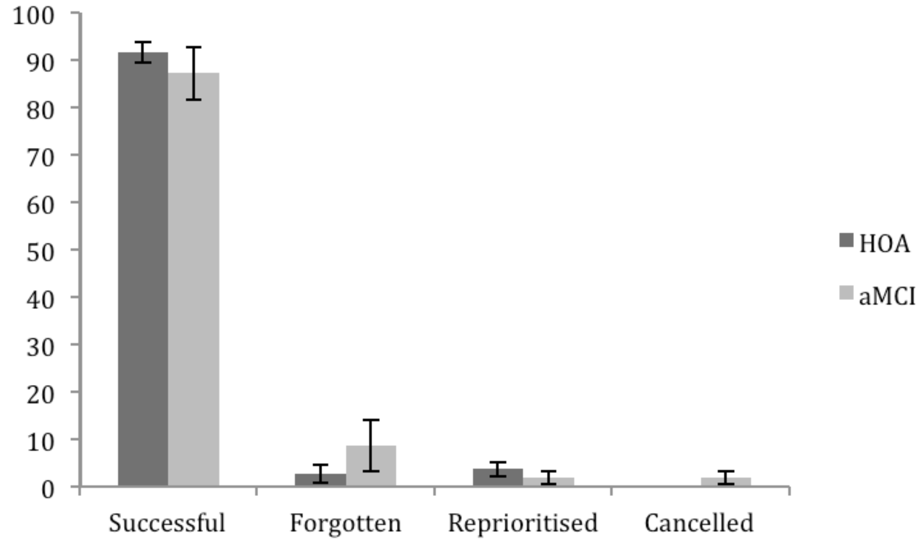

Figure 3.1. Task completion for the HOA and aMCI groups. Percentage of to-do list tasks completed successfully, forgotten, reprioritised and cancelled. Error bars in the figure represent standard errors.

There were no significant differences between the aMCI and HOA groups in terms of strategy use, $F(5,13) = 1.70$, $p = .20$, $\eta_p^2 = .38$. Considering the dependent variables separately, there were no differences between the groups in reported use of written strategies, $F(1,18) = 1.40$, $p = .25$, $\eta_p^2 = .07$, relying on habit, $F(1,18) = 0.50$, $p = .49$, $\eta_p^2 = .03$, pairing the task with another event, $F(1,18) = 3.87$, $p = .07$, $\eta_p^2 = .18$, being reminded by someone else, $F(1,18) = 0.48$, $p = .50$, $\eta_p^2 = .03$, or not using any strategy at all, $F(1,18) = 0.17$, $p = .68$, $\eta_p^2 = .01$. Figure 3.2 represents the strategy use of the aMCI and HOA groups.

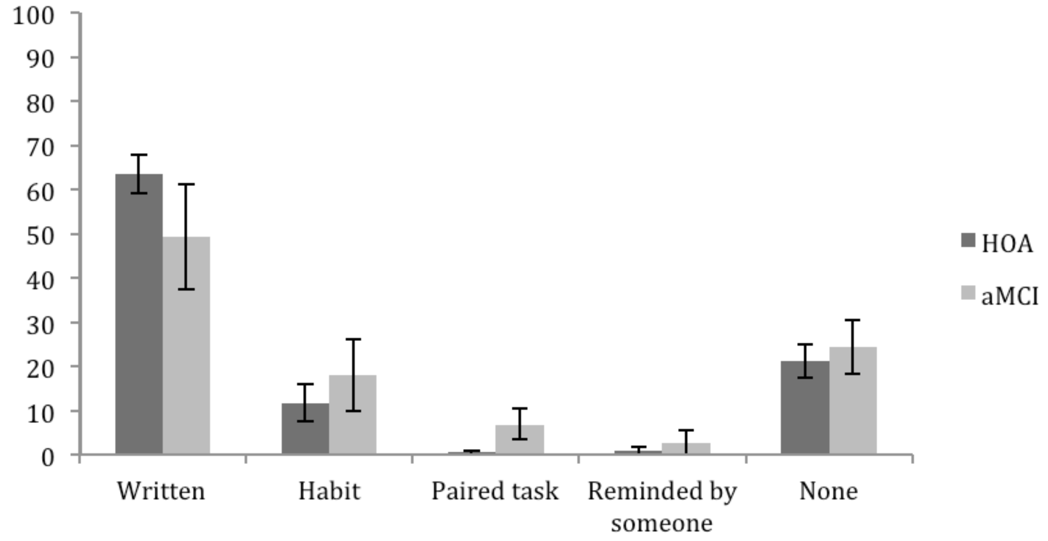

Figure 3.2. Strategy use associated with the to-do list tasks for the HOA and aMCI groups. Percentage of to-do list tasks using a written strategy, habit, pairing with another task, reminder from someone else, or no strategy. Error bars in the figure represent standard errors.

Discussion

The results of the pilot study, although preliminary, revealed that both groups exhibited high levels of self-reported successful task completion, around 90%. This is consistent with Beavis' (2001) healthy older adult group that reported success rates of approximately 88%. However, this high success rate for the aMCI group was unexpected in the context of their known memory impairment and self-reported complaints of memory difficulties. However, the aMCI group did self-report that when they were not successful in performing an intended task it was more frequently due to forgetting as compared to the HOA group. Nevertheless, there was a lot of variability in these results. The results regarding strategy use were also unclear; however, again there seemed to be a trend towards the aMCI group using fewer explicit strategies by relying on habit, conjunction cues and being reminded by someone else, whereas the HOA group tended to use more written strategies. Of note, is that both groups used no strategy at all around 25% of the time.

There are several caveats to these findings. Firstly, which is understandable given that this was a pilot study, is the small sample size and resultant limited power and large variances in performance. It is not surprising, therefore, that the findings were somewhat ambiguous. Another concerning factor was that a number of participants were not able to generate any tasks at all for their week. This is consistent with an intention-inferiority effect exhibited by older adults whereby they demonstrate greater difficulty with recalling to-be-performed tasks (such as PM tasks) than performed tasks (Maylor, Darby, & Sala, 2000). More specifically of concern was that three times as many individuals with aMCI compared to HOAs were unable to generate tasks (9 aMCI vs. 3 HOA). The resulting groups for the pilot study were not different in terms of MMSE, whereas we would have expected the aMCI group to have a significantly lower MMSE compared to the HOA group. The lack of a significant difference may be a product of the small sample. Alternatively, the lower functioning individuals with aMCI may have excluded themselves from the pilot study as they were either unable to understand the concepts or generate tasks.

One of the primary challenges presented by the results was the fact that individuals with aMCI generated significantly fewer numbers of tasks overall. One explanation for this could be a result of retrospective memory failure; they simply could not remember what tasks they had planned for the week. Alternatively, subtle executive deficits could be responsible; the aMCI individuals did not have sufficient planning, organization and meta-memory skills in order to generate the tasks. The fact that individuals with aMCI generated significantly fewer tasks may have had important ramifications on the success rates reported. The aMCI group may have only been able to generate the more salient PM tasks, such as those already written in a diary, and these tasks are likely easier to complete for that reason. These results may therefore overestimate the naturalistic PM abilities in aMCI. Based on this pilot, it is not possible to discern the cause of the task generation difficulties exhibited by the aMCI group. Nevertheless, adjustments to the administration procedures appeared to address this issue.

Another interesting feature of these results is the very high levels of reported task importance by both groups. A similar finding was reported by Beavis (2001); the mean importance rating for her healthy older adults was 5.81, consistent with the 5.78 reported by the HOA group in this pilot study. These high importance ratings are likely reflected in the high success rates of both groups, given the relationship between motivation and task completion (Kliegel, Martin, McDaniel, & Einstein, 2001). Furthermore, in relation to the difficulty with task generation, it is possible that those who struggled to generate tasks could have in fact contributed but may have believed that it was only these really important tasks that were of interest to the experimenter, which was certainly not the case.

In summary, both groups exhibited relatively high levels of successful completion for their own, everyday PM tasks. However, for the aMCI group, this was mediated by the fact they generated significantly fewer numbers of tasks and they may have represented a higher functioning sample of individuals with aMCI. In the full-scale study of Chapter 4, whilst not all of the limitations inherent to measurement outside of the laboratory could be addressed, the adoption of a more structured administration approach should aid data acquisition. With more data, the similarities and differences between the two groups with regard to self-generated naturalistic PM should become clearer. Furthermore, the performance of individuals with aMCI on experimenter introduced naturalistic PM tasks remains to be seen. Chapter 4, therefore, will examine naturalistic PM in aMCI by employing protocols of both experimenter introduced PM, using established telephone time-logging methods, and self-generated PM, building on the methodology developed in the pilot study.

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Chapter 4. Naturalistic Prospective Memory in Amnestic Mild Cognitive Impairment

Naturalistic Measures of Prospective Memory in Amnestic Mild Cognitive Impairment

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Abstract

Several studies have now reported that individuals with amnestic mild cognitive impairment (aMCI) are impaired on laboratory-based measures of prospective memory (PM). However, the age-PM paradox has revealed that impairment observed in the laboratory does not necessarily reflect functioning in day-to-day life. The current study examined naturalistic measures of PM by comparing participants with aMCI to healthy older adults on experimenter introduced PM tasks (Experiment 1) and on participants' own, self-generated PM tasks (Experiment 2). Individuals with aMCI were found to be globally impaired on each of the naturalistic measures of PM. Strategy use was found to be a distinguishing feature between the two groups with healthy older adults using more written strategies whilst individuals with aMCI relied more on another person providing a reminder. Also of note was that both groups only employed strategies around half the time for their own PM tasks. Findings are discussed in terms of implications for interventions and the day-to-day functioning of individuals with aMCI, a population that is struggling to maintain independence in the community.

Naturalistic Measures of Prospective Memory in Amnestic Mild Cognitive Impairment

Prospective memory (PM) refers to remembering to perform an intended action in the future (Einstein & McDaniel, 1990). Time-based PM requires self-initiated strategic monitoring of the environment to recognise the appropriate, specific time for execution of the PM task (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000); for example, remembering to make a phone call at 4.30pm. Event-based PM tasks, on the other hand, are cued by another event, which allows for more spontaneous retrieval of the PM intention (McDaniel & Einstein, 2011; McDaniel, Guynn, Einstein, & Breneiser, 2004), such as passing on a message when you meet your daughter for lunch.

The significance of PM for independent living has been clearly demonstrated in a range of populations (e.g., Fortin, Godbout, & Braun, 2003; Twamley, Ropacki, & Bondi, 2006; Woods et al., 2008). Schmitter-Edgecombe, Woo, and Greeley (2009) described how, in a population with mild cognitive impairment, PM performance predicted such activities of daily living as taking medication and completing household tasks. Disruptions of PM may account for as much as half of self-reported memory failures and, relative to other types of memory problems, PM difficulties generate the greatest frustration in the caregivers of individuals with impaired memory (Smith, Della Sala, Logie, & Maylor, 2000).

Individuals with amnestic mild cognitive impairment (aMCI) have a higher risk of progression to dementia of the Alzheimer’s type (Petersen, 2009) with an annual conversion rate of 5% to 12%, in comparison to 1% to 2% of cognitively healthy older adults (Mitchell & Shiri-Feshki, 2009). The conceptualisation of aMCI has traditionally focused on episodic memory impairments, with relative preservation of other cognitive domains and activities of daily living (Petersen et al., 1999), but recent research has also indicated more subtle deficits in executive attention (Albert et al., 2011; Brandt et al., 2009; Lonie, Herrmann, Donaghey, & Ebmeier, 2008). It is thought that it is the interaction between these two skills, both of which are important for PM functioning, that makes this population particularly vulnerable to deficits in PM; and indeed, individuals with amnestic mild cognitive impairment (aMCI) have demonstrated global impairment on laboratory measures of PM (Delprado et al., in press; Karantzoulis, Troyer, & Rich, 2009; Thompson, Henry, Rendell, Withall, & Brodaty, 2010).

Interestingly, healthy older adults have been found to be impaired compared to younger adults on laboratory-based measures of PM but can outperform their younger counterparts on naturalistic PM measures (e.g., Henry, MacLeod, Phillips, & Crawford, 2004; Rendell & Thomson, 1999; Schnitzspahn, Ihle, Henry, Rendell, & Kliegel, 2011); a pattern of findings referred to as the age-PM paradox. Motivation and strategy use have been posited as reasons for these discrepancies in performance between younger and older adults (Maylor, 1996), factors arguably preserved in aMCI. Therefore, in naturalistic settings, individuals with aMCI may be able to overcome their established PM deficits on laboratory measures, to perform more similarly to healthy older adults.

To date, investigations of PM in aMCI have largely been conducted within a laboratory setting with either novel (e.g., Blanco-Campal, Coen, Lawlor, Walsh, & Burke, 2009) or familiar tasks (e.g., Schmitter-Edgecombe et al., 2009). However, Karantzoulis, Troyer, and Rich (2009) employed the Memory for Intentions Screening Test (MIST; Raskin, 2009) with an aMCI population, and although the MIST consists of predominantly laboratory-based PM tasks, it also incorporates a single naturalistic task where the participants are instructed to telephone the researcher after a 24-hour delay. Karantzoulis et al. (2009) reported that, in addition to more difficulty overall on the laboratory-based tasks, significantly fewer individuals with aMCI than controls correctly executed the naturalistic intended action. Nevertheless, there are inherent reliability problems with using a single probe to represent PM functioning (Kelemen, Weinberg, Alford, Mulvey, & Kaeochinda, 2006) and a further study by Thompson, Henry, Withall, Rendell, and Brodaty (2011) addressed this issue by asking participants to perform a time-logging PM task on more than one occasion within the context of their everyday lives: participants were asked to turn on a handheld electronic organiser once per day for 2 days at a predetermined time and tap a response box that automatically appeared on the screen. Their dementia group exhibited significant difficulties with this task, which was related to their impairments on laboratory-based assessments, however, their aMCI group did not appear to show deficits compared to healthy controls on the naturalistic task. Therefore, whilst individuals with aMCI clearly show impairment on laboratory-based measures of PM, impairment in the context of their everyday lives is less clear.

Another factor to consider in terms of increasing the ecological validity of naturalistic measures is whether the task is dictated by the experimenter or whether participants generate their own PM tasks. Studies investigating free recall have found a ‘generation effect’ where individuals have demonstrated better memory for self-generated material than for material produced by others (see Bertsch, Pesta, Wiscott, & McDaniel, 2007 for a review), although the extension of this effect to the area of PM has not been as clear (Kinsella, Ong, & Tucker, 2009). Therefore, this paper explores naturalistic PM in aMCI by employing both experimenter introduced protocols (Experiment 1) and self-generated PM tasks (Experiment 2).

Experiment 1

The age-PM paradox emphasises the importance of considering the method of measuring PM, particularly in terms of laboratory vs. naturalistic settings. Phillips, Henry, and Martin (2008) explain how PM tasks can be further differentiated beyond the setting in which they were conducted. For example, natural tasks occur in the context of everyday life regardless of experimenter involvement, whereas artificial tasks are instigated by the experimenter. Furthermore, novel tasks tend to be abstract, whereas the content and task demands associated with familiar tasks are likely to have been previously encountered in everyday life. These dimensions of PM tasks need to be carefully accounted for in evaluation of PM performance in naturalistic environments.

One method that has typically been used to measure PM outside of the laboratory has been to request participants to make telephone calls to the experimenter at scheduled times. According to Phillips et al.’s (2008) classification criteria the telephone call paradigm constitutes a familiar but artificial (i.e., experimenter introduced) task conducted in an everyday setting. This method of measurement therefore involves an activity commonly encountered by participants whilst still allowing for experimental manipulation of the task conditions. For example, participants have variously been asked to make phone calls from once a day for five days (Maylor, 1990), to four times a day over 10 days (Fish et al., 2007), to twice a week for four weeks (Devolder, Brigham, & Pressley, 1990). Specific comparisons of performance across weeks have not been the focus of these studies but it could be expected that performance would improve with increasing familiarity with the task. For example, the performance of individuals with mild Alzheimer’s disease on a laboratory PM task was found to improve with practice and elaboration of the task instructions which was believed to be related to increased familiarity with the task demands (Kinsella, Ong, Storey, Wallace, & Hester, 2007). A similar pattern of practice effects might be expected in individuals with aMCI within a naturalistic environment. In spite of this, Thompson et al. (2011) measured naturalistic PM across a two day period and found performance was actually worse on the second day in comparison to the first. However, given the few trials of the task, the reason for this decline in performance was unclear.

To address these questions, the present study employed a familiar, naturalistic, but still experimenter introduced PM task (i.e., the telephone task) with an aMCI population. Given that individuals with aMCI are by definition relatively independent in their day-to-day functioning and would have the opportunity to employ whichever strategies they choose, we expected that they would perform comparably to healthy older adults on an experimenter introduced naturalistic measure of PM (see Thompson et al., 2011). This experiment also investigated whether performance improved with increasing familiarity with the task by including multiple trials. It was expected that practice effects would be evident in the current study, that is, with repetition of the task performance should improve (Kinsella et al., 2007). Finally, the cognitive correlates for the telephone task and the cognitive skills associated with performance across time on the telephone task were explored. It was expected that a similar profile would develop as in a previous study in aMCI where measures of retrospective memory and executive attention (set-shifting) predicted performance on a laboratory-based measure of PM (Delprado et al., in press).

Method

Participants. Participants were part of a larger study investigating the effects of a memory training program. Assessments for the present study were administered prior to the implementation of any intervention. Ethics approval was obtained from La Trobe University and participating health services. Participants consisted of 136 healthy older adults (HOA) and 113 individuals with aMCI[4]. To ensure equivalent groups, a subset of cases were selected to be matched in terms of age (within 4 years), education (within 3 years), and gender. The final HOA and aMCI groups for Experiment 1 consisted of 83 participants in each group.

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[1] There is overlap between the participants used in this study and those presented in Chapter 2. However, the measures and demands of study 1 did not confound the results of study 2, and vice versa. Participants did not overlap with those used in the pilot study of Chapter 3.

The aMCI participants were referred from Cognitive Dementia and Memory Services (memory clinics) and experienced aged care specialists throughout Melbourne and selected regional centres, and had been diagnosed through multidisciplinary diagnostic consensus (i.e., neurological, psychiatric, radiological, neuropsychological, and functional assessment) and satisfied Petersen's revised aMCI criteria (Petersen, 2004). This diagnosis was then confirmed using the following inclusion criteria: (a) subjective memory complaint (i.e., sought professional investigation or assessment due to concern about memory performance); (b) objective memory impairment evidenced by performance more than 1.5 *SD* below age-appropriate normative data on at least one of the four memory screening measures of delayed recall: Hopkins Verbal Learning Test – Revised (HVLT-R; Brandt, 1991); Logical Memory subtest from the Wechsler Memory Scale Third Edition (Wechsler, 1997b); Verbal Paired Associates subtest from the Wechsler Memory Scale Fourth Edition (Wechsler, 2009); and Rey Complex Figure Test (RCFT; Meyers & Meyers, 1995);[5] (c) absence of, or very mild impact of impairment in basic activities of daily life as determined by a Clinical Dementia Rating (CDR; Morris, 1993) score of no greater than 0.5; and on the Alzheimer's Disease Functional Assessment and Change Scale (ADFACS; Mohs et al., 2001), a score of 0 (independent) on the basic (personal) activities of daily living (ADL) scale, or scoring 1 (occasional assistance) on no more than two of the six items; (d) absence of dementia using NINCDS-ADRDA criteria (McKhann et al., 1984). Given that the aMCI participants were recruited from clinical services, where a diagnosis of aMCI had already been made based on multi-disciplinary clinical judgement and consensus, it was considered appropriate that aMCI participants only required impaired performance on one of the memory screening measures in this study (Petersen & Morris, 2005).

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[2] Actually, 64% of the aMCI sample performed more than 1.5 *SD* below age-appropriate normative data on *two* or more of the four memory measures used.

The HOA participants were recruited via local community centres. Inclusion criteria for the HOA group were: (a) absence of a subjective memory complaint (i.e., had not sought professional investigation or assessment due to concern about memory performance); (b) performance at 1.5 *SD* or above age-appropriate norms on each of the four screening measures of delayed memory (HVLT-R, Logical Memory, Verbal Paired Associates, and RCFT) [6]; (c) absence of impairment in basic activities of daily life as determined by a CDR score of 0; and on the ADFACS, a score of 0 (independent) on the basic (personal) ADL scale, or scoring 1 (occasional assistance) on no more than two of the six items.

Further inclusion criteria for both groups included being over 60 years of age, living in the community, and having at least seven years of education. Fluency in English and adequate vision and hearing were required. Exclusion criteria were: diagnosis of any significant medical condition that might affect cognition; history of psychiatric or learning disorders; and presence of acute anxiety or depression. General inclusion and exclusion criteria were assessed in questionnaire format and clinical interview.

Demographic features of the participants for Experiment 1 are shown in Table 4.1. The aMCI and control groups did not differ in age (p = .99), education (p = .55), gender (p = 1.00), or predicted premorbid intelligence (p = .80), according to the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). As expected, the Mini-Mental Status Examination (MMSE; Folstein, Folstein, & McHugh, 1975), used to assess current cognitive status, differentiated the groups (p < .001).

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[3] If only one of the memory scores was below criterion, an alternate version was administered and, if subsequent delayed recall performance fell within 1.5 *SD* of the mean, the participant was still included as a HOA. Following administration of an alternate-form memory test with eight HOA participants, six remained included and two were excluded. This criterion was used given that in healthy populations of older people without complaints of memory impairment, a single low score is not uncommon in an otherwise normal cognitive profile across multiple tests (de Rotrou et al., 2005).

Table 4.1

Experiment 1: Descriptive statistics for the aMCI and control groups

	HOA			aMCI		
	n	*M*	*SD*	*n*	*M*	*SD*
Demographic characteristics						
Age (years)	83	74.75	6.98	83	74.76	6.78
Education (years)	83	13.37	2.93	83	13.10	2.89
Gender (% male)	83	43.37		83	43.37	
MMSE*	83	28.92	0.90	83	27.13	1.86
WTAR predicted IQ	83	108.98	8.21	82	109.28	7.42
Cognitive functioning						
CVLT-II (long delay) ***	83	10.64	2.87	83	3.51	3.37
WAIS-III Digit Span backwards *	82	6.82	2.25	82	6.18	1.69
DKEFS Letter fluency	81	40.17	14.95	81	37.04	11.70
DKEFS Category fluency ***	80	38.24	7.92	82	31.60	7.27
DKEFS Switching fluency ***	81	12.84	3.06	82	10.07	2.81
TMT B-A [a] ***	78	54.80	39.40	81	88.00	73.00
TEA dual-task [a] ***	79	1.21	1.49	79	2.00	3.08

Note. MMSE = Mini-Mental Status Examination; WTAR = Wechsler Test of Adult Reading; CVLT-II = California Verbal Learning Test – Version II; WAIS-III = Wechsler Adult Intelligence Scale Third Edition; DKEFS = Delis-Kaplan Executive Function System; TMT B-A = Trail Making Test Part B less Part A; TEA = Test of Everyday Attention.

[a] Median and interquartile range values of raw (untransformed) variables are presented in this table. Analyses were performed on the square root transformed TMT B-A means (HOA: M = 8.02, SD = 2.19; aMCI: M = 10.14, SD = 3.14), and on the log transformed TEA dual task means (HOA: M = 1.52, SD = 0.41; aMCI: M = 1.72, SD = 0.47).

* Significant value ($p < .05$); ** Significant value ($p < .01$)); *** Significant value ($p < .001$).

Measures. ***Telephone task.*** Participants were asked to telephone the research office at four specified times across two weeks and leave a message stating their name and phone number. Calls were scheduled at least two days apart and counterbalanced across morning and afternoon, specific times (e.g., Monday at 9.30am) and four hour periods (e.g., Thursday between 1pm and 5pm) to prevent the timing of the task from becoming habitual. Times were negotiated with each participant to ensure that there were no foreseeable scheduling conflicts that would prevent them from calling. The telephone number of the research office, dates and times of calls were written on an appointment card and given to the participant as a prompt. Participants were allowed to use any memory aid or strategy they wished to use, with the exception of asking someone else to remind them. For the prospective component of the task, participants scored 4 points if they phoned within 5 minutes of their allocated time, 2 points within 1 hour, 1 point within 12 hours and 0 points if they failed to call or it was more than 12 hours after their scheduled call time. For the retrospective component of the task, participants scored a point for each element of the message they were asked to leave (name; telephone number). A total of 6 points could be obtained for each phone call and a total score of 24 over the two weeks.

Cognitive functioning. The long delay, free recall trial of the Californian Verbal Learning Test – Second Edition (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000) was used as a measure of retrospective memory. The backwards trial of the Wechsler Adult Intelligence Scale Third Edition (WAIS-III; Wechsler, 1997a) Digit Span subtest was used to assess working memory. To address executive attention of working memory, the verbal fluency trials (letter, category, switching) from the Delis-Kaplan Executive Function System (DKEFS; Delis, Kaplan, & Kramer, 2001) were used as these tasks reflect Baddeley's (2001) episodic buffer component of executive functioning (requiring attention monitoring and manipulation, and strategic access to long-term memory). Furthermore, the derived score subtracting Part A from Part B of the Trail Making Test (TMT B-A; Hester, Kinsella, Ong, & McGregor, 2005; Reitan & Wolfson, 1985) was used as it isolates the ability to switch attention, independent of manual dexterity (Corrigan & Hinkeldey, 1987). Larger B-A scores reflect increased difficulty with switching attention. The ability to divide attention was assessed using the dual-task decrement component of the Telephone Search While Counting subtest from the Test of Everyday Attention (TEA dual-task; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994).

Statistical Analyses. Data relating to the telephone task adequately conformed to assumptions of normality. Two of the other cognitive variables exhibited significant positive skew and kurtosis (TMT B-A and TEA dual-task), but following square root (TMT B-A^{SQRT}) and natural logarithmic (TEA dual-task^{LN}) transformations, both variables conformed more closely to assumptions of normality. To aid interpretation, the medians and interquartile ranges of the original, untransformed variables are reported in Table 4.1.

A 2x2 factorial design was adopted for Experiment 1 with diagnostic group (HOA; aMCI) as the between-subjects factor and task repetition (Week 1; Week 2) as the within-subjects factor. Group differences were assessed using separate mixed-model analyses of variance (ANOVAs) on the prospective and retrospective component scores of the telephone task. Effect size is reported as η_p^2 where, .01 is a small effect, .06 is a medium effect, and .14 a large effect (Cohen, 1988).

To explore how the seven measures of cognitive functioning are associated with performance on the telephone task across time, a change score was calculated by subtracting the total score for the telephone task for Week 2 from that of Week 1. The relationship between the measures of cognitive functioning and this change score for the telephone task was investigated using Pearson product-moment correlation coefficients. A correlation was also conducted between the total score of the telephone task and the cognitive measures.

Results

The means and standard deviations for measures associated with the telephone task are presented in Table 4.2. Comparison of performance on the prospective component of the telephone task revealed a significant main effect for diagnostic group, $F(1,164) = 16.90$, $p < .001$, with a moderate to large effect size, $\eta_p^2 = .09$. The HOA group performed significantly better than individuals with aMCI. There was a significant main effect for task repetition, $F(1,164) = 7.70$, $p = .006$, with a medium effect size, $\eta_p^2 = .05$. Both groups performed better in Week 1 as opposed to Week 2. There was no significant interaction effect, $F(1,164) = 0.44$, $p = .51$, $\eta_p^2 = .003$. Regarding the pattern of performance for each group across weeks for the prospective component of the task, the aMCI group exhibited fewer (22%) successful telephone calls (i.e., within 5 minutes) than the HOA group (39%). This was accounted for by a greater number of missed calls for the aMCI group (32%) as compared to the HOA group (13%). Late calls (i.e., within 12 hours) were equivalent across groups (46% aMCI, 48% HOA). From Week 1 to Week 2, the decline in successful performance for the HOA group could be accounted for by more missed calls (7% Week 1, 19% Week 2), whereas for the aMCI their decline was partially due to an increase in missed calls (30% Week 1, 33% Week 2) but also because of decreasing accuracy with more partial credit late calls (42% Week 1, 49% Week 2).

Table 4.2

Experiment 1: Telephone task performance for the aMCI (n=83) and control (n=83) groups

	HOA		aMCI	
	M	SD	M	SD
Total score	15.07	5.69	10.60	7.49
Prospective score				
Week 1	5.82	2.44	4.10	3.22
Week 2	4.98	2.93	3.58	3.01
Retrospective score				
Week 1	2.31	1.23	1.57	1.34
Week 2	1.96	1.31	1.36	1.21

Comparison of performance on the retrospective component of the telephone task again revealed a significant main effect for diagnostic group, $F(1,164) = 15.93$, $p < .001$, with a moderate to large effect size, $\eta_p^2 = .09$. The HOA group performed significantly better than individuals with aMCI. There was a significant main effect for task repetition, $F(1,164) = 7.40$, $p = .007$, with a small to moderate effect size, $\eta_p^2 = .04$. Again, both groups performed better in Week 1 as opposed to Week 2. The interaction effect was not significant, $F(1,164) = 0.50$, $p = .48$, $\eta_p^2 = .003$. Considering the pattern of performance for each group across weeks for the retrospective component of the task, both groups were at ceiling for remembering to leave their name in their message (97% aMCI, 97% HOA), whereas remembering to leave their telephone number seemed to be what was distinguishing the groups (25% aMCI, 39% HOA).

Descriptive statistics for the cognitive variables are presented in Table 4.1. A correlation was conducted between the change score for the telephone task (Week 2 subtracted from Week1) and the seven cognitive variables. For both the HOA and aMCI group, none of the cognitive variables significantly correlated with the change score (*p* ranged from .11 to .92; *r* ranged from .01 to .18). There were also no significant cognitive correlates for the total score of the telephone task (*p* ranged from .05 to .88; *r* ranged from .02 to .21).

Discussion

Unexpectedly, it was found that individuals with aMCI were impaired on an experimenter introduced naturalistic measure of PM when compared to a healthy age-matched control group. In contrast, Thompson and colleagues (2011) had reported that a sample of people with aMCI could perform comparatively to healthy older adults when required to perform a PM task in the context of their daily activities. One straightforward difference between these studies was sample size; the current study had substantially higher statistical power to detect significant group differences. These discrepant findings also need to be interpreted in the context of several other methodological differences in the design of the studies.

Firstly, Thompson et al.'s (2011) participants were instructed not to use written or other reminders to perform the PM task, whereas in the present study participants were allowed to use strategies. Use of strategies has been used as an explanation for why HOA can perform PM tasks successfully in familiar environments and yet will demonstrate poorer levels of performance in laboratory-based PM tasks as compared to younger adults (Maylor, 1996). Furthermore, Maylor (1990) found that, amongst healthy older adults, individuals who used conjunction cues to facilitate their telephone calls performed better than those who simply relied on their own memory (e.g., linked the telephone call to a regular routine such as morning coffee). Therefore, it is possible that the HOA group in this study were able to use strategies to support their PM performance more appropriately than those with aMCI.

A further issue is the complexity of the task that the participant was required to perform. In both studies, participants were requested to contact the experimenter through telephoning or time-logging at predetermined times; however, in the present study participants were also required to leave two items of information – their name and telephone number. Most previous research using naturalistic PM measures have simply asked participants to make a phone call (or in Thompson et al.'s study, time-logging), focusing on the prospective component of whether they remembered *when* to make the call. However, PM in day-to-day life inherently contains a retrospective component, remembering *what* needs to be done. In this study, both groups were at ceiling for remembering to leave their name, which is in keeping with social protocols of providing your name when leaving a message. However, when participants were also specifically asked to provide their telephone number (which, although less common than a name, is also often provided when leaving a message), performance was more variable and this component differentiated the aMCI and HOA groups. Therefore, when considering the measurement of PM, particularly with regards to the relationship to real world PM, it is also important to bear in mind the difficulty and complexity of the retrospective component of the task.

With regards to task repetition, all participants tended to perform better in the first week of the task; performance did not increase across trials. Although these results are not consistent with expected practice effects, they do follow the decline in performance that Thompson et al. (2011) reported, albeit over a much shorter period of time. Several interpretations can be considered. Firstly, participants' personal motivation may have declined by the second week, having already demonstrated to the experimenter how successful (or not) they could be in the first week; the perceived importance for continuing the task may have therefore diminished. Secondly, participants may have been forgetting the task instructions as the delay between instructions and task execution increased. However, the correlation between the various cognitive skills and the change in performance on the telephone task across weeks does not support this suggestion. Retrospective memory, or simply forgetting, did not seem to strongly account for the decline in performance. A further complicating factor that might have affected second week performance is that the predetermined call times for both weeks were negotiated prior to the first week. Participants may have had more difficulty in anticipating scheduling conflicts for the second week as opposed to the first week. Healthy older adults have been noted to perform better when they use some form of advanced planning of their daily schedule to support completing a PM task (Maylor, 1990); therefore, in the current study this may have been more difficult during the second week.

It was notable that none of the individual cognitive measures strongly correlated with performance across weeks, and there were also no significant correlations between the cognitive measures and the overall PM performance for the telephone task. This is contrary to previous findings of significant correlations between measures of retrospective memory and executive attention and laboratory-based measures of PM (Delprado et al., in press).This suggests that in naturalistic settings, non-cognitive factors may be playing more of a role in the performance of these individuals, both aMCI and HOA. Motivation may be one influencing factor; and in relation to the decline in performance across weeks, motivation may decrease with more time and distance from the impetus for the task (i.e., the request of the experimenter). Furthermore, the potential for participants to have high levels of motivation towards these tasks is questionable given that the tasks were dictated by the experimenter.

In an attempt to address the artificial motivation associated with experimenter introduced tasks, Experiment 2 explored participants' own self-generated PM tasks. Strategy use is another, non-cognitive factor that may have been influencing performance on the telephone task. Whilst participants were informed they could use any strategy they liked to remember, a record was not made of whether participants did in fact use strategies and if so, what sort. This is particularly important to consider as individuals with aMCI may have impaired strategy knowledge (Hutchens et al., in press). Furthermore, it was unclear why participants failed to complete the task, and whether there were different explanations for the aMCI and HOA groups. Experiment 2, therefore, developed the first experiment by recording self-reported strategy use and reasons for non-completion of naturalistic, self-generated PM tasks.

Experiment 2

In order to improve ecological validity, the second experiment of this study also investigated PM in an everyday setting but in this study used participants' own, self-generated PM tasks. In an earlier study, Marsh, Hicks, and Landau (1998) asked undergraduate participants to describe their own PM tasks for the week ahead and at the end of the week they were asked to record their success or failure in the PM tasks and the reasons behind their performance were explored. Subsequently, Beavis (2001), in an unpublished doctoral thesis, adapted Marsh and colleagues' (1998) methodology to investigate performance of healthy older adults on participant-generated PM tasks. She found that the performance of naturalistic PM tasks does not appear to decline with increasing age, at least for healthy, high functioning older adults and PM performance was supported by a range of self-generated memory strategies. The importance of using memory strategies to support PM performance in everyday settings was further investigated by Kim and Mayhorn (2008) who asked undergraduate students to keep a record of their planned, and subsequently performed, academic and work-related activities for a week, and described how nearly half of the participants reported using simple memory aids such as alarm clocks, parent or friend reminders, or other external cues to support self-generated PM in everyday life. However, the investigation of self-generated PM tasks and strategy use has yet to be explored in a cognitively impaired population with memory complaints such as aMCI. Therefore, the aim of the second experiment was to investigate performance of self-generated, everyday PM tasks in individuals with aMCI as compared to a HOA group. Since, by definition, activities of daily living are reported as relatively unimpaired in aMCI, it was expected that performance of self-generated PM tasks would be comparable across groups. The specific type of strategies used in performance of self-generated PM tasks and reasons for non-completions of tasks were also investigated.

Method

Participants. Participants were drawn from the same pool as Experiment 1, but given the additional commitment required of participants for Experiment 2, only a subset of the total sample, 21 individuals with aMCI and 24 HOA, was recruited. Furthermore, there was no temporal overlap of Experiment 1 and 2.

Demographic features of Experiment 2 participants are shown in Table 4.3. Groups did not differ in age (p = .86), education (p = .50), gender (p = .57), or predicted premorbid intelligence (p = .65). The aMCI group had a significantly lower MMSE, (p < .001).

Table 4.3

Experiment 2: Summary statistics for the HOA (n=24) and aMCI (n=21) groups

	HOA		aMCI	
	M	*SD*	*M*	*SD*
Demographic characteristics				
Age (years)	75.33	6.93	75.71	7.71
Education (years)	14.00	2.64	13.48	2.50
Gender (% male)	41.67		33.33	
MMSE ***	28.88	1.23	27.05	1.77
WTAR predicted IQ	110.71	7.51	109.71	6.97
Residence (% living alone)	41.67		33.33	
To-do list Measures				
Tasks generated (total)	20.33	3.49	20.76	3.56
Type of tasks (% time-based) *	53.10	12.84	43.85	11.19
Importance of task [a]	4.52	0.85	4.91	0.75
% Success time-based tasks ***	87.21	8.90	78.81	12.33
% Success event-based tasks ***	86.10	10.55	74.20	15.12

Note. MMSE = Mini-Mental Status Examination; WTAR = Wechsler Test of Adult Reading.

[a] Scored on a7-point Likert scale where 1 is not important and 7 is the very important.

* Significant value (p < .05); ** Significant value (p < .01)); *** Significant value (p < .001).

Measures. ***To-do list task.*** The methodology was based on that of Marsh et al. (1998) although the current study was conducted across two weeks. At the beginning of each week participants were provided with examples of everyday PM tasks and asked to identify their own PM tasks for the week. Participants were asked to rate on a 7-point Likert scale how important it was that the task was completed that week. At the end of each week, participants were reminded of their self-generated PM tasks and asked whether each task had been successfully completed and for those that were not, the reasons for non-completion, which were categorised as forgetting, reprioritisation (i.e., the participant decided that it was no longer appropriate to complete the task that week) or cancellation (i.e., external circumstances, such as another person or weather, prevented completion of the task). Regardless of whether the task had been successfully completed or not, for each task participants were asked what strategy they had used to help them remember. Strategies included: written (e.g., diary, calendar, to-do list); relying on habit; pairing with another task; relying on a reminder from someone else; or no explicit strategy.

Statistical Analyses. All data conformed to assumptions of normality. A series of one-way ANOVAs were used to compare the overall number of to-do list tasks generated, the proportion of time-based tasks generated, and average ratings of task importance between the aMCI and HOA groups. A chi-square was used to compare the residential situation (living alone; living with others) between groups as this may have an impact on strategy use, particularly when asking other people to provide reminders. Following this, success rates for the time- and event-based tasks were compared between groups using a mixed-model ANOVA. Given the high levels of self-reported task success, it was not statistically viable to divide time- and event-based tasks when examining reasons for non-completion. Therefore, a MANOVA was conducted to compare the aMCI and HOA groups on reasons for non-completion (forgetting; reprioritisation; cancellation) for all to-do list tasks. Following this, a Bonferroni-adjusted error rate of .02 (i.e., $\alpha/3$) was used to assess univariate results of the three dependent variables. A MANOVA was also conducted to compare strategy use (written; habit; pairing with another task; reminder from someone else; none) between groups. A Bonferroni-adjusted error rate of .01 (i.e., $\alpha/5$) was used.

Results

The means and standard deviations for measures associated with the to-do list task are presented in Table 4.3. Overall, the aMCI and HOA groups generated similar numbers of PM tasks for their to-do lists, $F(1,44) = 0.17$, $p = .69$. However, the HOA group did generate a significantly greater proportion of time-based PM tasks, $F(1,44) = 6.55$, $p = .01$. Ratings of task importance were similar for both groups, $F(1,44) = 2.59$, $p = .11$. The groups were not significantly different in the number of participants living alone, χ^2 (2, $N = 45$) = 0.33, $p = .57$.

Comparison of success rates for to-do list tasks (see Table 4.3) showed that there was a statistically significant main effect for diagnostic group, $F(1,43) = 13.55$, $p = .001$, with large effect size, $\eta_p^2 = .24$. A greater proportion of tasks were successfully completed by the HOA group in comparison to those with aMCI. There were no significant differences in success rates between time- and event-based tasks, $F(1,43) = 1.69$, $p = .20$, $\eta_p^2 = .04$, and the interaction effect was not significant, $F(1,43) = 0.63$, $p = .43$, $\eta_p^2 = .02$.

There was a statistically significant difference between the aMCI and HOA groups on the combined reasons for non-completion, $F(3,41) = 5.36$, $p = .003$, $\eta_p^2 = .28$. Considering the dependent variables separately, the aMCI group reported that they forgot to complete their tasks more often than the HOA participants, $F(1,43) = 12.46$, $p < .001$, $\eta_p^2 = .23$. There were no differences between the groups in reported reprioritisation, $F(1,43) = 1.73$, $p = .20$, $\eta_p^2 = .04$; or cancellation of tasks, $F(1,43) = 1.82$, $p = .18$, $\eta_p^2 = .04$. Figure 4.1 represents a comparison of the success rates and reasons for non-completion between the two groups.

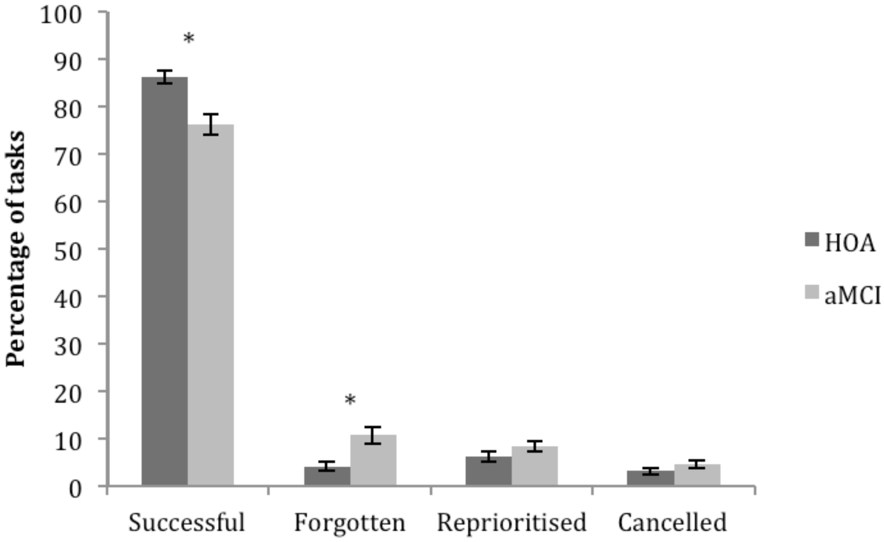

Figure 4.1. Task completion for the HOA and aMCI groups. Percentage of to-do list tasks completed successfully, forgotten, reprioritised and cancelled. Error bars in the figure represent 95% confidence intervals. * Significant value (p < .001).

There was a significant difference between the aMCI and HOA groups in terms of strategy use, $F(5,39) = 3.16$, $p = .017$, $\eta_p^2 = .29$. Considering the dependent variables separately, the HOA group used written strategies more often than those with aMCI, $F(1,43) = 13.91$, $p = .001$, $\eta_p^2 = .24$; whereas the aMCI group relied more on being reminded by someone else to complete their tasks, $F(1,43) = 6.31$, $p = .016$, $\eta_p^2 = .13$. There were no differences between the groups in reportedly completing tasks based on habit, $F(1,43) = 1.94$, $p = .17$, $\eta_p^2 = .04$; pairing the task with another event, $F(1,43) = 0.35$, $p = .56$, $\eta_p^2 = .01$; or not using any strategy at all, $F(1,43) = 0.56$, $p = .46$, $\eta_p^2 = .01$. Figure 4.2 represents the strategy use of the aMCI and HOA groups.

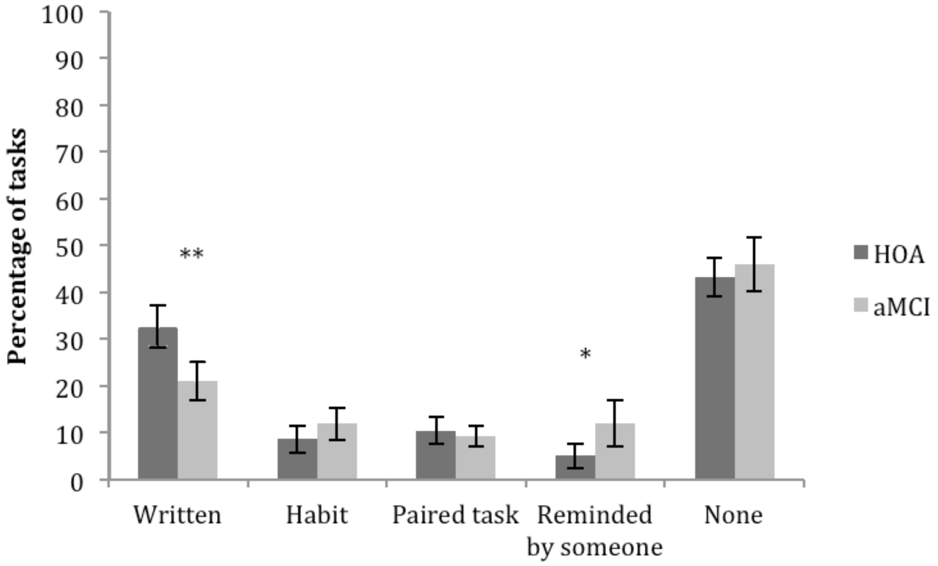

Figure 4.2. Strategy use associated with the to-do list tasks for the HOA and aMCI groups. Percentage of to-do list tasks associated with use of a written strategy, habit, pairing with another task, reminder from someone else, or no strategy. Error bars in the figure represent 95% confidence intervals. * Significant value ($p < .05$); ** significant value ($p < .01$).

Discussion

As compared to HOAs, individuals with aMCI were impaired on a naturalistic measure of PM even though the tasks were self-generated. Lack of comparative success was evident for both time- and event-based PM tasks. When questioned about reasons for non-completion of intended PM tasks, those with aMCI more frequently reported that they forgot whereas the reasons for failure for the HOA group were more spread across forgetting, reprioritisation or cancellation. However, this self-reported ‘forgetting’ by the aMCI group may not necessarily accurately reflect the situation. Individuals with aMCI may be accustomed to accounting for their errors as based on impaired memory and may have difficulty in developing or abstracting an alternative explanation for why they were unable to complete the PM task.

With regards to strategy use, the most common strategy for both groups was to make some form of a written note. This is consistent with previous literature that indicates that self-reported use of internal strategies decreases with age (Bouazzaoui et al., 2010), whilst self-reported use of external strategies increases (Fort, Adoul, Holl, Kaddour, & Gana, 2004). In respect to aMCI, it is interesting that as a group they used the strategy of asking someone else to remind them more frequently than the HOA group. This type of memory strategy could be argued to be less reliable, given that those individuals (typically family members or spouses) providing reminders would be subject to their own PM failures. Furthermore, this finding that individuals with aMCI tend to rely on others to support their PM performance is likely to place increased burden on caregivers and is consistent with other research indicating that PM difficulties cause the greatest frustration in the carers of individuals with impaired memory (Smith et al., 2000). Also of significance, is that both groups used no strategy at all around 45% of the time, indicating potential areas for interventions to target, both in aMCI and healthy ageing.

It should be noted, however, that the HOA group generated a greater proportion of time-based PM tasks in comparison to individuals with aMCI. Typically, event-based tasks have been reported as less cognitively demanding than time-based PM tasks (Groot, Wilson, Evans, & Watson, 2002), which is thought to be a result of the relatively automatic, spontaneous retrieval associated with overt event-based cues triggering PM, in contrast to the more cognitively effortful time-based tasks requiring conscious strategic retrieval of the task to be remembered (McDaniel & Einstein, 2011). Therefore, as the aMCI group generated a greater proportion of potentially less demanding PM tasks, the present findings may underestimate the actual deficits of individuals with aMCI in naturalistic PM performance.

General Discussion

In combination, the two experiments of the present study revealed that individuals with aMCI demonstrate significant difficulties in effectively performing naturalistic measures of PM. This impairment persisted even when participants were performing self-generated PM tasks rather than simply experimenter imposed tasks. These difficulties were observed in the context of performing naturalistic tasks (telephoning and leaving a message or carrying out self-generated intended activities), over extended study periods (two weeks), which provided a time frame of relevance to the performance of many everyday PM tasks, and with opportunity to use self-generated memory strategies. These factors were incorporated into the investigations to improve the ecological validity of the study.

The primary self-reported explanation for the naturalistic PM deficits in individuals with aMCI was forgetting, which could be seen to be a product of the episodic memory impairment that is characteristic of an aMCI diagnosis (Albert et al., 2011). However, given the unreliable nature of self-report, it is not clear whether retrospective memory failures alone accurately account for their impaired naturalistic PM. Furthermore, based on the first experiment, retrospective memory did not appear to be strongly correlated with performance on the experimenter introduced task, nor were any of the other cognitive measures. Motivation and strategy use have been suggested as potential explanations for the superior performance of HOAs over younger adults on naturalistic measures of PM (Maylor, 1996). However, the level of motivation was reported as high and equivalent for both groups in Experiment 2 and therefore does not seem to account for the differences in their PM performance. Strategy use, on the other hand, does appear to play a more significant role. Specifically, individuals with aMCI do not seem to be adequately compensating for their PM impairment and utilised less reliable strategies such as asking someone else to remind them.

Although individuals with aMCI did not appear to spontaneously overcome their primary PM deficit in their day-to-day lives there does still appear to be room for improvement. Interestingly, both aMCI and HOA groups reported relatively low levels of strategy use in Experiment 2, only employing strategies about half of the time. With clinical intervention, it is possible that individuals with aMCI may be able to increase strategy use and strategy efficacy (Troyer, Murphy, Anderson, Moscovitch, & Craik, 2008) in order to improve their everyday PM success rates. Interventions of this sort may be particularly important for relieving caregiver burden (Smith et al., 2000), especially given that in the second experiment individuals with aMCI appeared to rely more on others to support their PM performance. Furthermore, Experiment 1 demonstrated how it is important to minimise the delay between the provision of instructions and the execution of a PM task. Whilst it may not always be possible to control, the use of reminders closer to the PM task may be important in improving successful PM performance for any individual.

One concerning implication of the results of this study relates to the fact that individuals with aMCI are assessed as relatively independent in terms of their day-to-day functioning. However, recent research has indicated that individuals with aMCI do show evidence of impairments on instrumental activities of daily living (Brown, Devanand, Liu, & Caccappolo, 2011; Teng, Becker, Woo, Cummings, & Lu, 2010). The latest diagnostic criteria also recognises that individuals with aMCI may be less efficient and take more time with some of the more complex functional tasks (Albert et al., 2011). Although, the aMCI group in this study was still reporting relatively high levels of successful task completion, they did perform significantly below the HOAs; and therefore, whilst generally capable of independent functioning, individuals with aMCI are still vulnerable in the community. Monitoring of PM tasks where successful performance is crucial (e.g., remembering to take medication) may be recommended for individuals in this at risk population.

There are a number of methodological issues in the present study that are common across studies attempting to measure cognitive performance outside of the laboratory. Objective measurement is difficult to obtain when an individual is not being directly observed. Advancements in technology have come a fair way in addressing this issue, such as the use of GPS devices that can monitor both time and location (e.g., Sellen, Louie, Harris, & Wilkins, 1997) or making use of the internet (e.g., Logie & Maylor, 2009). But even simple technology can be effective, as in the first experiment of this study where a voicemail system was used to accurately log the time a participant called. In the second experiment, it became increasingly difficult to obtain reliable and accurate information from participants. For example, it is easy to imagine an individual not wishing to admit to failure in terms of task completion. However, in this study, rather than direct questioning, having a conversation with participants about their tasks and their performance made it easier to gauge the truthfulness of their responses. In future, involving informants such as family or close friends may corroborate participants' self-reports, although the informants themselves are also subject to reporting inaccuracies. Direct observation is one of the optimal solutions to avoid the pitfalls of self-report whilst measuring in an everyday setting, however, this approach requires a great deal of resources and is therefore not always practical, particularly with large sample sizes or when measuring across longer periods of time. Nevertheless, despite these methodological difficulties, the importance of finding a balance between experimental control and ecological validity is critical.

In conclusion, similar to reports of difficulties in performing laboratory-based PM tasks, individuals with aMCI demonstrate global PM deficits on naturalistic measures of PM conducted in the context of their day-to-day lives regardless of regardless of whether they are experimenter- or self-generated PM tasks. Individuals with aMCI self-reported that their naturalistic PM failures were more often a result of forgetting, which is consistent with the episodic memory deficits characteristic of an aMCI diagnosis. Furthermore, they do not appear to be able to develop a range of compensatory memory strategies but prefer to seek support of a close other. The study findings have significant implications for the independent functioning of individuals with aMCI, potential avenues for interventions, and relief of caregiver burden.

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Chapter 5. General Discussion

Summary of Findings

The overall aim of the current research was to develop a more comprehensive analysis of PM functioning in aMCI that had relevance to clinical diagnosis and development of management strategies. This was achieved by adopting methods of PM measurement that are achievable within a clinical assessment, and by extending investigation outside of the laboratory in order to depict the everyday PM functioning of individuals with aMCI.

Study 1 assessed PM performance in aMCI within the laboratory but employed naturalistic tasks and clinical measures. If the measurement of PM is to become a routine part of the neuropsychological assessment of pre-clinical dementia, then it is important to ascertain the potential role these PM measures could play in clinical practice. The clinical and diagnostic utility of these standardised measures was determined and the cognitive skills associated with PM performance on these measures explored. Specifically, this study first addressed whether the characteristic episodic memory impairment (Albert et al., 2011) combined with the frequent executive function deficits in aMCI (Brandt et al., 2009; Lonie, Herrmann, Donaghey, & Ebmeier, 2008) would manifest as pervasive difficulty with both time- and event-based PM tasks. This hypothesis was supported in that the individuals with aMCI demonstrated global impairment on both the time- and event-based scales of the Cambridge Assessment of Prospective Memory (CAMPROMPT; Wilson et al., 2005), which was the standardised clinical PM battery employed in Study 1. The CAMPROMPT is a complex measure of PM and demands considerable time in administration which is not always practical in clinical assessments. Therefore, it was compared to two simple, single-trial PM measures to evaluate their relative ability to predict and discriminate aMCI and healthy ageing and possibly provide quick and useful screening measures of PM. It was expected that the more comprehensive, standardised PM battery (i.e., CAMPROMPT) would have more discriminating power than the two single-trial tasks. Surprisingly, however, the brief PM tasks and the CAMPROMPT were equivalent in their ability to predict aMCI from healthy ageing. These results indicated that these single-trial PM measures, which could easily be integrated into clinical practice, may be useful screening tools for the diagnosis of aMCI. The specific cognitive processes associated with PM function were also explored. In particular, a measure of retrospective memory and a measure of complex attention predicted performance on both the time- and event-based scales of the CAMPROMPT for the aMCI group; and, the interaction between these skills may explain the global PM deficits exhibited by individuals with aMCI and the good discriminative ability of PM for identifying aMCI.

Study 2 moved further along Phillips, Henry, and Martin’s (2008) scale of PM measurement towards naturalistic measures of PM. Whilst there is a limited amount of existing literature that has employed naturalistic tasks, albeit experimenter-introduced (e.g., Karantzoulis, Troyer, & Rich, 2009; Thompson, Henry, Withall, Rendell, & Brodaty, 2011), as yet there has been no examination of self-generated everyday PM tasks in aMCI. This is important because of the strong relationship between PM and everyday functioning (e.g., Schmitter-Edgecombe, Woo, & Greeley, 2009) and yet the healthy ageing literature has revealed that an individual’s performance on laboratory-based tasks does not necessarily reflect their naturalistic PM performance (e.g., Henry, MacLeod, Phillips, & Crawford, 2004; Rendell & Thomson, 1999; Schnitzspahn, Ihle, Henry, Rendell, & Kliegel, 2011). Therefore, to gain the best understanding everyday functioning, it is important to assess individuals on everyday PM tasks. To address this gap in the literature, Study 2 adopted the methodology of Marsh, Hicks, and Landau (1998), which had previously been used successfully with university undergraduate samples. However, the applicability of this methodology to cognitively impaired populations such as aMCI was yet to be determined. The pilot study in

Chapter 3 indicated that, with some administration modifications, this methodology provides insight into the everyday PM functioning of healthy older adults and individuals with aMCI.

Building from this, Chapter 4 described the two experiments that comprise the second study of the thesis. The first experiment employed a familiar, naturalistic, but experimenter-introduced PM task in which participants were asked to make a series of telephone calls at predetermined times to the researcher. Given that those with aMCI are described as relatively independent with regards to their day-to-day functioning and that they had the opportunity to employ whichever strategies they chose, it was expected that under these conditions, individuals with aMCI would be able to overcome the PM deficits observed in the laboratory, as has been described in healthy ageing in terms of the age-PM paradox (Rendell & Thomson, 1999). Contrary to expectations, individuals with aMCI were again impaired in comparison to healthy older adults on this naturalistic, experimenter-introduced measure of PM. Furthermore, as with Study 1, the relationship between PM performance on this measure and a range of cognitive abilities was explored. In this case, there were no significant cognitive correlates for the naturalistic PM measure and it was concluded that in naturalistic settings, non-cognitive factors, such as context (e.g., Wilson & Park, 2008), may be playing more of a role in the PM performance of these individuals, both those with aMCI and healthy older adults. To further extend the ecological validity of investigation of PM in aMCI, the second experiment of Study 2 investigated PM in an everyday setting using participants' own, self-generated PM tasks and explored not only their success rates but reasons for non-completion and strategy use. Healthy older adults demonstrated significantly higher success rates for completing self-generated PM tasks compared to those with aMCI and this was reflected in both time- and event-based PM tasks. In terms of the reasons for non-completion of tasks, the aMCI group self-reported that they forgot to complete their tasks more often than the healthy older adults. The groups also differed in their pattern of strategy use. Healthy older adults used written strategies more often, whereas the aMCI group relied more on being reminded by someone else to complete their tasks. These findings have important implications for clinical practice in that these methods could be used to gain an understanding of an individual’s day-to-day PM tasks and guide interventions to improve their PM performance and everyday functioning.

Theoretical Implications

Models of Prospective Memory. Several dichotomies have been described in the PM literature; the primary approach that was the focus of this research was the distinction between time- and event-based PM. Study 1 showed that, somewhat contrary to expectations, the same pattern of cognitive skills predicted both time- and event-based PM performance in the aMCI group. Furthermore, both the time and event scales of the CAMPROMPT were equivalent in their diagnostic ability. As this finding was only for the aMCI group, this may simply reflect the compounding cognitive deficits in aMCI affecting all aspects of their PM performance, including time- and event-based tasks. Alternatively, these findings may indicate that the CAMPROMPT scales are not adequately differentiating between the different types of PM, or that the time and event distinction is not an adequate representation of PM. Therefore, as more complex models of PM develop, these should be incorporated within clinical measures of PM.

McDaniel and Einstein’s (2000) multiprocess framework of PM was another approach adopted in this study. The premise of their theory of PM is that the retrieval of a PM intention can occur as a result of two different processes that vary as a function of the characteristics of the PM task, target cue, ongoing task, and the individual. The first process involves active, strategic monitoring of the environment for the presence of the target cue. These systematic attentional processes are typically activated when the association between the target cue and the intended action is weak. On the other hand, when the target cue is sufficiently associated with the intended action, then automatic and reflexive retrieval processes should occur. In terms of the relationship to underlying cognitive skills, the automatic retrieval processes are associated with memory, specifically the reflexive-associative memory subsystem (McDaniel & Einstein, 2011; McDaniel, Guynn, Einstein, & Breneiser, 2004; Moscovitch, 1994), whereas the strategic monitoring processes and the systematic allocation of attention, on the other hand, is more closely related to frontal and executive skills (Burgess, Scott, & Frith, 2003; Simons, Scholvinck, Gilbert, Frith, & Burgess, 2006).

The findings of this research support the suggested contribution of both memory and executive functioning skills to PM performance. The significant cognitive predictors revealed in Study 1 are congruous with a general model of PM based on a retrieval memory measure and a measure that isolates the individual’s ability to shift and allocate attention (executive attention), which reflects the process in PM whereby an individual needs to continuously redirect attention from the ongoing task to monitor the environment for the appropriate cue and finally disengage attention from the ongoing task for execution of the PM intention (McDaniel & Einstein, 2000). Nevertheless, there are some qualifications that suggest that PM is even more complex than what is suggested by their multiprocess framework. For example, in Study 1, significant cognitive predictors were only found for the aMCI group whereas for the healthy older adults, it seemed that non-cognitive factors may be playing more of a role in their PM performance. Furthermore, in Study 2, there were no significant cognitive correlates with PM performance on the naturalistic measures. Again, this suggests that in naturalistic settings, non-cognitive factors may be playing more of a role in the performance of these individuals, both those with aMCI and healthy older adults. This reflects literature in the area of PM and health behaviours, such as medical adherence, where it has been found the motivational, judgemental, and contextual factors play a significant role

(Park & Liu, 2007; Wilson & Park, 2008). In this way PM can be seen as a complex behaviour that develops from numerous factors, rather than simply being a cognitive construct or amalgamation of distinct cognitive abilities.

Models of Amnestic Mild Cognitive Impairment. Models of aMCI have undergone substantial theoretical changes in recent years, changes which are supported by the findings from the present study. Firstly, in terms of the cognitive profile, aMCI was traditionally conceptualised as a purely amnestic disorder, with relative preservation of other cognitive domains (Petersen et al., 1999). Recent research has demonstrated more widespread cognitive impairment in this group, beyond retrospective memory alone. Although there is considerable individual variability, impairments in aspects of executive attention, as well as episodic memory, may now considered to be a component of aMCI (Lonie et al., 2008) and this is reflected in the underlying neuropathology. Specifically, individuals with aMCI have demonstrated neuropathology in mesial temporal lobe structures, particularly entorhinal cortex and the hippocampus (Pennanen et al., 2004; Tapiola et al., 2008), structures linked to the reflexive-associative memory system, which also supports event-based PM intentions (McDaniel & Einstein, 2011; McDaniel et al., 2004). Frontal system impairment has also been implicated in aMCI (Brandt et al., 2009; Kume et al., 2011); a neural system considered critical for strategic, systematic attention monitoring required by time-based tasks (Burgess et al., 2003; Simons et al., 2006). Therefore, individuals with aMCI have the potential to struggle with different components and types of PM due to multiple areas of impairment, which was confirmed in this research by the global impairment exhibited by those with aMCI on all PM measures used. In particular, Study 1 revealed the importance of retrospective memory and executive attention skills to the PM performance in individuals with aMCI.

Secondly, in addition to contributing to the current representation of the cognitive profile of aMCI, the findings from this research also contribute to another diagnostic feature of aMCI regarding everyday functioning. The traditional model of aMCI included relatively preserved activities of daily living (ADLs) and intact everyday functioning (Petersen et al., 1999). However, recent research has indicated that individuals with aMCI do show evidence of mild inefficiencies on instrumental ADLs (Brown, Devanand, Liu, & Caccappolo, 2011; Teng, Becker, Woo, Cummings, & Lu, 2010), and for the amnestic subtype, these impairments are particularly significant in the area of financial management (Bangen et al., 2010). Furthermore, the latest diagnostic criteria also recognises that individuals with aMCI may be less efficient and take more time with some of the more complex functional tasks (Albert et al., 2011). The current research helps to develop this picture of everyday functioning in aMCI because of the strong relationship between PM and independent living (e.g., Fortin, Godbout, & Braun, 2003; Twamley, Ropacki, & Bondi, 2006; Woods et al., 2008). In fact, for individuals with aMCI, PM performance has predicted such ADLs as taking medication and completing household tasks (Schmitter-Edgecombe et al., 2009). In particular, Study 2 revealed how those with aMCI were impaired on naturalistic measures of PM conducted in an everyday setting and including self-generated PM tasks, many of which could have been classified as ADLs. For example, some of the PM tasks generated by participants included remembering to take medication, ringing a gardener for a quote or emailing the accountant about finances (see Appendix E for a comprehensive list of examples). Therefore, the current research confirms the view that individuals with aMCI exhibit some deficits with regards to their ADLs, as opposed to the previous representation of aMCI as having relative preservation of their everyday functioning.

Clinical Implications

This research has also contributed substantially to the clinical practicalities of using PM to describe and play a role in the differential diagnosis in aMCI. While impairments in multiple areas of cognition, including executive functioning, are now considered important to the cognitive profile of aMCI (Lonie et al., 2008), the area of prospective memory remains under-utilised in the diagnosis of aMCI. Retrospective memory measures are used as the sole identifiers of impairment within the amnestic domain and, although a range of tasks may be employed to identify non-amnestic impairment (such as measures of language, visuospatial skills, attention, and executive functioning), these do not typically include PM measures (Belleville et al., 2006). Study 1 directly compared the diagnostic utility of a range of PM measures with a traditionally used retrospective memory measure. The retrospective memory measure was found to have the highest discriminative power; however, this is not unexpected given that the retrospective measure used to predict group membership was very similar to one of the screening measures that were used to diagnose the aMCI group (i.e., two different word list learning tasks). Therefore, the apparent superiority of a traditional retrospective memory measure over PM measures should not be over-interpreted. In fact, all four PM measures showed good discriminatory ability. Perhaps most surprising, was that the brief, single-trial PM tasks were as effective as the more complex PM battery (i.e., CAMPROMPT) in distinguishing aMCI from healthy ageing. Given that these tasks are quick and easy to administer, these results have significant practical implications. For example, these tasks might be used as screening tools in clinical assessment to indicate the possibility of aMCI and the need for more comprehensive neuropsychological follow-up. Furthermore, allowing for specific diagnostic potential, cut off scores were provided for the clinical measures in Study 1.

Although not essential for the diagnosis of aMCI, the findings from Study 2 also contributes further to the clinical understanding and representation of aMCI. On an individual level, the methodology from Study 2 could be applied to gain a better understanding of that person’s everyday functioning, particularly with regards to their strategy use and reasons behind unsuccessful PM attempts. In terms of strategy use, Study 2 revealed that both the aMCI and healthy ageing groups reported relatively low levels of strategy use, only employing strategies about half of the time. With clinical intervention, it is possible that individuals with aMCI, and indeed healthy older adults, may be able to increase strategy use and strategy efficacy (Troyer, Murphy, Anderson, Moscovitch, & Craik, 2008) in order to improve their everyday PM success rates. This sort of intervention may be particularly important for relieving caregiver burden given that PM difficulties generate the greatest frustration in the caregivers of individuals with impaired memory (Crawford, Smith, Maylor, Della Sala, & Logie, 2003). These reports from caregivers are understandable given another finding from Study 2, that individuals with aMCI appeared to rely more on others to support their PM performance. Furthermore, on an individual level, beyond simply looking at whether strategies were used or not, an analysis of the *types* of strategies used, such as relying more on internal or external strategies, may guide interventions in clinical practice.

Methodological Issues and Limitations

One of the primary issues for the current research has been the balance between ecological validity and experimental control, a concern that is not unique in the literature. Some have suggested that laboratory-based tasks are limited in their ability to reflect real-world PM performance. For example, Neisser (1978) argued that memory research conducted under controlled laboratory conditions has produced no important knowledge because of its limited ecological validity and that investigators should turn to uncontrolled, naturalistic observation outside the laboratory. In support of this notion, Sbordone (1996) found that the relationship between many neuropsychological tests and everyday functioning was weak, despite otherwise acceptable psychometric properties. On the other hand, Banaji and Crowder (1989) argued that experimental control is crucial in order to be able to generalise knowledge. In continuing the debate, Roediger (1991) emphasises a compromise between ecological validity and experimental control, in the PM literature evident by incorporating naturalistic stimuli within the laboratory.

With regards to this debate, Study 1 demonstrated how ecological validity could be obtained within the laboratory by sacrificing some experimental control and replicating naturalistic conditions. Specifically, the CAMPROMPT allows the use of notes as part of the standardised administration of the task, thereby simulating the naturalistic environment in a way that few other neuropsychological measures permit. Nonetheless, using this measure, there are ways to improve the experimental control whilst maintaining the features key to ecological validity. In this study, a record was made of whether or not participants took notes; however, the quality of their notes and the extent to which they referred to their notes was not documented. In future, this would be a valuable area to measure, not only to improve experimental control, but also to guide potential interventions.

In terms of naturalistic methodologies, the pilot study in Chapter 3 revealed the practical difficulties in utilising these approaches, particularly with impaired populations. The specific method employed in this research, based on Marsh, Hicks, and Landau (1998), was initially developed with university students and has been adopted with a healthy ageing population (Beavis, 2001), but has not been used with individuals with cognitive impairment. These naturalistic measures are often less structured measures, corresponding with less experimental control. In this pilot study, this proved difficult for the individuals with aMCI who had difficulty imposing their own structure upon a task that was somewhat unstructured. Despite this, Study 2 revealed that with appropriate adjustments to the administration, these naturalistic methods can be successful and provide useful information.

One of the other difficulties with these naturalistic methods is the reliance on self-report for the acquisition of data. There is a lot of discussion about the problems associated with self-report, particularly in relation to the use of questionnaires (e.g., Gibson, Macan, Potter, & Cunningham, 2010; Hannon, Adams, Harrington, Fries-Dias, & Gipson, 1995; Uttl & Kibreab, 2011). More relevant to the findings of this research, is a report from Roberts, Clare, and Woods (2009) that there is a large degree of individual variability in awareness of strategy use in aMCI. Therefore, the self-reported strategy use in the second experiment of Study 2 may not be a reliable indicator of actual strategy use. The reliability of these self-report measures needs to be verified by a confluence with objective measures. This was achieved, in part, in this study by the inclusion of an experiment-introduced PM task that allowed for an objective assessment of success on the task.

Another methodological issue that was apparent in these studies was the limited information provided by a single probe of PM. Even though the CAMPROMPT was presented in this study as a more comprehensive PM battery in the context of comparison to the single-trial PM measures, the CAMPROMPT is still limited in the number of PM trials it includes. Therefore the reduced reliability associated with limited PM tasks (Kelemen, Weinberg, Alford, Mulvey, & Kaeochinda, 2006) remains an issue for all the PM measures in this study. However, on the other hand, with the inclusion of more and more trials, a PM moves from becoming episodic to habitual (Park & Kidder, 1996), which changes the parameters of the task. These habitual tasks may be generated and measured intentionally because one of the uncertainties in the PM theory is why people fail habitual everyday PM tasks despite the fact that habitual tasks are often easier than episodic PM tasks (McDaniel &

Einstein, 2007). Nevertheless, everyday episodic PM tasks tend to be easier to support by external strategies and as a result remains a clinically relevant area to assess.

Future directions

The area of PM has undergone major developments in recent years, including the development of numerous PM measures. In the area of aMCI, the available literature has predominantly been based on experimental measures exploring the construct of PM. As a result, the literature provides little support for clinicians seeking guidance in evidence based practice. Therefore, as well as working to understand the theoretical basis of PM, future research in this area would benefit from focusing on making available measures that are standardised, reliable, and with good clinical and ecological validity. Moreover, advances in technology have created new avenues to explore in the development of PM measures, such as the use of GPS technology to record both time and location information associated with PM (Sellen, Louie, Harris, & Wilkins, 1997), which may be particularly useful in terms of obtaining objective measurement outside the laboratory.

The development of future PM measures also need to take into account advances in the models of PM. Furthermore, a distinction needs to be made between forwarding theoretically interesting models, versus models that are clinically relevant. For example, future research in PM may benefit from consideration of PM as a complex behaviour, to be individually described, as opposed to a cognitive construct that can be measured with a single task targeting that particular aspect of cognition. This becomes particularly relevant outside the laboratory, where even if PM is to be considered a distinctive aspect of cognition, what becomes more important clinically, is how these cognitive processes manifest as behaviour in the context of day-to-day life.

In terms of MCI, future research may benefit from exploring patterns of PM performance within the different subtypes (amnestic or non-amnestic, single or multi-domain) and the relationship between their PM performance and the underlying neuropathology. The amnestic profile remains a particularly important area to investigate because it represents a group at significant risk of progressing to Alzheimer’s disease (Mitchell & Shiri-Feshki, 2009). Nevertheless, clinically, it has been suggested that individuals with a purely amnestic profile are relatively rare (Alladi, Arnold, Mitchell, Nestor, & Hodges, 2006). Typically people will present with a mixed profile, and as such it becomes more valuable to understand which aspects within the MCI profile, rather than simply the presence or absence of MCI, will be indicators of potential impairments in PM.

Conclusions

Future understanding of PM and aMCI will be dependent upon numerous delicate balances: between PM as a complex behaviour to be described and a cognitive construct to be discretely measured; measurement within the laboratory and in the context of everyday life; theoretical interest versus clinical needs; ecological validity and experimental control. Whilst the perfect balance may not have been achieved in this research, it has aimed to draw attention to these issues for future investigations in PM and aMCI.

In summary, this research demonstrated that individuals with aMCI were globally impaired on each of the PM measures utilised. These PM deficits persisted across different types of PM, such as time- and event-based PM tasks, and also across different PM settings, such as in the laboratory and in the context of everyday life, regardless of whether they were experimenter- or self-generated PM tasks. As PM requires retrospective memory skills along with complex attention and executive skills, the interaction between these skills may explain the global PM deficits in aMCI and the good discriminative ability of PM for diagnosing aMCI. Nevertheless, whilst the important role of retrospective memory and executive attention for PM was confirmed in the laboratory, it appears that non-cognitive factors, such as the different patterns of strategy use, may play a greater role in a naturalistic setting. Specifically, individuals with aMCI do not appear to be able to develop a range of compensatory memory strategies to support their PM performance, but prefer to seek the support of a close other. These findings have significant implications for the independent functioning of individuals with aMCI, potential avenues for interventions, and relief of caregiver burden.

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Appendix A

La Trobe University Higher Degrees Committee (Research):

Alternative Thesis Format Guidelines.

La Trobe University
Higher Degrees Committee (Research)
Guidelines for preparing thesis by publication

1. While dissertations submitted for award of higher degrees often contain work by the candidate that is already published (or accepted for publication), it is also permissible for candidates to submit a higher-degree thesis that is in the form of a series of thematically-focused articles or chapters that are either published or accepted for publication by reputable journals or publishers. The presentation of the articles will take the same format as doctoral and masters by research theses, and will include full publication details for the published/accepted material.

2. Where the thesis submitted for a degree by published work includes jointly authored publications, the candidate is expected to have made a significant and leading contribution to such work. The candidate will provide at the time of submission a declaration for each article or chapter, stating the extent and nature of his or her contribution and justifying the inclusion of the material. In each case, a signed declaration from at least one co-author is to be provided, verifying the extent and nature of the candidate's contribution.

3. The presentation of a thesis as a collection of articles or chapters will include at least one substantial integrating chapter, or a separate introduction, general discussion and conclusion that in combination reveal the way the articles and chapters are thematically linked. This integrating material will not itself contain new or innovative research material. Where a dissertation contains a mixture of published and unpublished work which in combination represent a substantial and original contribution to knowledge, then it will be examined in the normal way, and will not be treated as a submission for a higher degree by published work.

4. The number of articles to be included will depend on the significance, originality and length of each and takes account of (a) the University's requirements for the degree, and (b) the amount of research normally expected to be undertaken for the degree in question. Discipline areas may set specific requirements, in addition to those described in these guidelines.

5. Normally most of the work submitted will have been completed during the period of candidature. It is permissible to include work published prior to commencement of higher degree research candidature at La Trobe University when this fits with, and adds substantial content to, the research studies being assessed by the examiner(s).

6. A book published or definitely accepted for publication by a reputable publisher can also be submitted for examination for a Masters, PhD or professional doctorate, provided that guidelines 2 and 5 above apply.

7. The thesis will be examined in the normal way. In cases where the Chair of HDC(R) is persuaded that there has already been sufficient peer review of the contribution(s) a decision can be made to reduce the number of examiners to one examiner for a Master's degree and two examiners for a Doctorate.

Appendix B

Script and Record Form for Naturalistic PM:

Generating a To-do List (Pilot Study: Version 1).

<u>Instructions for filling out your</u>
<u>Things to do Sheet</u>

1. Please fill in all the things you have to do or would like to do over the next 4 days (Monday to Thursday) on the following sheets. The section headings are there to help you, so don’t worry too much about the section where you write your things to do. Please be as detailed as possible and write in both the things you have already planned to do and any regular things. It may be useful to refer to you diary or calendar whilst doing this.

2. Then, please indicate how often you do that task by ticking the relevant box. E.g. weekly sports game, or calling a friend each day.

3. Next, rate how important it is that you do that task from 1-7:
   1_____2_____3_____4_____5_____6_____7
   Not important Very Important

4. Finally, please put the finished sheet in a place where you cannot see it, and use your usual methods for carrying out the things you have to do.

5. On Friday, take out this sheet and tick which tasks you did and which you did not. If you did not do something, please tick the column that best explains why (see choices below) or write in your own reason.

   a. Plan completed;
   b. You completely forgot;
   c. You reprioritised because the plan was no longer important;
   d. Someone else cancelled;
   e. Other circumstance made it impossible to complete the plan, e.g. weather;
   f. Other reason, please explain.

6. Regardless of whether you did the task or not, please indicate what memory strategies you employed in trying to remember to do these tasks (see choices below). You may tick more than one strategy.

   a. No specific memory strategies were used;
   b. You wrote it in your diary or calendar;
   c. You wrote it down on some other note, post-it etc. Note, if you referred back to your Things to do Sheet during the week, please tick this memory strategy;
   d. It is something you do regularly so it has become a habit to do;
   e. You arranged to do it when doing another task so it would help you remember;
   f. You asked someone else to remind you;
   g. Other memory strategy, please explain.

You will do this twice over the next two weeks.

At the end of the two weeks, please check that you have filled out all the relevant parts of each sheet and return them in the envelope provided.

Name:__________________ Date:_______ Week: __

		Appointments *E.g. trip to the dentist*				**Things to arrange** *E.g. lunch with family*				**Things to do around the house or garden** *E.g. cleaning or mowing the lawn*			
	Times/year												
	Importance (1-7)												
Was it done? *(Please tick)*	Yes												
	No, Forgot												
	Reprioritised												
	Cancelled												
	Couldn’t do												
	Other												
Memory Strategy? *(Please tick)*	None												
	Diary												
	Written down												
	Habit												
	Paired with another task												
	Reminded by someone												
	Other												

				Was it done? (*Please tick*)						**Memory Strategy?** (*Please tick*)						
		Times/year	Importance (1-7)	Yes	No, Forgot	Reprioritised	Cancelled	Couldn’t do	Other	None	Diary	Written down	Habit	Paired with another task	Reminded by someone	Other
Things to communicate *E.g. writing letters, making phone calls*																
Regular things *E.g. taking tablets or feeding pets*																
Other things *E.g. bringing in the neighbours’ rubbish*																

Appendix C

Script and Record Form for Naturalistic PM:

Generating a To-do List (Pilot Study: Version 2).

To-do List Task

Part One: First Appointment

1. *Rationale/Summary.* As part of these assessments we also want to see how you manage your own everyday memory tasks because often doing these tests in an office is different to how you manage in real life. So what I would like to do now is get an idea of the things you have to remember to do over the next week. Then I will give you a call next week to see how you went with completing the things you had to do.

2. *Time Tasks.* Everyone tends to have a whole range of things they need to do during the week but first of all what I want to find out about are the tasks that have to be done at specific times. So this might mean things like appointments with doctors, specialists, hair dressers, attending meetings, courses, lectures or classes, watching or listening to a particular tv/radio show, medications that need to be taken at a particular time and so on. What tasks of this sort do you need to do in the upcoming week?

3. *Event Tasks.* Some other tasks don't necessarily need to be done at a certain time but instead have to be done in connection with something else. For example, remembering to bring certain papers, tickets or notes to some other appointment, remembering to buy something in particular whilst at the shops, or visit the bank, newsagent or dry cleaners whilst shopping, post a letter on your way home, passing on a message to a friend the next time you see them and so on.

4. *Other Tasks.* Now are there any other things you might have to do this week or if you get a chance like things around the house, garden, taking out the rubbish, arranging things, making phone calls, writing letters, feeding pets etc.

5. *Task Frequency.* Now I'd like to check with you how often you tend to do these sorts of tasks because some you might do every week whilst others might be more of a one off.

6. *Task Importance.* Next I want to get an idea of how important it is for you to complete each task using a scale from 1 to 7 where 7 means it is very important you complete the task and 1 means it isn't very important that the task is completed.

7. *Arrange Follow up Phone Call.* Now I have an idea of the sorts of things you have to remember to do over the next week, I'd like you to just carry on using your usual methods for remembering to do these things. Could we arrange a time for next week when I can give you a call to see how you did at completing your tasks?

To-do List Task

Part Two: Follow up Phone Call

8. *Task Completed?* I spoke to you last week about some things you had to remember to do over the past week. Now I want to see how well you did at completing those tasks. (*Read out each of the participant's tasks. If a task was not completed tick the most appropriate reason*).

    a. Plan completed;
    b. You completely forgot;
    c. You reprioritised because the plan was no longer important;
    d. Someone else cancelled;
    e. Other circumstance made it impossible to complete the plan, e.g. weather;
    f. Other reason, please explain.

9. *Memory Strategy/Aid?* Now I want to see what sort of strategies or aids you were using to help you to remember these tasks. (*Go through each task regardless of whether it was completed or not and tick the appropriate strategy*).

    a. No specific memory strategies were used;
    b. You wrote it in your diary or calendar;
    c. You wrote it down on some other note, post-it etc. Note, if you referred back to your Things to do Sheet during the week, please tick this memory strategy;
    h. It is something you do regularly so it has become a habit to do;
    i. You arranged to do it when doing another task so it would help you remember;
    j. You asked someone else to remind you;
    k. Other memory strategy, please explain.

Repeat for a second week.

Name:__________________ Date:_______ Week: __ Follow up Phone Call:_______

EVENT							TIME								
														Times/year	
														Importance (1-7)	
														Yes	**Was it done?** *(Please tick)*
														No, Forgot	
														Reprioritised	
														Cancelled	
														Couldn’t do	
														Other	
														None	**Memory Strategy?** *(Please tick)*
														Diary	
														Written down	
														Habit	
														Paired with another task	
														Reminded by someone	
														Other	

Appendix D

Script and Record Form for Naturalistic PM:

Generating a To-do List (Final Version).

Everyday PM Tasks

Part One: First Appointment

1. *Rationale/Summary.* As part of these assessments we would like to get an idea of the things you have to remember to do in your day-to-day life over the next week. Then I will give you a call next week to see how you went with completing the things you had to do. I don't want you to do anything special with these tasks, just behave as you normally would.

2. *Generating tasks.* So what tasks do you have to do this week? For example, some people have (*insert example from list below*). Do you have any tasks like this? (*Repeat using each example from the list, one at a time. Prompt them to generate tasks after each example*).

    - Appointments: doctor, specialist, hairdresser.
    - Other scheduled sessions: classes, lectures, meetings, courses, exercise/gym.
    - Television or radio programs.
    - Medications: certain times or with a meal?
    - Make phone calls: to book appointments, investigate holidays, arrange a repair man.
    - Make phone calls: to friends or family, passing on messages.
    - Write or post letters.
    - Pay bills.
    - Visit the bank, newsagent, dry cleaners whilst shopping.
    - Remembering to take something to an appointment: papers, tickets or notes.
    - Remembering to buy something in particular at the shops.
    - Things around the house: cleaning, repairing, gardening, taking out the rubbish, feeding pets, doing something for a neighbour.

3. *Task Frequency.* Now I'd like to check with you how often you tend to do these sorts of tasks.

4. *Task Importance.* Next I want to get an idea of how important it is for you to complete each task using a scale from 1 to 7 where 7 means it is very important you complete the task and 1 means it isn't very important that the task is completed.

5. *Arrange Follow up Phone Call.* Now I have an idea of the sorts of things you have to remember to do over the next week, I'd like you to just carry on using your usual methods for remembering to do these things. Could we arrange a time for next week when I can give you a call to see how you did at completing your tasks?

Everyday PM Tasks

Part Two: Follow up Phone Call

6. *Task Completed?* I spoke to you last week about some things you had to remember to do over the past week. Now I want to see how well you did at completing those tasks. *(Read out each of the participant's tasks. If a task was not completed tick the most appropriate reason*).

    a. Plan completed;
    b. Forgotten;
    c. Reprioritised;
    d. Cancelled (by someone else or some other circumstances).

7. *Memory Strategy/Aid?* Now I want to see what sort of strategies or aids you were using to help you to remember these tasks. (*Go through each task regardless of whether it was completed or not and tick the appropriate strategy*).

    a. No specific memory strategies were used;
    b. Written down (note, post-it, diary, calendar etc.);
    c. Habit;
    d. Paired it with another task;
    e. Reminded by someone else.

Repeat for a second week.

Name:__________________ Date:_______ Week: __ Follow up Phone Call:_______

EVENT							TIME								
														Times/year	
														Importance (1-7)	
														Yes	**Was it done?** *(Please tick)*
														No, Forgot	
														Reprioritised	
														Cancelled	
														None	**Memory Strategy?** *(Please tick)*
														Written	
														Habit	
														Paired with another task	
														Reminded by someone	

Appendix E

Examples of Participants' Self-generated Prospective Memory Tasks.

Time-based Prospective Memory

Attend hair appointment
Attend nephew's football game
Attend dentist appointment
Attend doctor appointment
Pick up friend to drive them to their appointment
Remember home appointment about personal alarms
Attend neighbourhood drinks/party
Attend a course workshop
Giving a lecture
Watch/record particular TV show
Remember to go to the bank on Monday because Tuesday is a public holiday
Remember to phone overseas friends and family (at appropriate time)
Get cheapest petrol on the Wednesday before going on holidays
Buy lottery ticket on Wednesday (for specific jackpot)
Buy Newspaper on Thursday for the TV guide
Call newsagent to cancel newspaper the day before going on holiday

Event-based Prospective Memory

Remember to fast for blood test
Ring GP to make appointment
Remember particular questions to ask the doctor
Medications with breakfast
Remember to take all the tickets/papers to the airport
Remember to take a bottle of wine to dinner
Get stamps from post office for the Christmas cards
Collect dry cleaning
Buy slippers when at the shops
Ring gardener for a quote
Ring to book Melbourne day tour group
Email accountant about the finances
Ask a friend to take notes for meeting that will be missed
Arrange someone to fix fax machine
Ask son how to set up the DVD player
Post letter on way home
Send parcel with belongings grandchildren left when they visited
Return book to a friend