Prospective Memory Function in
Mild Cognitive Impairment and Early Dementia

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ABSTRACT

When compared with controls, both Mild Cognitive Impairment (MCI) and dementia are each associated with impaired memory for future intentions, or “prospective memory’ (PM). However, prior studies have failed to agree on how effectively measures of this construct differentiate between these two clinical conditions. Further, the degree and nature of the PM impairment remains to be clarified, as does the degree to which this impairment is secondary to deficits in other aspects of cognition.

In this research program, participants with MCI, dementia, and controls were compared on a number of measures of PM. Measures included Virtual Week, a laboratory measure that closely represents the types of PM tasks that actually occur in everyday life, self- and informant-reports, a brief unstandardised assessment, and a naturalistic task which was done in participants’ everyday life. Virtual Week was repeated after a one year time period to assess change in PM. The overarching goal was to explore and better understand PM impairment in these groups, while also providing an evaluation of the appropriateness of different assessment methods.

On the standardised laboratory measure (Virtual Week), both clinical groups exhibited impairment in PM function irrespective of the specific task demands. While other cognitive deficits contributed to these difficulties, a unique PM component was identified. PM failures were also observed on a naturalistic measure administered in everyday life, and were found to be related to poorer performance on a cognitive screening measure as well as a validated laboratory PM task. Although MCI and dementia-related difficulties were
observed both at baseline assessment and one year follow up on Virtual Week, the magnitude of the difficulties did not differ significantly between the two time points. It is suggested that the absence of significant decline across this time period reflects either a relatively stable level of PM function across this time period (a possibility that could be tested by using a longer follow-up period in future research), or the influence of selective attrition. For all three groups, both self-reports and informant-reports showed poor validity, at best correlating only weakly with objective assessments. Self-reported impairments were equivalent across the three groups, and informant-reports of impairment, while higher for those with dementia, did not distinguish MCI from controls. A brief but unstandardised assessment of PM successfully detected differences between the groups with dementia, MCI and controls. However the effect size was very small and therefore this task is likely to be of limited practical use in clinical or research assessments.

Overall, this research program provides evidence of group differences in PM between those with MCI and dementia and controls, but shows that different assessment methods differ in their sensitivity to these effects. It appears that PM function may be optimally assessed with a validated laboratory test such as Virtual Week, but attesting to the ecological validity of these difficulties, dementia effects are also detectable on a naturalistic task. Self-report and informant-report, and a brief unstandardised task were not as sensitive an assessment method for PM in these groups. Taken together, the studies reported in this research program have important implications for clinical practice, and also inform theoretical models of PM function in dementia.
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Posters


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Overview

Prospective memory (PM) refers to memory for future intentions, such as remembering to take medication, to turn off appliances, pay bills and keep appointments. It involves “remembering to carry out actions” (Huppert & Beardsall, 1993), or “remembering to do things in the future” (McDaniel, Einstein, & Rendell, 2008). PM involves recognising that a task needs to be undertaken in the future, encoding the task and the cue to perform the task, storing the task and the cue, monitoring for and recognising the cue while engaged in other ongoing tasks, with retrieval of the content of the task when the cue is recognised. Thus PM is not a single cognitive process but contains elements of multiple cognitive processes including attention, working memory, retrospective memory and executive functioning (Shum & Fleming, 2009).

This ability is crucial to the maintenance of functional independence, which is a fundamental concern for older adults (Chasteen, Park, & Schwarz, 2001). Problems with PM cause more deficits in activities of daily living, instrumental activities of daily living and caregiver burden than do retrospective memory (RM) failures (Smith, Della Sala, Logie, & Maylor, 2000). It is therefore of considerable concern that PM is often disrupted in the context of normal adult ageing (Henry, MacLeod, Phillips, & Crawford, 2004; Kvavilashvili, Kornbrot, Mash, Cockburn, & Milne, 2009)and to an even greater extent in dementia, even in the mild (Martins & Damasceno, 2008) and preclinical stages (Duchek, Balota, & Cortese, 2006; Jones, Livner, & Backman, 2006).
As will be discussed, there is evidence of PM impairment in individuals with Mild Cognitive Impairment (MCI), a condition in which cognitive difficulties are present, but diagnostic criteria for dementia are not met (Petersen, 2004).

The primary aim of this research program is to better understand the nature of PM in both of these clinical groups by assessing individuals who meet diagnostic criteria for either MCI or dementia and comparing their performance on multiple indices of PM function with that of controls. PM performance varies as a function of age, task demands and assessment setting, and these dimensions of PM will be explored. In conducting these analyses the relative strengths and weaknesses of different methods of assessing PM function in both normal and abnormal adult ageing will be evaluated. Finally, changes in PM over a one-year period will be assessed.

**Background**

In contrast to PM, retrospective memory (RM) refers to memory of past knowledge and events. Most memory assessment and research to date has focused on this type of memory function, using tests of learning, recall and recognition such as the Wechsler Memory Scales (Wechsler, 1945, 1997b) and Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964). Normal adult ageing is associated with decline in some cognitive abilities (Rabbitt & Lowe, 2000), including RM (Ivnik, Malec, Smith, Tangalos, Petersen, Kokmen, & Kurland, 1992; Kral, Cahn, & Mueller, 1964). Memory impairment is also the primary DSM-IV diagnostic criterion for dementia, defined as the “impaired ability to learn new information or to recall previously learned information” (American
However, despite considerable research interest focused on how PM is affected in normal adult ageing (Henry et al., 2004; Kvavilashvili et al., 2009), and suggestions that PM difficulties may be a prevalent feature of early stage dementia (Huppert, Johnson, & Nickson, 2000), there is no mention of PM in either the DSM-IV diagnostic criteria for dementia (1994) or the criteria for MCI (Artero, Petersen, Touchon, & Ritchie, 2006). Moreover, to date there has been little study of PM in the context of cognitive impairment and dementia. Such research is important given recent findings that measures of PM are sensitive even to mild dementia (Duchek et al., 2006), make an independent contribution beyond that of RM to prediction of dementia three years later (Jones et al., 2006), and discriminate dementia from normal ageing more effectively than measures of RM (Duchek et al., 2006). In view of such evidence documenting PM changes in ageing and cognitive impairment, and the benefits of earlier diagnosis, it is appropriate and timely for the present research program to directly assess how PM is affected in MCI and dementia relative to demographically matched controls, using multiple assessment techniques. The primary aim of Study 1 is therefore to quantify the nature and magnitude of PM difficulties in those with MCI and dementia, and to test whether a previously validated measure of this construct, Virtual Week (Rendell & Craik, 2000), represents a useful assessment tool for measuring PM in these groups.

With respect to characterising the nature of PM difficulties in these groups, one of the earliest distinctions between types of PM tasks was between time-based and event-based cues (Einstein & McDaniel, 1990; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). Time based PM cues require
an action to be performed at a certain time (such as keeping an appointment at a
given time) or after a certain amount of time has elapsed (take a cake out of the
oven after 20 minutes). Event-based PM cues require an action to be performed
in response to a specific cue or event, such as taking medication after a meal.
More recently, research attention has shifted to consideration of other potential
determinants of PM difficulties, such as task regularity (Rendell & Henry, 2009).
Specifically, some PM tasks occur on a regular basis (such as taking medication)
whereas others are irregular PM tasks (such as remembering to post a letter). A
further aim of Study 1, therefore, is to clarify whether any observed PM
difficulties observed for those with MCI and dementia differ as a function of cue
type (time-based, compared with event-based), as well as the regularity of the
PM task (regular, compared to irregular).

While research to date suggests that behavioural measures such as Virtual
Week represent valid tools for assessment of PM (Rendell & Craik, 2000;
Rendell & Henry, 2009), such tests are not used routinely in the diagnosis of
dementia. Clinicians commonly rely on an individual’s subjective report of
memory impairment (often combined with that of an informant) along with
neuropsychological assessment in order to diagnose dementia (Thöne-Otto &
Walther, 2008). Importantly, the validity of self-rated measures of memory
impairment has been questioned (Jorm, 2003), and is of particular concern when
assessing individuals with dementia, where loss of insight (anosognosia) is a
common feature of the disorder (Berwig, Leicht, & Gertz, 2009). This is an
important issue in view of the suggestion that subjective complaints be included
in the diagnostic criteria for MCI (Petersen, 2004; Winblad, Palmer, Kivipelto,
Jelic, Fratiglioni, Wahlund, Nordberg, Backman, Albert, Almkvist, Arai, Basun,

Given concerns about subjective reports, clinicians tend to prefer informant-reports of memory problems. Informants are typically a spouse, adult child or other relative or close associate of the individual, who is able to give a reliable account of any difficulties experienced (Jorm, 2003; Tierney, Herrmann, Geslani, & Szalai, 2003). However, informant-reports also rely on the ability of the informant to notice, acknowledge and report problems experienced by their associate. Therefore, the aim of Study 2 is to provide a direct comparison of self-rated and informant-rated PM impairment in normal ageing, MCI and dementia, and assess their convergent validity with each other, and with more objective tests of PM. These data will have important implications for clarifying the validity of self- and informant-rated PM assessments in both normal and abnormal cognitive ageing.

The third study will test a prediction stemming from an influential theoretical model of PM, by assessing the degree to which cue relates to PM function in participants with MCI and dementia. As has been discussed, relative to RM, PM is considered to impose greater demands on internal control mechanisms to attend to the environment and to shift attention in order to notice PM cues (Craik, 1986). In other words, PM is more self-initiated than RM because successful prospective remembering requires an intentional shift of attention from an ongoing task to a cue for a PM event. One of the most influential models of PM is the Multi Process Model (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000). One of the central tenets of this model is that the degree to which a particular PM task may be regarded as capacity
consuming is dependent on the nature of the PM task itself. One characteristic that has been highlighted as particularly important is the extent to which the PM target event is relatively focal or non-focal to the ongoing task. Thus, some PM tasks are dependent on cues that are a part of the ongoing task, such as looking for a target word during an ongoing task of word presentation and recall (Einstein & McDaniel, 1990), and these are correspondingly termed as focal tasks. According to the Multi Process model, such tasks do not require constant monitoring for cues, and so do not draw cognitive resources away from other tasks. Other PM tasks however, are unrelated to the ongoing task. These are termed non-focal tasks and require increased monitoring for cues to the PM task. Importantly, a non-focal cue may be embedded in the ongoing task, but not being attended to as part of the ongoing task.

Einstein and McDaniel’s (2005b) Multi Process Theory of PM predicts that since focal PM tasks do not require constant monitoring for a PM cue, performance on such tasks is less capacity demanding relative to non-focal tasks. One of the aims of the present research is therefore to test predictions derived from the Multiprocess Framework through a comparison of a focal and a non-focal task. In Study 3, a brief assessment of PM will be evaluated with half of the participants attempting a focal PM task and the other half a non-focal PM task.

As will be discussed in Chapter 4, there is now considerable evidence that relative to matched controls, both MCI and dementia are associated with disproportionate impairment on cognitive tasks which are more capacity consuming. According to the Multi Process Theory of PM (McDaniel & Einstein, 2000), monitoring for a PM cue would be more capacity consuming
when the cue is non-focal, than when the cue is focal. Thus MCI and dementia
effects should be larger when the PM cue is non-focal as opposed to a focal cue.
Thus it is expected that in Study 3 there should be an interaction between
focality and group, with those with MCI and dementia disproportionately
impaired on non-focal tasks relative to controls.

Study 4 will focus on another feature of PM task performance that has
been attributed considerable importance, and specifically, the degree to which
the environment in which the PM task is embedded may be regarded as
ecologically valid. A meta-analysis of PM studies that compared younger and
older adults found that the direction of age effects differed systematically as a
function of assessment context (Henry et al., 2004). Thus, whilst substantial age-
related deficits were identified in laboratory based PM tasks, more naturalistic
assessments show age-related improvements in PM performance (Rendell &
Craik, 2000). Strikingly, the magnitude of the age-related benefit seen in
naturalistic settings was equivalent to the deficit seen in laboratory settings
(Henry et al., 2004). As will be discussed, however, there has been only limited
empirical investigation of whether assessment context is an important
consideration in understanding how PM is affected in abnormal adult ageing.
Therefore, Study 4 will compare laboratory-based and naturalistic assessments of
PM in order to explore the importance of ecological validity to PM tasks for
participants diagnosed with MCI and dementia.

Finally, although research interest in PM is increasing, there has been
very little research on the progression of PM impairment. In particular, there
have been no studies of changes in PM performance over time in ageing, either
with or without cognitive impairment. Study 5 will therefore explore changes over a one-year period.

In summary, PM task performance varies as a function of age, task demands and assessment setting. Whilst there is considerable evidence that older adults perform more poorly relative to their younger counterparts in laboratory environments (Henry et al., 2004; Kvavilashvili et al., 2009), there is limited work on PM function in the context of MCI and dementia. Preliminary findings indicate that PM measures are sensitive to the effects of dementia (Duchek et al., 2006; Maylor, Smith, Della Sala, & Logie, 2002), and may even represent an earlier indicator of cognitive impairment in this population than RM (Huppert & Beardsall, 1993; although see Martins & Damasceno, 2008). The aim of this body of work is therefore to clarify the extent, nature and mechanisms underpinning PM difficulties in those with MCI and dementia. This is important not only theoretically but also from a clinical perspective. Specifically, these data may be used to inform clinical practice with respect to assessment procedures in the context of suspected dementia, as well as aiding the development of methods to optimise PM function in older adults with cognitive impairment.

After providing a brief overview of the clinical conditions of dementia and MCI, and a review of the relevant literature regarding PM processes, dimensions, models, and assessment techniques, current findings relating to PM function in each of these groups as well as normal ageing will be discussed.
Dementia

Dementia is the progressive decline in cognitive abilities and functional skills in comparison with an individual’s previous level of function (American Psychiatric Association, 2004). This may be determined by a history of decline in performance and by abnormalities noted from clinical examination and neuropsychological tests (Lezak, Howieson, & Loring, 2004). Diagnostic criteria for dementia typically emphasise impairment of memory plus cognitive decline in other domains (1994; McKhann, Drachman, Folstein, Katzman, Price, & Stadlan, 1984; Roman, Tatemichi, Erkinjuntti, Cummings, Masdeu, Garcia, & al., 1993). However, while these criteria specify impairment in ‘memory’, they do not attempt to specify what aspects of memory should be assessed (McKhann et al., 1984; Spaan, Raaijmakers, & Jonker, 2005).

Dementia is not a single disease, but rather, is an umbrella term used to describe a number of differing types of neurodegenerative diseases. Alzheimer’s disease and vascular dementia are the two most common subtypes of dementia reported in Australia (Brodaty, 1990; Khachaturian, Brodaty, Broe, Jorm, Masters, Nay, Haikerwal, Rees, & Low, 2004) as well as internationally (Roman et al., 1993; Zekry, Hauw, & Gold, 2002). Alzheimer’s disease, the most common subtype of dementia, accounts for an estimated 59% of cases of dementia in Australia (Khachaturian et al., 2004). It is characterized by early short-term memory loss and language difficulties, and gradually becomes more severe over several years. Vascular dementia is caused by cerebrovascular conditions including multi-infarct disease stroke and small vessel disease of the brain. Vascular dementia accounts for an estimated 20 to 30% of cases in Australia (Khachaturian et al., 2004). Mixed dementia is the coexistence of
Alzheimer’s disease and vascular dementia. Less common dementias include dementia with Lewy bodies, frontotemporal lobar dementia, HIV/AIDS dementia complex, alcohol related dementia, human prion diseases including Creutzfeldt-Jacob dementia, Huntington’s disease with dementia, progressive supranuclear palsy, and dementia due to other infectious or metabolic causes.

Disease progression produces further symptoms including loss of function in activities of daily living (ADLs) and instrumental activities of daily living (IADLs). ADLs include washing, eating, dressing, toileting and mobility, and consequently refer to the more basic activities of daily self-care. IADLs are more complex skills and include food preparation, shopping, cleaning, and managing finances. Deficits in IADLs tend to occur in the moderate stage of dementia and therefore tend to temporally precede deficits in ADLs which typically emerge in the late stage of dementia.

The estimated global prevalence of all types of dementia is 36 million (Prince & Jackson, 2009). The number of Australians with dementia is expected to increase from 245,000 in 2009 to 591,000 in 2030, and by 2050 the total number of persons in Australia with dementia is projected to exceed 1.13 million, a fivefold increase since 2000 (Access Economics, 2009). Australia now identifies about 1,450 new cases of dementia weekly with a projected increase to 7,400 weekly by 2050. This makes dementia the largest and fastest growing cause of disability and disease burden among older Australians (Access Economics, 2009).
Mild Cognitive Impairment

A decline in some, but not all, aspects of cognitive function has long been recognised in ageing (Cohen, 1996; Kochan, Brodaty, Crawford, Slavin, Low, Trollor, & al., 2009a; Rabbitt & Lowe, 2000). However, while mild cognitive difficulties are not clinically significant and represent a normal part of ageing (Craik, 2008; Haaland, Price, Larue, Haaland, Price, & Larue, 2003; Nilsson, 2003), deficits of a greater (although still relatively subtle) magnitude are now recognised to be a possible transition period between normal ageing and very early dementia (Petersen, Doody, Kurz, Mohs, Morris, Rabins, Ritchie, Rossor, Thal, & Winblad, 2001). Mild Cognitive Impairment (MCI) is a syndrome characterized by subjective and objective cognitive decline greater than would be expected for an individual’s age, but which does not cause notable functional impairment (Petersen, 2007). The diagnostic criteria for MCI have been established over the past decade, and require that performance on a cognitive screening test be within the normal range for age, but at least 1.5 standard deviations below age-appropriate norms on a memory or other cognitive test. In addition, daily functioning is not significantly affected and the diagnostic criteria for dementia are not met (Artero et al., 2006; Petersen, 2007; Winblad et al., 2004). MCI is typically diagnosed in an individual who presents with a subjective cognitive complaint, with neuropsychological and clinical assessments confirming the presence of a decline in at least one domain of cognition but with no extant functional impairment. Thus the absence of any functional impairment is the key difference between MCI and dementia. Importantly, functional impairment is more likely to arise from a PM failure, such as forgetting to pay bills or switch off the oven, than from an RM failure such as forgetting.
something you were told (Huppert & Beardsall, 1993; McKitrick, Camp, & Black, 1992). MCI was initially typically diagnosed as a research category rather than a clinical diagnosis, however the prevalence of such impairments has resulted in greater clinical as well as research interest in the concept (Low, Brodaty, Edwards, Kochan, Draper, Trollor, & Sachdev, 2004).

In a study of 1704 non-demented participants aged 70 to 89 years, Petersen et al. (2007) showed that the most common form of MCI involved memory (termed “amnestic MCI”). The second most common type involved attention (“non-amnestic MCI”). Of the 1704 participants assessed, 83% were cognitively normal, whereas 17% had MCI. Of those with MCI, 74% had the amnestic subtype (representing 12% of the total sample) and 26% had non-amnestic MCI (representing 5% of the total sample).

The prevalence of MCI increases with age. In Petersen et al.’s (2007) study, approximately 10% of those in the 70- to 74-year-old age group had MCI, whereas this was true of 25% in the 85-89 age group. Thus MCI increases with age and is more prevalent than dementia as a geriatric cognitive disorder. Given these high prevalence rates of MCI, understanding the extent and boundaries of the cognitive difficulties that characterise the condition is helpful for research, clinical and treatment planning purposes. In addition, individuals with the clinical condition of MCI are at increased risk of developing dementia (Albert & Blacker, 2006; Artero, Tierney, Touchon, & Ritchie, 2003; Petersen, Smith, Waring, Ivnik, Tangleos, & Kokmen, 1999), thus MCI is of particular interest when differentiating normal memory changes with age from those that are part of a disease-related change. The inclusion of participants with MCI in this
research program will be informative with regards to how early in the process of dementia-related memory decline PM impairments emerge.

**Prospective Memory**

Prospective remembering refers specifically to the remembering of future intentions. Thus PM is required to pay bills, turn off appliances and keep appointments. PM is therefore of vital importance in maintaining functional independence, a fundamental concern among older adults. PM also has a role in maintaining social relationships. Remembering to meet with friends, or acknowledging friends and relatives' birthdays or other significant occasions (through actions such as sending a card) rely on PM. Failures of PM may cause more deficits in ADLs and IADLs, and more caregiver burden, than RM failures (Smith et al., 2000).

For instance, remembering to take medications correctly is a real-world PM task that has important implications for functional independence (Gould, McDonald-Miszczak, & King, 1997). Noncompliance with medication regimens is strongly related to PM performance (Woods, Moran, Carey, Dawson, Judicello, Gibson, Grant, Atkinson, Group, Woods, Moran, Carey, Dawson, Judicello, Gibson, Grant, & Atkinson, 2008) and can have serious health consequences; for example, it is estimated that up to 24% of readmissions of elderly people to hospital are accounted for by incorrect adherence (Insel, Morrow, Brewer, & Figueredo, 2006; Schwartzberg, 1982). In one study, poor medication adherers (those taking less than 75% of their medication as prescribed) were 2.6 times more likely than good adherers to die within one year after a myocardial infarction (Horwitz, Viscoli, Berkman, Donaldson, Horwitz,
Murray, Ransohoff, & Sindelar, 1990). In an Australian study it was found that 22% of admissions to acute geriatric facilities were due to drug related problems (Atkin, Finnegàn, Ogle, Talmont, & Shenfield, 1994).

Despite the importance of PM for maintaining functional independence, it has not traditionally been included in clinical and research neuropsychological assessments of memory and cognition. While there is a growing body of research focused on PM in relation to normal ageing, only limited research to date has assessed PM in abnormal ageing.

**The Process of Prospective Remembering**

PM is considered to involve a RM component because performing a PM task requires not only recalling that something is to be done, but also recalling what it is that needs to be done (Ellis & Kvavilashvili, 2000; Jones et al., 2006). Therefore, PM must be considered in conjunction with, but also separately to, RM. PM is considered to be particularly dependent on internal control mechanisms (Craik, 1983, 1986) to attend to the environment and shift attention to notice PM cues. In other words, PM is more self-initiated than RM because successful prospective remembering requires a shift of attention from the ongoing task to the PM task. For example, a shift of attention from the routine of driving the car home after work is required in order to focus on the PM task of the intention to stop at the shop on the way home. In contrast, RM is prompted by an external cue requiring information to be retrieved. In clinical and research assessments, RM is typically examined using tests of learning, recall and recognition such as the Wechsler Memory Scales (Wechsler, 1945, 1997b) and
Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964) in which memory retrieval is prompted by the examiner requesting that information be recalled.

PM also differs from RM in that the cue to prospective remembering is typically embedded in an ongoing task. Ongoing tasks are activities individuals are involved in, such as working, driving a car or watching television. Ongoing tasks undertaken in the research laboratory, such as face recognition tasks, simulate real-world involvement in activities. While involved in an ongoing task a PM cue indicates that a response is needed. Typical cues are noticing the time or seeing the shop on the way home. Noticing a PM cue interrupts the ongoing task in order for the PM response to occur. This is in contrast to RM which is typically cued by an external request such as a request from an examiner to recall a list of words. This difference in cues between PM and RM implies that PM is more effortful than RM, since the cue to prospective recall is entirely reliant of self-initiated processing whereas retrospective recall is in response to an external reminder (Craik, 1986). Self-initiated retrieval processes are, like other effortful control processes, thought to be particularly sensitive to the effects of abnormal adult ageing (Amieva, Phillips, Della Sala, & Henry, 2004), thus PM may be more sensitive than RM to early cognitive difficulties in MCI and dementia.

**Dimensions of Prospective Memory**

PM tasks vary along several important dimensions. The most influential distinctions to date include “Time-Based” versus “Event-Based” (Einstein & McDaniel, 1990), “Focal” versus “Non-Focal” (Hicks, Cook, & Marsh, 2005;
McDaniel & Einstein, 2000) and “Regular” versus “Irregular” (Einstein & McDaniel, 1996; Rendell & Craik, 2000).

One of the earliest distinctions between types of PM tasks was between time-based and event-based (Einstein & McDaniel, 1990; Einstein et al., 1995). Time based PM requires an action to be performed at a certain time (such as keeping an appointment at a given time) or after a certain amount of time has elapsed (take a cake out of the oven after 20 minutes). Event-based PM requires an action to be performed in response to a specific cue or event, such as taking medication after a meal. Some researchers also refer to “activity-based” PM, such as remembering to turn off the iron when finished (McDaniel & Einstein, 2007), although this is more commonly seen as a part of event-based PM. Early research comparing time and event-based cues typically suggested that time-based PM tasks are more capacity consuming than event-based tasks because they impose greater demands on self-initiated retrieval processes, rather than being cued by an external event (Maylor et al., 2002; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). However a more recent meta-analysis of PM and ageing did not identify this distinction as a key determinant of performance differences across age groups (Henry et al., 2004). The authors concluded that not all PM tasks can be considered to be heavily reliant on self-initiated retrieval, and that other properties of the PM cue, and its relationship to the ongoing task, need to be considered. Few studies have assessed this distinction between time-based and event-based task types in the context of abnormal adult ageing. Study 1 will therefore compare time-based and event based PM tasks in individuals with MCI or dementia and controls.
As noted, it has also been suggested that one potentially important aspect of PM is the degree to which the task to be completed is regular or irregular. Regular tasks are completed according to a fixed schedule, such as taking medication every morning or attending a weekly social event, whereas irregular tasks are not regularly scheduled in relation to any particular time or recurring event. Irregular PM tasks include infrequent appointments, such as collecting dry cleaning or keeping a dental appointment which may only occur once or twice a year. Regular tasks are thought to become more automatic than irregular tasks, and thus relatively less effortful than irregular tasks to recall. Research has found this translates into better performance on regular than irregular tasks in a variety of populations including schizophrenia (Altgassen, Kliegel, Rendell, Henry, & Zöllig, 2008; Henry, Rendell, Kliegel, & Altgassen, 2007), multiple sclerosis (Rendell, Jensen, & Henry, 2007b) and users of the drug methylenedioxymethamphetamine (MDMA or "Ecstasy"; Rendell, Gray, Henry, & Tolan, 2007a). Consistent with this, regular tasks have also demonstrated smaller age-related impairment than irregular tasks (Kliegel, Rendell, & Altgassen, 2008b; Rendell & Craik, 2000). Regular and irregular tasks will be therefore also compared in Study 1.

McDaniel and Einstein (2000) have distinguished PM cues that are embedded within the requirements of the task being undertaken (i.e., “focal”) from cues that are not part of the information being processed in the task at hand (“non-focal”). For example, when encountering and talking with a friend to whom you wish to convey a message, one is attending to the friend, thus the friend is the “focus” of attention and so the PM cue is focal. In laboratory studies, a focal cue may be to monitor for a specific word while viewing words
on a screen and remembering to press a button whenever that word appears on screen (Kliegel, Jager, & Phillips, 2008a). An example of a non-focal cue is passing the turn off to the grocery store while driving the usual route home (and attending to traffic), while the intention to be remembered was to detour to the grocery store to buy bread. In terms of the definitions offered by Einstein and McDaniel (2005; McDaniel & Einstein, 2000), a focal cue overlaps with the information constellation relevant to performing the ongoing task whereas a non-focal cue is present in the environment but is not part of the information being considered by the person. Stated simply, a focal cue is part of the ongoing task and is therefore being attended to. A non-focal cue is not intrinsically linked to performance on the ongoing task and so is not being attended to. A non-focal cue may still be in the visual or auditory field (e.g., background patterns on a computer screen during a cognitive testing task). It may even be a part of the ongoing task but it is not being attended to as part of the ongoing task (e.g., noting a cue of eyeglasses on a famous face in a face naming task when the presence of eyeglasses is a PM cue to press a specific computer key rather than naming the face). Research typically suggests that focal PM tasks are less effortful than non-focal tasks and are therefore less capacity consuming (McDaniel et al., 2008). Consistent with this perspective, greater costs to ongoing task performance are incurred by a non-focal (rather than focal) PM task (McDaniel et al., 2008). As will be discussed in Studies 1, 3 and 4, age effects on PM vary across tasks and studies (see Henry et al., 2004, for a review) and a recent meta-analysis showed that whether a cue was focal or non-focal was an important determinant of the magnitude of age effects (Kliegel et al.,
Focal and non-focal tasks will therefore also be explored further in Study 3.

These dimensions of cue-type, task regularity and cue focality have been explored with older adults in studies focussed on ageing, however there is limited research into the impact of these task dimensions on PM function in MCI or dementia. One of the aims of this research program therefore is to explore these important dimensions of PM in participants with MCI and dementia. Thus Study 1 will compare time-based with event-based, as well as regular with irregular tasks, and Study 3 will compare focal with non-focally cued tasks.

Although a number of studies have compared time-based and event-based cues and task regularity in participants with MCI and dementia, studies to date have not manipulated cue focality. As will be detailed in Study 3, individuals with MCI and dementia are disproportionately impaired relative to controls on measures that impose heavy demands on effortful processing (Amieva et al., 2004; Belleville, Chertkow, & Gauthier, 2007; Okonkwo, Wadley, Ball, Vance, & Crowe, 2008; Traykov, Raoux, Latour, Gallo, Hanon, Baudic, Bayle, Wenisch, Remy, & Rigaud, 2007; Wylie, Ridderinkhof, Eckerle, & Manning, 2007; Zamarian, Semenza, Domahs, Benke, & Delazer, 2007). In accordance with the Multi Process model, it is predicted that MCI and dementia effects on PM performance would be greater on tasks where the cue is non-focal (and therefore more effortful) than where the cue is focal. This hypothesis will be tested in Study 3.
Cognitive Abilities Implicated in Prospective Remembering

Multiple cognitive operations are considered to be implicated in successful prospective remembering, but limited research has explored the cognitive correlates of PM in the context of abnormal adult ageing. The key cognitive parameters thought to be implicated in PM (RM, working memory, executive functioning), will each be assessed as part of this research program in order to clarify how each relates to PM function. Inclusion of measures of these constructs will permit a better understanding of the degree to which PM is specifically affected in MCI and dementia, as opposed to simply reflecting a secondary consequence of other more general cognitive difficulties.

Retrospective Memory

There is considerable evidence for RM impairment in the context of MCI and dementia (Belleville, Sylvain-Roy, de Boysson, & Ménard, 2008; Huppert & Beardsall, 1993; Maylor et al., 2002; Petersen, 2004). Memory deficits are also central to the diagnostic criteria for dementia in DSM-IV (American Psychiatric Association, 1994) and in NINCDS–ADRDA (McKhann et al., 1984) and NINCDS-AIREN (Erkinjuntti, 1994; Roman et al., 1993) criteria. However (although not overtly specified) these definitions typically focus upon the presence of RM deficits, which are assessed by traditional memory batteries such as the Wechsler Memory Scale (Wechsler, 1997b).

Whilst RM is implicated in PM task performance, there is more to PM than simply RM *per se*. In other words, PM and RM should be regarded as overlapping, but distinct constructs. There is considerable empirical and theoretical research showing that PM and RM are at least partially distinct
cognitive operations (Ellis & Kvavilashvili, 2000; Kliegel & Jager, 2006; Zeintl, Kliegel, & Hofer, 2007). For example, PM has been shown to make a contribution to prediction of dementia three years later that was independent of RM (Jones et al., 2006). One of the aims of the present study will be to further clarify the extent to which RM deficits contribute to any PM difficulties observed in ageing, MCI and dementia.

The retrospective component of PM for intentions is generally measured in research studies to test whether deficits in performance reflect difficulties with PM, and not with what is often termed the RM component of the PM task (i.e., remembering what it is that needs to be done). A written or verbal check of the instructions upon completion of the PM task is thus a standard procedure when assessing this cognitive ability (Carlesimo, Casadio, & Caltagirone, 2004; Jones et al., 2006; Troyer & Murphy, 2007; Vogels, Dekker, Brouwer, & de Jong, 2002). In order to explore the contribution of the RM component to PM tasks in those with MCI and dementia, Studies 1 and 3 will include checks of participants’ recall and recognition of the PM task.

**Working Memory**

Working memory refers to the system involved in the temporary storage and manipulation of information that is not (yet) committed to long-term memory (Baddeley, 1986, 2001). Baddeley’s (1986, 2001) model of working memory separates out three components: a central executive, which is a supervisory process of allocation and division of attentional processes, along with the phonological loop where auditory information is stored and rehearsed and a visuospatial sketchpad where visual and spatial information is temporarily
stored. There is mixed evidence as to the contribution of working memory to PM function. Some studies have shown a positive association between PM and working memory (e.g. Cherry & LeCompte, 1999), other studies have found no evidence for a relationship (e.g. Brandimonte & Passolunghi, 1995; Maylor, 1990), while others still have posited an overlapping, but distinct relationship of the two constructs (Guimond, Braun, Rouleau, & Godbout, 2008).

There are differences in the design of these studies. For example, only Cherry and LeCompte (1999) and Maylor (1990) are specifically investigations of ageing. The equivocal findings may also reflect differing measures of working memory which access differing components of the construct. Specifically, the coordination of a PM task and an ongoing task have been shown to impose substantial demands upon the central executive component of working memory but relatively few demands on the simple storage component (Marsh, Hancock, & Hicks, 2002; Marsh & Hicks, 1998).

In studies of PM, Marsh and Hicks (1998) have shown that an ongoing task involving working memory had little effect on a PM task unless the central executive component of working memory was targeted. This suggests that it is important to target the executive component of working memory, rather than just simple storage, in order to quantify the overlap between working memory and PM processes. This is consistent with the concept of a “dual-task trade off” (Hicks et al., 2005). Tasks such as Digit Span (Wechsler, 1997a, 1997b) increase the involvement of the central executive by measuring backwards (and not just forwards) span. The assessment of working memory included in the present research program (described in Study 1) is analogous to Digit Span, and will therefore involve both the storage and central executive components. In normal
adult ageing, working memory has been well demonstrated to be related to, but also partially independent of, PM (Cherry & LeCompte, 1999; Zeintl et al., 2007). Study 1 will provide the first empirical assessment of the degree to which these constructs also overlap in the context of abnormal adult ageing.

**Executive Functioning**

Rather than being considered a unitary ability, executive functioning refers to the ensemble of higher-level processes that permit contextually sensitive and flexible behaviour, such as inhibitory control, mental flexibility and planning (Maylor, 1990; Nathan, Wilkinson, Stammers, & Low, 2001; Salthouse, Atkinson, & Berish, 2003; Zhang, Han, Verhaeghen, & Nilsson, 2007). Executive difficulties manifest in a number of different forms, such as difficulty in planning and initiating tasks, difficulty in switching between tasks or sustaining focus on a task, as well as in the organisation and integration of cognitive skills (Crawford & Henry, 2005; Mateer, 1999; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000).

Executive functioning has been shown to be associated with PM function in various populations, including childhood (Kerns, 2000) and ageing (Zeintl et al., 2007) as well as clinical populations such as traumatic brain injury (Knight, Titov, & Crawford, 2006) and schizophrenia (Kondel, 2002). Evidence from studies of traumatic brain injury (Knight et al., 2006) and schizophrenia (Henry et al., 2007) indicates that deficits in PM are greater when the ongoing task imposes demands on executive functioning. Older people have been found to show more failures of time-based PM when the ongoing task involves more complex activities, which is possibly due to increased executive demands.
(d’Ydewalle, Bouckaert, & Brunfaut, 2001). The role of both working memory and executive functioning in PM function has practical implications as both these correlates of PM have been found to be significant predictors of medication adherence in late adulthood (Insel et al., 2006), which as noted depends on intact prospective remembering.

In summary, there is well-documented evidence of impairment in RM, working memory and executive functioning in both MCI (Belleville et al., 2008; Brooks & Gardiner, 1994; Kerns & Decker, 1985; Petersen et al., 2001; Traykov et al., 2007) and dementia (Belleville et al., 2008; Jak, Bangen, Wierenga, Delano-Wood, Corey-Bloom, & Bondi, 2009; Leys, 2002; Pasquier, 1999). There is also an increasing body of literature documenting PM impairment in MCI (Blanco-Campal, Coen, Lawlor, Walsh, & Burke, 2009; Duchek et al., 2006; Karantzoulis, Troyer, & Rich, 2009; Kazui, Matsuda, Hirono, Mori, Miyoshi, Ogino, Tokunaga, Ikejiri, & Takeda, 2005; Schmitter-Edgecombe, Woo, & Greeley, 2009; Troyer & Murphy, 2007) and in dementia (Blanco-Campal et al., 2009; Jones et al., 2006; Kazui et al., 2005; Kinsella, Ong, Storey, Wallace, & Hester, 2007; Martins & Damasceno, 2008; Troyer & Murphy, 2007). However, to date, there has been only limited study of how cognitive skills such as RM, executive functioning and working memory relate to prospective remembering in each of these groups.

**Measurement Issues in Prospective Memory**

The increasing research interest in PM has been matched by an increasing interest from a clinical perspective, especially given its crucial role in maintaining independent living, an issue which is particularly important in
dementia care (Brodaty, Thomson, Thompson, & Fine, 2005; van der Roest, Meiland, Comijs, Derksen, Jansen, van Hout, Jonker, Droes, van der Roest, Meiland, Comijs, Derksen, Jansen, van Hout, Jonker, & Droes, 2009). Although no cure yet exists for dementia, early detection is important as it enables affected individuals and their caregivers to make informed plans and choices about future care. A number of brief screening tools for cognitive impairment exist for this purpose (Brodaty, Kemp, & Low, 2004) yet none includes PM screening. A reliable and valid brief assessment of PM therefore seems likely to be a very useful clinical tool. It is therefore a notable omission that the most widely used memory assessment batteries such as the Wechsler Memory Scale do not include PM in their subtests, even in the most recent fourth edition (Wechsler, 1997b; Wechsler, 2009).

Brevity aside, there are very few standardised measures of PM available for use in clinical assessment (Thöne-Otto & Walther, 2008). Two tests are available which do assess PM: the Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn, Baddeley, & Hiorns, 1989) and the Cambridge Test of Prospective Memory (Wilson, Emslie, & Foley, 2004; Wilson, Emslie, Foley, Shiel, Watson, Hawkins, Groot, & Evans, 2005). However, as will be discussed in the following sections, problems of validity, and in particular reliability, have been identified for each of these tests.

**Brief Measurement of Prospective Memory**

When brief clinical assessments of PM have been conducted, unstandardised measures have traditionally been used, such as instructing an examinee to ask for a red pen when given a particular task in the assessment session (Dobbs
&Rule, 1987). Such brief assessments are required in clinical settings, where a PM assessment is likely to be a part of a lengthy neuropsychological or clinical assessment. The difficulty with such assessments is that they lack any published norms or reliability and validity information (Thöne-Otto & Walther, 2008).

Early research studies also used brief measures to index PM, and have typically used measures that appeared high in ecological validity, such as asking participants to return postcards on certain days or to telephone the experimenter at certain times (Harris, 1984). However these methods exerted no control over the context of the PM task or the use of external cues. Thus PM research was increasingly conducted in laboratory settings, using tasks such as pressing a particular computer key in response to a cue on the screen (e.g. Einstein & McDaniel, 1990). Although ecological validity is forfeited, an important feature of laboratory assessments is that they allow analysis of PM without the influence of external aids such as calendars or clocks (Maylor, 1995), and more readily permit specific task and cue types to be differentiated. Due to time constraints in clinical assessment, brief unstandardised measures have more conventionally been used instead of longer, standardised psychometric tests of PM. Study 4 will therefore test the validity of such an assessment, by administering a brief index of PM similar to those conventionally used in clinical assessments, and evaluating its sensitivity to the presence of MCI and dementia, as well as its convergent validity relative to a longer standardised index of this construct and a dementia screening test.
Standardised Tests of Prospective Memory

One standardised test of memory used for clinical purposes that includes PM is the Rivermead Behavioural Memory Test (Wilson, Cockburn, & Baddeley, 1985) which assesses memory through tasks argued to be analogous to those encountered in everyday life. Three subtests assess PM: belonging, appointment and message. In the belonging subtest the examinee is asked at the beginning of the assessment session to handover to the examiner a personal possession, which is then stored out of sight. The examinee is instructed to remember to ask for the belonging to be returned at the conclusion of the assessment session. In the appointment subtest, the examinee is instructed that when an alarm sounds, to ask the examiner when their next appointment will be. In the message subtest, the examinee is instructed to leave an envelope containing a message at a certain point whilst completing an earlier subtest. The belonging and appointment subtests are given as a single trial only. The message subtest has an immediate and a delayed trial.

The Rivermead Behavioural Memory Test was developed as a screening test for memory impairment and the authors do not promote it as being sufficiently sensitive to identify mild memory deficits (de Wall, Wilson, & Baddeley, 1994). In a factor analysis of memory test batteries, the three tasks which putatively assessed PM (belonging, appointment and message) did not load on a single factor as expected (Efklides, Yiultsi, Kangellidou, Kounti, Dina, & Tsolaki, 2002), raising questions about the construct validity of this measure. In another study, Kazui et al. (2005) examined the ability of the Rivermead Behavioural Memory Test to discriminate between normal ageing, MCI and Alzheimer’s disease. The complete test (all 12 subtests combined) showed
sensitivity of 1.0 and specificity of 0.92 at discriminating individuals with MCI from normal controls, and sensitivity of 0.73 and specificity of 0.87 at discriminating Alzheimer's disease from MCI. However the three PM subtests specifically were not useful in discriminating Alzheimer's disease, MCI and normal ageing. Indeed, on the PM subtests, there was evidence of floor effects for the group with Alzheimer's disease, with all participants in this group failing two of the three PM tasks, and 98% failing the third. The utility of this battery as a test of PM is also limited by its failure to take specific dimensions of PM into account, such as the time versus event-based cues, or regular versus irregular distinctions previously described. Moreover, Maylor (1995) argues that the message subtest is not a true measure of PM because retrieval is not self-initiated. Instead, the examinee is cued by the instructions given by the examiner to perform the task of delivering the message. Equally, the appointment subtest could be argued not to be a true measure of PM because the response is prompted by an alarm rather than being self-initiated.

The Cambridge Test of Prospective Memory (CAMPROMPT; Wilson et al., 2004; Wilson et al., 2005) is an objective and standardized clinical measure of PM. The CAMPROMPT is based on activities in daily life and comprises three time-based tasks such as remembering to change tasks in seven minutes time and three event-based tasks such as reminding the examiner to make a phone call when an alarm sounds, revised from an earlier version (Groot, Wilson, Evans, & Watson, 2002). A limitation of this test is that it does not discriminate focal from non-focal, or regular versus irregular, PM tasks, yet these dimensions are known to affect PM performance in older adults (Henry et al., 2004; Kliegel et al., 2008a; Rendell & Craik, 2000; Rey, Feldman,
Hernandez, Levin, Rivas-Vazquez, Nedd, & Benton, 2001). Test-retest reliability of the CAMPROMPT is estimated to be .64 (Wilson, Emslie & Foley, 2004). In terms of validity, the CAMPROMPT correlated with the RBMT at .38 and between .20 and .50 with a battery of other (non-PM) neuropsychological test scores (Albanese & Brody, 2007).

More recently developed tests of PM include “The Virtual Street”, a computer program that links 1200 photographs of a shopping street, which are navigable by a computer touch screen to allow movement around the shopping street (Knight et al., 2006). A study of older and younger participants showed poorer performance by the former group (Knight, Nicholls, & Titov, 2008). However the Virtual Street test does not include any distinctions between time and event-cued tasks, regular and irregular tasks, or focal and non-focal cues.

Another recently developed test is the Memory for Intentions Screening Test (MIST; Raskin, 2009). The MIST aims to be an ecologically valid test and includes both time-and event-based PM cues. However, the measure does not differentiate between irregular (versus regular) tasks, and focal (versus non-focal) cues. The psychometric properties have been reported to be sound, with the MIST being validated against two PM items from the RBMT with a correlation of .80. The parallel form reliability was found to be .89 (Raskin, 2009) and split-half reliability to be .70 (Woods, Moran, Dawson, Carey, Grant, & the H. I. V. Neurobehavioral Research Center Group, 2008). Inter-item reliability of individual trials was poor (Cronbach’s alpha = .48) but of subscales was good (Cronbach’s alpha = .89). There are preliminary data in normal controls and a variety of clinical populations which suggests the MIST is a sensitive measure of PM difficulties in these groups (Raskin, 2009).
A test that has shown considerable promise in research studies of PM is Virtual Week (Rendell & Craik, 2000; Rendell & Henry, 2009). Virtual Week takes the structure of a board game, in which participants move through each day as they circuit the board, with a series of events occurring and tasks to be remembered each day. The test can be computerised to facilitate data capture. A screenshot of a computerised version is presented in Figure 1.1. Virtual Week has evidence of good reliability and validity, with reliability estimates from .84 to .94 (Rose, Rendell, & McDaniel, 2007) and validity established through controlled studies showing group differences with poorer performance in the aged (Rendell & Craik, 2000; Rose et al., 2007) and in clinical populations including schizophrenia (Henry et al., 2007), multiple sclerosis (Rendell et al., 2007b) and substance abuse (Rendell et al., 2007a). As with Virtual Street, Virtual Week has been argued to be more ecologically valid than more conventional laboratory assessments, in that it mirrors the types of PM tasks that occur in daily life (Rendell & Henry, 2009).

One of the most important advantages of Virtual Week as a measure of PM is the inclusion of time and event-based PM cues and regular and irregular tasks. A unique and important aspect of this test is that a differentiated profile of impairment on Virtual Week may therefore be informative of the degree of PM impairment per se, and also of the particular circumstances in which PM impairment is more likely to arise (and consequently the manner in which rehabilitation efforts should be targeted).
While a number of promising measures of PM have now been developed, of these, Virtual Week is notable for its psychometric properties, for including tasks that vary in their relative demands, and having documented sensitivity to both the effects of normal adult ageing, as well as psychiatric and neurological illness. Thus Virtual week was the test chosen for a group comparison of PM performance in Study 1.

**Self-Report and Informant Report**

In addition to assessment of PM using standardised behavioural measures, PM can also be assessed using self- and informant-report. The *Everyday Memory*
Questionnaire (EMQ; Sunderland, Harris, & Baddeley, 1983) was one of the first questionnaire-measures developed to index memory performance. The EMQ consists of 35 self-report items assessing PM, episodic memory, procedural memory, memory for faces, places, and routes, and concentration/ following a story (a revised version contained 28 items; Sunderland, Harris, & Baddeley, 1984). However, despite the fact that multiple aspects of memory are included, no clear factor structure to the EMQ has been identified (Cornish, 2000; Efklides et al., 2002). Further, only three of the 35 items on the EMQ assess PM specifically.

A more recently developed self-report measure is the Prospective and Retrospective Memory Questionnaire (PRMQ; Crawford, Smith, Maylor, Della Sala, & Logie, 2003; Smith et al., 2000). The PRMQ provides a multi-faceted assessment of memory. It distinguishes between failures of PM (e.g., deciding to do something and then forgetting to do it) and RM (e.g., forgetting something you were told), as well as between failures of short-term (e.g., mislaying something you just put down) and long-term memory (e.g., not recognising a place previously visited), and failures of self-cued (forgetting what was watched on television the previous day) and environmentally-cued memory (e.g., forgetting to buy a birthday card, even when you see the shop). The PRMQ self-report version has a clear factor structure with a general memory factor as well as PM and RM factors, and has considerable evidence for both validity and reliability (Crawford et al., 2003). The informant-report version shows the same three factors, although in an unimpaired population, the informants' ratings tended to load higher on the general memory factor than on the specific prospective or retrospective factors (Crawford, Henry, Ward, & Blake, 2006)
Smith et al. (2000) used the PRMQ to assess older adults with and without dementia. Those with dementia were rated by an informant (usually a spouse or adult child), while those with no cognitive impairment completed a self-rated questionnaire. The results indicated that PM failures were more frequently reported than RM failures for both groups, with all responses for the dementia group close to the impaired end of the scale. For participants with no cognitive impairment, married couples were asked to rate themselves and each other in order to control for any differences due to completing a questionnaire about somebody else. There were no significant differences between ratings of self and other, suggesting that the two measurements showed concordance, although the correlations between self-reports and informant-reports were not reported.

Further, although Smith et al. (2000) used informant-report to control for the assumed unreliability of self-ratings of those with dementia due to lack of insight, they did not explore actual self-ratings of those with Alzheimer’s disease, nor include any ratings of individuals with milder cognitive impairments. Most importantly, they also did not test how informant-report data related to objective performance on a behavioural measure of PM. These are important issues, particularly in view of the fact that meta-memory, or the knowledge of one’s own memory performance, has been shown to be inaccurate even in normal ageing, with subjective complaints being common in individuals without objective memory impairment (Slavin, 2006). Indeed, a recent study of memory and ageing in participants with MCI and healthy controls found no differences in frequencies of subjective cognitive complaints between these groups, and very weak associations of impairment in performance on objective
neuropsychological assessments with self-reported and informant-reported subjective cognitive complaints, with partial rs ranging from -0.07 to -0.16 (Slavin, Brodaty, Kochan, Crawford, Trollor, Draper, & Sachdev, 2010). In the present research program, all participants will be measured on self-report, informant-report and objective testing to permit the convergent validity of all three forms of assessment to be evaluated quantitatively. These data will be reported in Study 2.

**Naturalistic Assessment of Prospective Memory**

Naturalistic assessment of PM is important in order to ascertain the generalisability of laboratory observations to everyday life; or *ecological validity* (Phillips, Henry, & Martin, 2008). As noted previously, systematic differences have been identified across naturalistic and laboratory settings (Rendell & Thomson, 1999), with the age advantage identified for the former being of equivalent magnitude to the age deficit seen for the latter (Henry et al., 2004). Such findings have been referred to as the ‘age-prospective memory paradox’ (Rendell & Thomson, 1999). One suggestion having important implications for designing a naturalistic study is that for the age advantage to occur, the PM task must be carried out amid the real life tasks of the participant, as opposed to experimenter controlled tasks typical of laboratory and clinically based assessments (Bailey, Henry, Rendell, Phillips, & Kliegel, 2010). In order to compare PM performance in MCI and dementia on a naturalistic task with performance on a laboratory based test, Study 4 will use a naturalistic assessment of PM and compare the results with the findings of Study 1 (using the Virtual Week laboratory assessment).
**Prospective Memory and Ageing**

Most PM research to date has focussed on cognitively normal adult ageing. Indeed, important PM task dimensions have been identified from studies of normal adult ageing, including the manipulation of time-based versus event-based tasks, regular versus irregular tasks and focal versus non-focal cues. As noted, while most evidence suggests that the time-based versus event-based distinction may not be a key determinant of age effects (Henry et al., 2004), these other distinctions have been found to be of more consequence. Age effects are typically greater for irregular than regular tasks (Rendell & Craik, 2000; Rendell & Thomson, 1999) and non-focal than focal PM cues (Kliegel et al., 2008a). Further, a meta-analysis of studies of age-related changes in PM concluded that age-related changes appear to vary as a function of task setting, with an age-related deficit identified in laboratory settings, and an age-related advantage of equivalent magnitude identified in naturalistic settings (Henry et al., 2004).

One of the key aims of the present research program is to explore how these specific task parameters of time versus event-based cues (Study 1); regular versus irregular tasks (Study 1); focal versus non-focal cues (Study 3); as well as the specific task environment (laboratory versus naturalistic, Study 4), relates to PM function in the context of abnormal adult ageing. As will be discussed, while there is considerable research showing that PM *per se* is impaired in both MCI and dementia, there has been only limited empirical investigation of how performance varies as a function of each of these parameters. What follows is a brief overview and summary of this literature.
Prospective Memory in Mild Cognitive Impairment and Dementia

PM failure is a troublesome aspect of dementia, as evidenced by common complaints from caregivers that the affected individual forgets to do even simple tasks when they should (Camp, Foss, & Stevens, 1996). Subjective PM complaints are reported by individuals with MCI and dementia (Eschen, Martin, Gasser, & Kliegel, 2009). PM may also be of diagnostic significance for the early detection of dementia. Preliminary evidence indicated that PM decline is an early feature of both MCI and early dementia, with a study by Huppert and Beardsall (1993) suggesting that MCI may be more sensitive to PM than RM failures. That study was based on a single PM task (i.e., a one-off trial scored as correct or incorrect). Such studies, based on a single-item PM task, or a small number of tasks (such as the PM subtests of the Rivermead Behavioural Memory Test; see p. 29) may be at risk of poor reliability due to the few opportunities to perform the PM task (McDaniel & Einstein, 2007) and lack of opportunity to manipulate important dimensions of PM (Rendell & Henry, 2009). As previously discussed (see pp. 15-19 and 34), PM performance has been found to vary systematically as a function of task setting (laboratory-based or naturalistic) as well as a number of task parameters (including time versus event-based, focal versus non-focal, and regular versus irregular). How PM is affected in the context of abnormal adult ageing is therefore likely to be too complex to be evaluated by use of a single PM task.

It is therefore of considerable concern that to date, studies of PM in MCI and dementia have tended to use a single task or small number of tasks to target this construct (see Study 1, Introduction). There is consequently a paucity of
research comparing performance on the different dimensions of PM in these groups. The overarching aim of the present research program is to provide a comprehensive assessment of how PM function is affected in both MCI and dementia relative to demographically matched controls, and to assess the importance of these PM parameters in these groups. Based on previously reviewed evidence indicating the importance of the following distinctions in the context of normal ageing, Study 1 will assess PM across time and event-based cues and regular and irregular tasks, Study 2 across self-report, informant-report and standardised assessments, Study 3 across focal and non-focal cues, and Study 4 across naturalistic and laboratory settings.

Further, although recognition of the importance of PM is increasing, there has been very little research to date on the progression of PM impairment and no published studies to date in ageing, either with or without cognitive impairment. Longitudinal studies of PM have been conducted with other populations, namely depressed participants (Withall, Harris, & Cumming, 2009a) and users of the drug methylenedioxymethamphetamine (MDMA or "Ecstasy"; Zakzanis & Young, 2001; Zakzanis, Young, & Campbell, 2003), however to date no longitudinal studies of PM in cognitive impairment have been conducted. A longitudinal assessment of participants with MCI or dementia and healthy controls was therefore the focus of Study 5.

Summary

PM has attracted increasing clinical and research interest in recent years, however there are still many issues to be clarified, particularly with regards to PM functioning in MCI and dementia. The overarching goal of the present
research program was to contribute to and address gaps in this literature by investigating the extent and nature of PM impairment in MCI and dementia, and by examining the utility of differing assessment methods in these clinical groups.

Aim One. Specifically, extant literature indicates that a comprehensive assessment of PM function requires a manipulation of both key task parameters and task setting. Some of the most important distinctions are considered to be time-based versus event-based cues, regular versus irregular tasks (Rendell & Craik, 2000; Rendell & Thomson, 1999), focal versus non-focal cues (Kliegel et al., 2008a) and naturalistic versus laboratory settings (Henry et al., 2004). Very few MCI or dementia studies differentiate between these aspects of PM. Consequently the first aim was to assess how each of these key task parameters (Studies 1 and 3) and manipulation of task setting (Study 4) impacts PM function in each of these clinical groups.

Aim Two. It has also been argued that PM is separable from, but also imposes demands on, multiple cognitive parameters including RM, working memory and executive functioning. However, the relationship between these cognitive abilities and PM has been subject to only limited assessment in the context of abnormal ageing. The second aim was therefore to include measures of each of these constructs and assess how they relate to PM function (Study 1). This represents an important contribution to existing research, which has focused primarily on normal ageing.

Aim Three. Although used in clinical practice, the validity of self-report versus informant-report measures of PM has been questioned (Jorm, 2003; Slavin et al., 2010). The third aim was therefore to empirically test how both
types of assessment relate to one another, as well as behavioural measures of this construct (Study 2).

_Aim Four._ Analogously, despite increasing research showing that measures of PM have the potential to function as sensitive screening tools for abnormal cognitive decline in late adulthood, an ongoing issue in clinical practice relates to problems with the validity of the brief assessments typically used to index this construct (Thöne-Otto & Walther, 2008). The fourth aim was therefore to clarify the convergent and discriminant validity of a brief (relative to a more comprehensive) assessment of PM (Study 3).

_Aim Five._ Finally, there is no published research into the changes in PM in a longitudinal study in the populations of interest. The final aim was to quantify changes over a one-year period in each of the three groups, MCI, dementia and controls (Study 5). These data will have important implications for understanding the role of such assessment procedures in both clinical practice and research. Taken together the proposed research program has the potential to inform clinical assessment and diagnosis of MCI and dementia, enabling early diagnosis and treatment of cognitive complaints.
CHAPTER 2.

Study 1: Clinical Assessment of Prospective Memory Function in Mild Cognitive Impairment and Early Dementia using "Virtual Week"\(^1\)

To date, seven dementia studies have examined PM performance and have included controls, thus allowing the presence and magnitude of PM impairment to be quantified. All seven of these studies reported that individuals with dementia exhibit PM difficulties relative to controls (Blanco-Campal et al., 2009; Duchek et al., 2006; Jones et al., 2006; Kazui et al., 2005; Kinsella et al., 2007; Martins & Damasceno, 2008; Troyer & Murphy, 2007). Particularly striking were Kinsella et al.’s (2007) findings. In their study, a simple event-based PM task was administered, in which participants were required to remember to make a word substitution whenever a target word appeared in a passage of text. Despite minimal RM demands (participants were required to recall only one target word), and a relatively mild level of dementia, the Alzheimer’s disease group performed close to floor-level on this task. Therefore, PM difficulties appear to be a prominent and consistent feature of dementia.

Such findings are unsurprising given that the neural structures affected in the most common types of dementia, even in the early stages, are also known to be implicated in PM function. In particular, prominent atrophy and tau deposition is observed in temporal and frontal neocortices (e.g. Barnes, Ourselin, & Fox, 2009; Scheltens & Scheltens, 2009). There is evidence that the frontal

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lobes play a key role in various cognitive control operations, such as planning and monitoring, each of which are considered essential to PM performance (see Glisky, 1996; Reynolds, West, Braver, Reynolds, West, & Braver, 2009; Zöllig, West, Martin, Altgassen, Lemke, & Kliegel, 2007). Further, recent evidence has highlighted the importance of temporal neural structures in subserving many important aspects of PM function (den Ouden, Frith, Frith, & Blakemore, 2005; Reynolds et al., 2009).

Research attention has increasingly focused on clarifying whether PM difficulties may have diagnostic significance for early detection of dementia over and above the contribution of RM, with most studies to date supportive of this possibility. Thus, it has been shown that measures of PM make an independent contribution beyond that of RM to the diagnosis of dementia (Duchek et al., 2006) and to the prediction of dementia three years later (Jones et al., 2006). Specifically, Jones et al. (2006) administered measures of PM and RM to preclinical Alzheimer’s disease and control participants, three years prior to dementia diagnosis. The results indicated that the preclinical Alzheimer’s disease participants were impaired on both measures, and within the PM task itself, the prospective and retrospective components were comparably impaired. Further, the PM task contributed significant unique variance to the prediction of Alzheimer’s disease. These data were particularly striking given that a relatively insensitive measure of PM was used: a single trial that involved reminding the experimenter to make a telephone call after all the tests had been completed. Duchek et al. (2006) also found that an event-based PM task contributed additional unique variance to discriminating mild dementia from controls, above and beyond measures of RM.
Another way of addressing how early in the disease process PM difficulties arise, and whether the presence of PM difficulties has diagnostic significance, is to examine those diagnosed with MCI. MCI is characterized by subjective and objective cognitive decline greater than expected for an individual’s age and education level, but which does not cause significant functional impairment (Petersen, 2007). Although there is ongoing debate as to whether MCI represents a prodrome of dementia, relative to the general older adult population, this group has a substantially elevated risk of developing dementia and presents with cognitive and brain changes that are generally intermediate between individuals with dementia and non-clinical controls (Albert & Blacker, 2006; Petersen, 2007).

As in dementia, PM is disrupted in MCI and not simply because of problems with the retrospective component of the PM task (Blanco-Campal et al., 2009; Karantzoulis et al., 2009; Kazui et al., 2005; Schmitter-Edgecombe et al., 2009; Troyer & Murphy, 2007). Karantzoulis et al. (2009) found that individuals with amnestic-MCI were impaired relative to controls on measures of time- and event-based PM, and that these difficulties reflected failures in both the prospective and retrospective components of the tasks. Schmitter-Edgecombe et al. (2009) found that amnestic and non-amnestic MCI participants were impaired on a simple event-based measure of PM (remembering to request a medicine bottle every time a specific task was completed). Since all participants were able to recall the PM task instructions, the PM failure could not be attributed to problems with the retrospective component of the task. It was also argued that the level of MCI-related impairment on the PM measure was greater than the corresponding impairment observed on a separate measure of RM.
Finally, Blanco-Campal et al. (2009) found that an event-based PM task was superior to two RM tasks in discriminating between MCI of suspected Alzheimer’s disease aetiology and normal controls.

However, a key issue in clinical practice is whether there are group differences, not only between normal ageing and pathology, but between different clinical states. Only two PM studies to date have simultaneously assessed both MCI and dementia in comparison to healthy controls, and these came to different conclusions (Kazui et al., 2005; Troyer & Murphy, 2007). Kazui et al. (2005) compared individuals with MCI, Alzheimer’s disease and demographically matched controls on the Rivermead Behavioral Memory Test (RBMT; Wilson et al., 1989), which includes three PM subcomponents, each consisting of a single task. Although both the MCI and the dementia groups exhibited PM impairment relative to controls, PM performance was comparable for the two clinical groups. Troyer and Murphy (2007) also found that two PM measures (time- and event-based PM) were impaired in both clinical groups, but those with Alzheimer’s disease were more impaired than the amnestic MCI group.

It therefore remains unclear whether measures of PM are sensitive to group differences between these two clinical conditions. The difference in Mini Mental State Examination (MMSE) scores between the MCI and Alzheimer’s disease groups was greater in Kazui et al.’s (2005) study (26.7 versus 21.9) than in Troyer and Murphy’s (2007) study (27.8 versus 25.5), thus the absence of PM performance differences in the former study did not simply reflect more closely overlapping clinical groups. One possibility is that the differences between these studies reflect method variance, and specifically, differences in the sensitivity of
the PM measure used to index this construct. McDaniel and Einstein (2007) concluded that most PM tasks lack reliability, with some tasks as low as 20%. It was argued that this lack of reliability is attributable to the few opportunities typically given to perform the PM task, with this in particular an issue for many clinical assessments such as the RBMT. In Kazui et al.’s (2005) study, the RBMT was used to index PM, with scores on each one of the three RBMT PM tasks reported separately. By contrast, Troyer and Murphy’s (2007) study would have had greater sensitivity, with scores based on a total of eight targets assessed.

The present study’s first aim was to assess whether a measure of PM with documented reliability and sensitivity shows group differences in performance between normal ageing, MCI and dementia. This study used an adapted version of a board game to test PM, Virtual Week, which has documented sensitivity to age-related cognitive impairment (Rendell & Henry, 2009; Will, Rendell, Ozgis, Pierson, Ong, & Henry, 2009). An important advantage of Virtual Week is the inclusion of PM tasks that vary in their relative task demands. In the context of clinical practice, a differentiated profile of impairment on Virtual Week may be informative of the degree of PM impairment _per se_ and, also of the particular circumstances in which PM impairment is more likely to arise (and consequently the manner in which rehabilitation efforts should be targeted).

Of the MCI and dementia studies conducted to date, only three have compared performance across multiple task parameters, and consequently helped clarify whether specific types of PM processing are particularly disrupted. Troyer and Murphy (2007) found that although participants with dementia were equivalently impaired on measures of time- and event-based PM, participants with MCI were particularly impaired on the former. Similarly, while
Karantzoulis et al. (2009) found that MCI participants were impaired on both time- and event-based PM, the magnitude of the deficit for time-based PM was nearly twice as large. Finally, Blanco-Campal et al. (2009) manipulated the specificity of the instructions and perceptual salience of the PM cue and found that the non-specific, non-salient condition was associated with greater MCI-related impairment. Kazui et al. (2006) also presented performance separately across the three individual PM tasks of the RBMT, but did not present any statistical comparison of these task-types. Taken together these studies imply that PM tasks that impose relatively greater demands on self-initiated retrieval processes, or strategic resources, may be particularly sensitive to the presence of MCI, although they may not differ in their relative sensitivity to dementia.

The second aim was to further assess whether the specific demands of the PM task interact with group status. Virtual Week not only differentiates between event- and time-based PM, but between regular and irregular tasks. This was the one task distinction that was found by Rendell and Craik (2000) to interact with age, with age-related deficits substantially attenuated on regular compared to irregular tasks. Kliegel et al. (2002) argue that remembering the content of the many different irregular tasks requires more processing resources than remembering the content of the same two regular tasks each day, and in particular, imposes greater demands on RM. Consequently, it seems likely that irregular tasks will be more sensitive to the presence of MCI than regular tasks.

The third aim was to provide an assessment of whether PM as indexed by Virtual Week is sensitive to differences between healthy controls, MCI and dementia, even after covarying for group differences in RM, working memory and executive functioning. This assessment was considered important since each
of these cognitive abilities are related to PM function in normal adult ageing (Martin, Kliegel, & McDaniel, 2003; McDaniel & Einstein, 1992), with preliminary evidence supporting such a relationship in the context of abnormal adult ageing (Schmitter-Edgecombe et al., 2009; Troyer & Murphy, 2007; although see Martins & Damasceno, 2008).

Specific hypotheses of this study were as follows. Firstly, that group differences would occur in PM performance on Virtual week, with the dementia group showing more impairment than the MCI group, who would in turn show more impairment relative to controls. Secondly, it was hypothesised that irregular tasks would show more sensitivity to MCI than regular tasks. Thirdly, it was hypothesised that differences in PM between groups (dementia, MCI and controls), would remain once the cognitive correlates of PM (RM, working memory and executive functioning) had been statistically covaried.

**Method**

**Participants**

The sample comprised 140 community-dwelling residents of Sydney, (Australia). Of these, 39 met Diagnostic and Statistical Manual of Mental Disorder (DSM-IV) criteria for dementia. Diagnoses of subtype were not known in all cases but included 10 cases of Alzheimer's disease, two mixed Alzheimer's disease and vascular dementia, one Lewy body dementia and one dementia pugilistica, however these diagnostic groupings are not explored in this study as the groups would be too small for meaningful analysis. Forty-eight participants met the modified criteria for MCI (14 amnestic single-domain, 6 amnestic multi-
domain, and 28 non-amnestic cases; Artero et al., 2006; Petersen, 2007), and 53 were controls without cognitive impairment.

The majority of participants (> 90%) were recruited from a large epidemiological study of ageing (Kochan et al, 2009) which commenced two years prior to the current study. The second source of recruitment was from a Memory Disorders Clinic, with many of these participants newly diagnosed with dementia at the time of recruitment. MCI and dementia were diagnosed by consensus conference of the memory clinic or epidemiological study. The same consultant psychiatrist and the same neuropsychologist oversaw both of these conferences and the test batteries used were identical. The same criteria were applied in both situations.

All participants had adequate eyesight, hearing and English language ability for the assessment. Participants were excluded if they had a previous diagnosis of psychiatric or neurological illness². Typical medications included cholinesterase inhibitors (taken by 10 participants in the dementia group), and treatments for physical illnesses. The groups did not differ in age, $F(2, 135) = 1.68, p = .191, \eta_p^2 = .02$, education, $F(2, 98) = 0.50, p = .611, \eta_p^2 = .01$, or gender, $\chi^2(2, N = 140) = 1.77, p = .412; \phi = .11$, but MMSE scores differentiated the groups, $F(2, 134) = 19.66, p< .001, \eta_p^2 = .23$; see Table 2.1). Follow-up Tukey tests indicated that participants with dementia had lower scores on the MMSE relative to controls ($p< .001$), and to the MCI group ($p = .001$), but the MCI and control groups did not differ ($p = .329$). MMSE scores indicate that dementia

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² These exclusion criteria were applied by the epidemiological study. Thus no ineligible participants were referred for recruitment to this PM study.
participants were in the very mild stage of illness, consistent with the majority of this group being less than two years post-diagnosis.

**Procedure**

Ethics approval was obtained from the South-Eastern Sydney Illawarra Area Health Service–Eastern Section Human Research Ethics Committee for all studies in this research program. After participants gave signed informed consent, the following measures were administered to participants in an individual, 60 to 90 minute, testing session. The session concluded with Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), a 30 point test of general cognition commonly used to screen for dementia.

**Virtual Week**

Performance on an adapted version of this laboratory measure of PM was the primary dependent measure of interest. As noted, Virtual Week was selected as it has been consistently identified as a reliable indicator of PM (for a review, see Rendell & Henry, 2009), and the incorporation of the different types of PM tasks means that PM performance can be investigated systematically in relation to different PM task demands.

Virtual Week is a computerized board game, in which participants move around the board with the roll of a dice. A ‘token’ moves automatically to show the participant’s position on the board. The times of day people are typically awake are marked on the board, with each circuit of the board representing a day. As participants move around the board a series of events occur, in which a screen pops up describing an event (e.g., “you stop at a café for lunch”), the
participant is required to make choices about the event (e.g., what to eat) and in some of these events remember to carry out an event-based PM task (e.g., take medication). The original version (Rendell & Craik, 2000) was modified in the present study for older adults with MCI and early stages of dementia, by reducing the overall task requirements to four (instead of 10) PM tasks per virtual day, over two (instead of seven) simulated days (plus a practice day). Two PM tasks were time-based (i.e., triggered by passing a particular time on the board), and two were event-based (i.e., triggered by encountering a specific event in the game). For each virtual day, one of the time-based and one of the event-based tasks was regular (a routine task involving remembering to take medication which recurred every day), and one of the time-based and one of the event-based tasks was irregular (a one-off, non-recurring task that differed for each virtual day). The list of all tasks encountered in this study is included in Appendix B. Virtual Week was administered on an HP Tablet Notebook TC4400 via a touch-screen computer interface. The Virtual Week game board, cards and dice were electronically presented and the participants interacted with the game by tapping the screen with a pen-stylus. As in Rendell and Craik (2000), participants were given pre-game instructions and then a practice virtual day to ensure they understood all features of the game, thus regular tasks occurred three times and irregular tasks only once.

Responses were scored as the number (out of 8) Correct, Missed, Wrong, Late, Early, Little Late, Little Early or Cancel. Correct scores indicated the target item was remembered at the correct time (correct time was after the dice roll for the move that took the token onto or past the target square and before the next roll of the dice); participants were marked Wrong when they selected the wrong
task; Missed indicated the participant did not remember the target item at any
time; Little Late items were remembered after the correct time criterion but
within two further rolls of the dice, and Late items were after the Little Late
criterion and before the end of the virtual day. Little Early and Early items were
the converse of Late items; Little Early was within two dice rolls before the
correct time criterion and Early was before the Little Early criterion and after the
start of the virtual day. Cancel was when participants opened the perform task
list and closed the list without selecting a task. In the present study, Cronbach’s
alpha for the total score was estimated to be .74.

Retrospective memory

After completion of the virtual days, the participant was asked to recall the PM
tasks. Once the participant could recall no more tasks, a list of eight randomly
ordered correct tasks and eight foils was given to the participant to check off the
tasks that were in the game. This provided a measure of both recall and
recognition of the tasks. Cronbach’s alpha was estimated to be .65 for recall and
.69 for recognition.

Working Memory

The Colorado Assessment Tests (CATS) Visual Span task (Davis & Keller,
2002) is a computerized version of a block tapping task (Corsi, 1972) used to
assess working memory. It is analogous to established digit-span testing
(Wechsler, 1997a), with spans of increasing length being presented, and recalled
by the examinee in a forwards and then backwards direction. Normative data
shows increasing performance with age until the twenties and then declining performance thereafter (Davis & Keller, 2002).

Executive functioning

The Tower of London test (Davis & Keller, 2002; Shallice, 1982) is used to assess executive control, and specifically planning and execution skills, which are considered to be particularly relevant to PM function (Phillips et al., 2008). The CATS Tower of London (Davis & Keller, 2002) is a computerized version of the task which involves moving different coloured pegs to match an arrangement shown in a target picture. The CATS version includes trials of varying complexity, thereby overcoming ceiling effects seen in previous versions of the Tower of London (Tunstall, 1999). Normative data for the CATS version show increasing performance with age until the twenties and then declining performance thereafter (Davis & Keller, 2002). Studies using a similar (non-computerized) version of the task have reported good reliability and criterion-related validity (Culbertson & Zillmer, 1998).

Results

Background Cognitive Measures

Between-groups ANOVAs showed group differences in Visual Span, $F(2, 134) = 17.01, p < .001, \eta^2_p = .20$; and the Tower of London, $F(2, 131) = 9.34, p < .001, \eta^2_p = .13$ (see Table 2.1). Planned follow-up Tukey HSD tests indicated that both measures differentiated between dementia and controls (both $ps < .001$). Visual Span differentiated between the control and MCI groups ($p = .016$), and between the MCI and dementia groups ($p = .006$). Tower of London differentiated
between the MCI and dementia groups ($p = .002$), but not the MCI and control groups ($p = .770$).

**Prospective Memory: Virtual Week**
The number of correct PM responses are presented in Figure 2.1 as a function of group (control, MCI, dementia) and PM cue (time, event). These data were analysed with a $3 \times 2 \times 2$ mixed ANOVA with the between-subjects variable of group and the within-subjects variables of PM task (regular, irregular) and PM cue (time, event). None of the two or three way interactions were significant, (all $F$s $< 1.2$, $p$s $> .320$). There was no main effect of PM task, $F(1, 137) = 0.42$, $p = .520$, $\eta^2_p < .01$, but there was a main effect of PM cue $F(1, 137) = 24.90$, $p < .001$, $\eta^2_p = .15$ and of group, $F(2, 137) = 23.32$, $p < .001$, $\eta^2_p = .25$. The main effect of PM cue indicated better performance in response to time-based than event-based cues. Follow-up Tukey HSD tests of the group main effect indicated that the dementia and MCI groups were each impaired relative to the control group (both $p < .001$) and the dementia group in turn performed more poorly than the MCI group ($p = .035$).

An exploratory analysis revealed that there was no difference in PM performance between MCI subtypes, $F(2, 45) = .583$, $p = .56$, $\eta^2_p = .03$. 
Table 2.1. Demographic characteristics of the control, Mild Cognitive Impairment (MCI), and dementia participants.

<table>
<thead>
<tr>
<th>Participant characteristics</th>
<th>Control (n = 53)</th>
<th>MCI (n = 48)</th>
<th>Dementia (n = 39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>77.8</td>
<td>78.6</td>
<td>79.8</td>
</tr>
<tr>
<td>Education (years)</td>
<td>11.3</td>
<td>12.2</td>
<td>12.03</td>
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<tr>
<td>Gender (% male)</td>
<td>41.5</td>
<td>54.2</td>
<td>51.3</td>
</tr>
<tr>
<td>MMSE</td>
<td>28.7</td>
<td>28.0</td>
<td>25.3</td>
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Prospective memory

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<th></th>
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<th>SD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>VW number correct (max = 8)</td>
<td>3.58</td>
<td>2.05</td>
<td>2.00</td>
<td>2.04</td>
<td>0.97</td>
<td>1.29</td>
</tr>
<tr>
<td>Regular tasks (max = 4)</td>
<td>1.79</td>
<td>1.29</td>
<td>1.08</td>
<td>1.25</td>
<td>0.49</td>
<td>0.68</td>
</tr>
<tr>
<td>Irregular tasks (max = 4)</td>
<td>1.79</td>
<td>1.08</td>
<td>1.00</td>
<td>1.13</td>
<td>0.49</td>
<td>0.82</td>
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Retrospective memory

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<th></th>
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<th>M</th>
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<tr>
<td>VW tasks recalled</td>
<td>5.40</td>
<td>1.53</td>
<td>4.32</td>
<td>1.76</td>
<td>3.09</td>
<td>2.18</td>
</tr>
<tr>
<td>VW tasks recognized</td>
<td>7.54</td>
<td>0.81</td>
<td>7.04</td>
<td>0.93</td>
<td>6.00</td>
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Cognitive functioning

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<th>M</th>
<th>SD</th>
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<tbody>
<tr>
<td>Visual Span</td>
<td>11.86</td>
<td>3.58</td>
<td>9.96</td>
<td>3.57</td>
<td>8.10</td>
<td>3.92</td>
</tr>
<tr>
<td>TOL (Excess moves)</td>
<td>7.39</td>
<td>5.47</td>
<td>8.33</td>
<td>6.11</td>
<td>16.91</td>
<td>18.04</td>
</tr>
</tbody>
</table>

Note: MMSE refers to the Mini-Mental State Examination; VW refers to Virtual Week; TOL refers to Tower of London.
Figure 2.1. Number of correct responses on the Virtual Week as a function of prospective memory cue type (time & event) for controls and participants with Mild Cognitive Impairment (MCI) and dementia. Data are collapsed across regular and irregular tasks. Bars represent one standard error of the mean.
The pattern of errors on Virtual Week is shown in Figure 2.2. Most of the errors involved a failure to respond (missed responses), with all other error types being relatively infrequent. Thus the PM tasks were nearly always either remembered reasonably accurately or not remembered at all.

Figure 2.2. Types of error responses on Virtual Week for controls and participants with Mild Cognitive Impairment (MCI) and dementia. Data are collapsed across the time and event-based, and the regular and irregular, task types. Bars represent one standard error of the mean.

3 ‘Cancel’ could be selected multiple times, thus errors are technically unlimited, whereas the ‘Correct’ score has a maximum of 8.
Differentiating the Prospective and Retrospective Components of Virtual Week

The next step in the analyses involved assessing whether any of the group differences observed on Virtual Week could be attributed to difficulties with the RM component of the task (i.e., correctly recalling the tasks that needed to be done). Performance on this component was measured through recall and recognition tests of the eight Virtual Week tasks (see Table 2.1). The results indicated a main effect of group for total number of items correctly recalled, $F(2, 128) = 16.86, p < .001, \eta^2_p = .21$, and recognized, $F(2, 128) = 11.20, p < .001, \eta^2_p = .60$. Although there was no main effect of PM task, a follow-up $t$-test comparing percentage recall of regular ($M = 82.31, SD = 36.23$) and irregular ($M = 46.28, SD = 26.51$) tasks indicated that of the two task types, regular tasks were more likely to be recalled following completion of Virtual Week, $t(129) = 11.96, p < .001, \eta^2_p = .47$. Likewise, the percentage recognition of regular ($M = 97.69, SD = 13.73$) tasks was higher than recognition of irregular ($M = 87.05, SD = 19.50$) tasks, $t(129) = 7.43, p < .001, \eta^2_p = .58$. These data are consistent with earlier studies showing that irregular (relative to regular) tasks impose greater demands on RM. To explore the patterns of shared variance in Virtual Week, two analyses of covariance (ANCOVA) were conducted with the dependent variable of PM Total Score and either total number of Virtual Week items (i) recalled or (ii) recognized entered as covariate. Following entry of each covariate, the group effect size ($\eta^2_p$) was reduced from .25 to .10 and .18, respectively, but remained significant ($ps = .002$ and $< .001$, respectively). Consequently, although interpretation of ANCOVA designs requires caution (Miller & Chapman, 2001), these data suggest that difficulties with the retrospective component of the task contributed to the group effects observed on Virtual Week, but significant residual
variance is attributable to a separable prospective component. Consistent with this interpretation, the correlations between Virtual Week and a dummy variable for controls versus the combined clinical groups remained significant after partialling out the number of Virtual Week items correctly recalled ($r_p = .30, p = .001$) and recognized ($r_p = .41, p < .001$). However the correlations between Virtual Week and a dummy variable for MCI versus dementia did not remain significant after partialling out the number of Virtual Week items correctly recalled ($r_p = .10, p = .375$) and recognized ($r_p = .17, p = .129$).

**Cognitive Correlates of Prospective Memory Function**

Group effects were observed on the measures of Visual Span and Tower of London. Correlational analyses indicated that Virtual Week performance was related to both these measures ($r s = .49$ and .27, respectively; both $ps < .01$). In order to explore the patterns of shared variance in the dataset, further exploratory ANCOVAs were conducted, this time with the dependent variable of PM Total Score, and one of the cognitive measures entered as a covariate. After exploring the influence of Visual Span and Tower of London as covariates individually, the final ANCOVA entered both measures as covariates simultaneously. The group effect size ($\eta^2_p$) was reduced from .25 to .13, .20 and .12, respectively, but for all ANCOVAs remained significant (all $ps < .05$). Further partialling out RM (recall) reduced these effect sizes to .06 (partialling out RM and Visual Span), .08 (partialling out RM and Tower of London) and .05 (partialling out RM, Visual span and Tower of London), with all three remaining significant (all $ps < .05$). Again, consistent with this interpretation, the correlation between Virtual Week and a dummy variable for controls versus the combined clinical
groups remained significant after partialling out Visual Span ($r_p = .33, p < .001$), Tower of London ($r_p = .42, p < .001$), and both cognitive measures simultaneously ($r_p = .33, p < .001$). The correlations between Virtual Week and a dummy variable for MCI versus dementia remained significant after partialling out Tower of London ($r_p = .22, p = .046$), but not after partialling out Visual Span ($r_p = .20, p = .065$) or both cognitive measures simultaneously ($r_p = .18, p = .110$).

**Discussion**

These data confirm previous research studies in showing that individuals with MCI and dementia exhibit PM difficulties relative to demographically matched controls. However since prior studies have failed to agree on whether reliable group differences exist on measures of this construct between MCI and dementia (Kazui et al., 2005; Troyer & Murphy, 2007), the present results are important in showing that individuals with dementia are more impaired on Virtual Week than those with MCI. These data affirm the importance of using measures of PM that have documented reliability and validity. As noted previously, Virtual Week has been well validated, and shown to be sensitive to age-related cognitive impairment specifically (Rendell & Henry, 2009; Will et al., 2009). It seems likely that the discrepancies in prior studies primarily reflected method variance, and in particular, fewer opportunities given to perform the PM task in the Kazui et al. (2005) study (three) relative to Troyer and Murphy’s (2007) study (eight). As in the latter study, the present study afforded participants eight opportunities to execute the PM task.

The second aim of the present study was to assess whether individuals with MCI and dementia exhibit a differentiated profile of impairment on Virtual
Week. In line with prior research results, it was predicted that PM tasks which imposed relatively greater demands on strategic resources may be particularly sensitive to the presence of MCI, although they may not differ in their relative sensitivity to dementia. In fact no interaction between group and either cue type (time, event) or task type (regular, irregular) was observed, indicating that both clinical groups exhibited a relatively generalized level of impairment on Virtual Week that did not vary as a function of specific task demands.

In the PM literature most weight has typically been attributed to the distinction between time- and event-based cues. Prior studies that have manipulated cue-type in groups with MCI have shown individuals with MCI to be disproportionately impaired when responding to time-based cues (Karantzoulis et al., 2009; Troyer & Murphy, 2007) but those with dementia to be equivalently impaired (Troyer & Murphy, 2007). It is suggested that the absence of an interaction with cue type in the present study may reflect the unique manner in which Virtual Week operationalises these parameters. Relative to most laboratory time-based PM tasks, the time-based tasks in Virtual Week have considerable external cues (the time is cued by the activities relevant to the virtual time of day and the time is also clearly seen and ‘encountered’ on the Virtual Week board game). The provision of these cues may therefore have equated these tasks to the event-based tasks in terms of their reliance on self-initiated processing, representing the situation in daily life where some times of day can have strong environmental cues. Consequently, it is not advisable to over-interpret the absence of interaction with cue-type identified in the present study.
More compelling was the absence of any interaction between group and task regularity on Virtual Week. It is possible that this interaction did not emerge because the regular tasks were only performed three times and may therefore not be sufficiently “automated” to show differential group effects. Previous research has shown that the regular tasks in Virtual Week require fewer processing resources (and indeed, in the present study a post-hoc analysis of task recall following completion of Virtual Week also suggested that the regular tasks imposed fewer demands on RM; i.e., irregular, relative to regular, tasks were less likely to be successfully recalled retrospectively). This interpretation is also consistent with the analyses in which number of Virtual Week items correctly recalled and recognized were covaried. While the use of ANCOVA in non-randomized designs has been subject to some debate, it has been suggested that this methodology may be useful (despite non-random assignment) in the context of exploration of a dataset to understand patterns of shared variance (Huitema, 1980; Miller & Chapman, 2001). Although speculative, taken together these analyses suggest that while difficulties with the retrospective component of the task (as well as working memory and executive functioning) may each have contributed to the group effects observed on Virtual Week, significant residual variance may be attributable to a separable, prospective component. However, given the noted difficulties of ANCOVA use in non-randomized designs, coupled with the use of single indicators to tap the key cognitive constructs of interest, clearly further research is needed to test this interpretation of these data.

A strength of Study 1 is the recruitment of participants diagnosed by use of consistent diagnostic criteria for MCI and dementia, however some limitations must be acknowledged. Some of the dementia group were taking dementia
medication, but it was not possible to conduct formal analyses assessing medication status and cognitive performance due to the very differing medication types and dosages participants received. The role of medication status in PM function in this group therefore remains an important issue for future research. Given that the purpose of such medication is to improve cognition, one possibility is that use of such medication may serve to attenuate dementia effects on PM.

As noted previously, Study 1 used a modified version of Virtual Week, in which task demands were reduced. Despite these modifications some participants, particularly those with dementia, performed at zero. Thus, while a key strength of Virtual Week is its sensitivity to even very early signs of cognitive decline, further modifications which decrease task difficulty would be needed to further extend its usefulness as a research tool in this particular population.

In conclusion, it has long been recognized that deficits in the ability to implement delayed intentions are likely to lead to problems in daily functioning. Study 1 indicates that both MCI and dementia are associated with PM deficits, and supports the use of Virtual Week in clinical practice as a tool to quantify the magnitude of these impairments. It is suggested that while failures of RM, working memory and executive functioning each potentially contribute to PM difficulties in each of these groups, they may not be sufficient to account for the magnitude of the PM impairment observed.

Whilst the use of Virtual Week has allowed PM impairment to be quantified in MCI and dementia, in clinical practice these groups tend to present due to self-reported or informant-reported subjective memory complaints. Thus, having shown that Virtual Week is sensitive to PM difficulties in MCI and
dementia, Study 2 will assess the convergent validity of self-report and informant-reported measures of this construct, as well as convergent validity with Virtual Week test performance in each of the groups.
CHAPTER 3.


Increasing clinical and research attention is being focused on the diagnostic entity of MCI, which refers to a level of cognitive functioning intermediate to that seen in normal adult ageing and mild dementia (Petersen, 2001). This increased focus is unsurprising given that individuals with MCI are at increased risk for developing dementia relative to age-matched controls without this diagnosis (Petersen et al., 2001). The basic diagnostic criteria require a decline in cognition with basic daily functioning unaffected, with the criteria for dementia not being met (Artero et al., 2006; Petersen, 2007; Winblad et al., 2004). These criteria are generally well accepted in clinical research and practice. However, the more controversial criterion is the requirement that a subjective cognitive complaint also be present, typically (but not necessarily) in the domain of memory (Petersen, 2004; Winblad et al., 2004).

The requirement for a subjective cognitive complaint is noteworthy because it assumes some degree of insight exists into one’s own cognition at the stage of MCI developing. For this reason, Petersen (2004) recommends this complaint be corroborated by an informant. This approach has been included in the revised diagnostic criteria for MCI (Artero et al., 2006; Winblad et al., 2004). Recent research does not support the assumption of insight into cognitive change in late adulthood. For example, the incidence of subjective memory complaints as assessed in a recent epidemiological study of ageing in people without dementia was 89.5% for participants’ own report, and 64.2% for informant-
reported complaints, with 70.4% of participants having a self-reported non-memory cognitive complaint and 32.5% having an informant-reported non-memory cognitive complaint (Slavin et al., 2010). This rate of subjective cognitive complaints clearly exceeds the incidence of MCI and dementia in this cohort. It potentially reflects a high prevalence of “worried well” individuals and suggests that self-or informant-reported cognitive complaints are not a valid source of clinical information on which to base a diagnosis of MCI or dementia (Ahmed, Mitchell, Arnold, Dawson, Nestor, & Hodges, 2008).

Initial referral for cognitive assessment is usually precipitated by subjective cognitive complaints of the individual or an informant-caregiver (Streams, Wackerbarth, & Maxwell, 2003), and self-and informant-reports are typically available at the assessment interview. However in terms of diagnostic decision making (when clinicians are assessing individuals with suspected dementia) the validity of self-report is considered to be questionable (Jorm, 2003). Indeed, a common feature of dementia is anosognosia, or lack of insight, which when coupled with the relatively high prevalence of ‘worried well’ in older adult cohorts, make self-report assessments for dementia inherently problematic (Cherbuin, Anstey, & Lipnicki, 2008).

Self-awareness of one’s own memory performance (or “meta-memory”) has been shown to be fairly inaccurate when compared to objective cognitive assessments, even in normal ageing (Slavin, 2006; Slavin et al., 2010). A study of subjective complaints of PM found a relationship between subjective complaints and objective impairment in PM for only half of a sample of older adults (Zeintl, Kliegel, Rast, & Zimprich, 2006). Another study that looked
specifically at PM found that self-reported memory problems were not reliably correlated with a PM task (Dobbs & Rule, 1987).

It might therefore be argued that a subjective complaint from an informant who knows the person well represents a more valid diagnostic indicator for both MCI and dementia. Indeed, Jorm (2004; Jorm & Jacomb, 1989) showed some evidence for the validity of informant-report when using the highly structured interview format of the Informant Questionnaire for Cognitive Decline in the Elderly (IQCODE). Thus informant-reports may offer a useful source of information for all clinical and research participants, not just those with a diagnosis of dementia.

Farias, Mungas and Jagust (2005) also found differences between self- and informant-report on a questionnaire of functional impairment, particularly in dementia patients, and interpreted this to mean that those with dementia under-report functional impairment. This interpretation seems to assume that informant-report is more accurate than self-report. However this may not be the case, given that other studies have shown that informant-reports also can be unreliable. For example, Doble, Fisk, and Rockwood (1999) showed that informants' reports may overestimate an individual's level of function compared to an objective assessment, especially at milder levels of impairment. This highlights the importance of comparison of self-reports and informant-reports with objective assessments.

Study 2 aims to provide a comprehensive assessment of how self- and informant-rated measures of PM relate to one another, as well as to an objective behavioural measure of this construct in both cognitively impaired (MCI and dementia) as well as healthy older adults. To achieve this goal, the Prospective
and Retrospective Memory Questionnaire (PRMQ; Smith et al., 2000) was administered to individuals with MCI or dementia, as well as healthy controls and informants for all three groups. The PRMQ is a 16-item questionnaire available in both self-report and informant-report versions. It measures PM (e.g., deciding to do something and then forgetting to do it) and RM (e.g., forgetting something you were told). Additionally, the PRMQ distinguishes between short-term memory (e.g., mislaying something you just put down) and long-term memory (e.g., failure to recognise a place previously visited), as well as between self-cued recall (e.g., forgetting what was watched on television the previous day) and environmentally-cued recall (e.g., forgetting to buy a birthday card, even when you see the shop).

The PRMQ was designed to measure these distinctions using an eight category structure i.e., self-cued, short-term PM; self-cued, short term RM; environmentally-cued, short-term PM; environmentally-cued, short-term RM; self-cued, long-term PM; self-cued, long-term RM; environmentally-cued long-term PM; and environmentally-cued, long-term RM). Smith et al. (2000) assessed item content validity by sending the questions and categories to eight independent experts in memory research, whose consistency of classification of the items reached 96%. However Smith et al. (2000) did not explore any other psychometric properties of the PRMQ. A subsequent confirmatory factor analysis on the self-report version identified a clear three factor structure, comprising a general memory factor as well as the PM and RM factors (Crawford et al., 2003). The informant-report version shows the same three factors, although in an unimpaired population, the informants’ ratings tended to load higher on the general memory factor than on the specific prospective or
retrospective factors (Crawford et al., 2006). There is substantial evidence for the informant version’s reliability and validity (Crawford et al., 2006).

Smith et al. (2000) developed the PRMQ and used it to assess older adults with and without dementia. Those with dementia were rated by an informant (usually a spouse or adult child), while those with no cognitive impairment completed a self-rated questionnaire. The results indicated that PM failures were more frequently reported than RM failures for both groups, with all responses for the dementia group close to the impaired end of the scale. In order to test the possibility that completing a questionnaire on behalf of another per se is associated with greater ratings of impairment, a sub-group of cognitively healthy, married couples were asked to rate both themself and their spouse in order to assess influences of completing a questionnaire about somebody else. There were no significant differences found between ratings of self and other, suggesting that the two measurements did cohere, although the correlation between self-reports and informant-reports were not reported.

Although Smith et al. (2000) used informant-report to control for the assumed unreliability of self-ratings by those with dementia (expected due to lack of insight of that population), they did not explore actual self-ratings of those with Alzheimer’s disease, nor include any ratings of individuals with milder cognitive impairments. Most importantly, the question of how informant-report data related to objective performance on a behavioural measure of PM was not tested. Yet meta-memory, or knowledge of one’s own memory performance, has been shown to be inaccurate even in normal ageing. As noted previously, subjective complaints are common in individuals without objective memory impairment (Slavin, 2006; Slavin et al., 2010). This raises the
possibility that informant-reports may offer a more useful source of information than self-report for all research participants, not just those diagnosed with dementia (Slavin, 2006; Slavin et al., 2010). In the present research program, all participants are measured on self-report, informant-report and objective testing to allow a thorough comparison of the results from all forms of assessment.

Eschen et al. (2009) partially addressed the limitations of Smith et al.’s (2000) study by having participants with MCI or mild Alzheimer’s disease, as well as cognitively healthy controls, self-rate their PM performance on the PRMQ. That study found equal self-ratings of PM impairment across all three groups. Self-reported PM did not correlate with measures of executive functioning in the clinical groups (Eschen et al., 2009). Eschen et al.’s (2009) findings therefore also suggest that the validity of self-report assessment may be limited. However informant ratings were not collected in this study, nor were the self-report assessments compared with performance on a behavioural measure of prospective memory.

The present study addresses this gap in knowledge by assessing participants from both clinical and non-clinical older adult populations (MCI, dementia and healthy controls) across both self-reported and informant-reported versions of the PRMQ, and compares these with an objective measure of PM (Virtual Week) in addition to performance on a cognitive screening tool (the MMSE). As noted in Study 1, Virtual Week has been shown to be a valid and sensitive indicator of PM difficulties in each of these groups. The degree to which these questionnaire-based measures relate to the MMSE is also considered important in order to evaluate the specificity of any observed association seen with Virtual Week.
It was hypothesised that, as in Study 1, there would be group differences in both self-reported and informant-reported PM and RM ratings, with the group with dementia reporting more failures than those with MCI, who would in turn report more failures than controls. It was further hypothesised that, consistent with Slavin (2010), self-reported memory complaints would be higher than informant-reported memory complaints. Less clear was whether self-rated and informant-rated measures would be positively correlated, or related to the two behavioural measures (Virtual Week and the MMSE). While theoretically these measures should cohere, as noted, prior research has indicated that self-and informant-rated reports may not always be related to objective PM difficulties, or with one another, with the suggestion that this lack of coherence may be particularly pronounced in cognitively impaired populations owing to difficulties with insight. One possibility is that any relationship between self- and informant-reports with objectively measured PM may be unique to the healthy ageing sample, and not the two clinical groups. The results of this study will therefore have important conceptual, as well as practical, implications for informing the debate on the potential use of such measures as valid indicators of PM difficulties in older adult populations, and as potential diagnostic tools specifically.
Method

Participants
The measures for the current study were completed by 138 of the 140 participants who were sampled for Study 1 (two participants declined Study 2 due to fatigue after completion of Study 1). The mean age of these participants was 78.6 years ($SD = 5.12$; range = 64 to 92 years) and 48.6% were males and 51.4% were females. As for Study 1, the participants were originally recruited from the University of New South Wales Memory and Ageing Study and the Prince Of Wales Hospital, Aged Care Psychiatry, Memory Disorders Clinic. Of the 138 participants, 53 were cognitively healthy, 48 met criteria for MCI and 37 met criteria for dementia. Additionally, 117 informants took part in this study (although all participants were asked to identify informants at the outset of Study 1, there were 21 informants who were not located or did not consent). The demographic data for participants and informants are presented in Table 3.1.

The three groups (dementia, MCI, controls) did not differ in age, $F(2, 135) = 2.47$, $p = .088$, $\eta_p^2 = .04$, education, $F(2, 135) = 0.95$, $p = .910$, $\eta_p^2 = .01$, or gender, $\chi^2(2, N = 138) = 1.77$, $p = .412; \phi = .11$), but MMSE scores differentiated the groups, $F(2, 135) = 20.29$, $p < .001$, $\eta_p^2 = .23$, (see Table 3.3). Follow-up Tukey tests indicated that participants with dementia had lower scores on the MMSE relative to controls ($p < .002$), and to the MCI group ($p = .024$), but the MCI and control groups did not differ ($p = .204$). As in Study 1, the MMSE scores indicate that dementia participants were in the very mild stage of illness, consistent with the majority of this group being less than two years post-diagnosis.
Table 3.1. Demographic characteristics of the control, Mild Cognitive Impairment (MCI), and dementia participants.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>MCI</th>
<th>Dementia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 53)</td>
<td>(n = 48)</td>
<td>(n = 37)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>77.6</td>
<td>78.6</td>
<td>80.1</td>
</tr>
<tr>
<td>Education (years)</td>
<td>11.7</td>
<td>11.7</td>
<td>11.4</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>41.5</td>
<td>54.2</td>
<td>51.4</td>
</tr>
</tbody>
</table>

Informant characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>MCI</th>
<th>Dementia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63.3</td>
<td>63.2</td>
<td>60.1</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>31.4</td>
<td>33.3</td>
<td>28.6</td>
</tr>
<tr>
<td>Relationship (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spouse</td>
<td>41.0</td>
<td>30.6</td>
<td>34.6</td>
</tr>
<tr>
<td>Child</td>
<td>23.9</td>
<td>25.0</td>
<td>42.3</td>
</tr>
<tr>
<td>Other relative</td>
<td>6.5</td>
<td>8.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Friend</td>
<td>26.1</td>
<td>36.1</td>
<td>19.2</td>
</tr>
<tr>
<td>Other</td>
<td>2.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Years known</td>
<td>42.4</td>
<td>39.8</td>
<td>43.5</td>
</tr>
<tr>
<td>Cohabit (% yes)</td>
<td>43.2</td>
<td>41.9</td>
<td>55.0</td>
</tr>
<tr>
<td>Hours contact weekly*</td>
<td>6.0</td>
<td>9.3</td>
<td>5.9</td>
</tr>
</tbody>
</table>

*Hours contact is measured for those not cohabitating only.
The informants for each group did not differ in age \( F(2, 85) = .39, p = .681, \eta_p^2 = .01 \), or gender, \( \chi^2(2, N = 116) = .18, p = .913; \phi = .04 \), relationship to the participant, \( \chi^2(10, N = 102) = 7.56, p = .672; \phi = .27 \), or number of years that they had known the participant, \( F(2, 79) = .32, p = .729, \eta_p^2 = .01 \). There was no difference in the proportion that were cohabiting with the participant, \( \chi^2(2, N = 136) = 0.98, p = .612; \phi = .10 \), or (for those not cohabiting) the number of hours of contact per week the informants had with the participants, \( F(2, 38) = 1.18, p = .317, \eta_p^2 = .06 \).

**Materials and procedure**

**Participant Self-Report Questionnaire (PRMQ) and Informant Version of PRMQ**

The Prospective and Retrospective Memory Questionnaire (PRMQ) is a 16-item questionnaire about memory failures. It assesses PM and RM for both short-term and long-term, and for self-cued and environmentally-cued memory (Smith et al., 2000). Participants rate the frequency with which they experience each particular memory failure on a 5-point scale as follows: Never = 1; Rarely = 2; Sometimes = 3; Quite Often = 4; Very Often = 5. The internal consistency of the scale in the present study was high, with overall Cronbach’s alpha estimated at .89 for the self-report form and also at .89 for the informant-report form. Internal consistency coefficients for the PM and RM subscales for each of the three groups are reported in Table 3.2.
Table 3.2. PRMQ Internal consistency coefficients (Cronbach’s Alpha) for the control, Mild Cognitive Impairment (MCI), and dementia participants.

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 53)</th>
<th>MCI (n = 48)</th>
<th>Dementia (n = 37)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-report:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prospective memory</td>
<td>.86</td>
<td>.86</td>
<td>.81</td>
</tr>
<tr>
<td>Retrospective memory</td>
<td>.79</td>
<td>.71</td>
<td>.77</td>
</tr>
<tr>
<td><strong>Informant-report:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prospective memory</td>
<td>.87</td>
<td>.92</td>
<td>.92</td>
</tr>
<tr>
<td>Retrospective memory</td>
<td>.82</td>
<td>.81</td>
<td>.89</td>
</tr>
</tbody>
</table>

*Note:* MCI refers to Mild Cognitive Impairment.

Cognitive Assessments

The *Mini Mental State Examination* brief assessment of general cognition (MMSE; Folstein et al., 1975) and Virtual Week assessment of PM (Rendell & Craik, 2000) were administered (see Study 1) prior to the PRMQ being given to participants and informants. If the informant was not present at the assessment, the PRMQ was sent by mail with a cover letter, informant’s information and consent form and reply-paid return envelope. The questionnaire included the participant’s subject number only, with no other identifying information, however the cover letter and informant’s information sheet identified the participant and made it clear that the questionnaire was about the participant, not about the informant, and was entirely confidential.
Results

Diagnostic Group Differences on the PRMQ

The mean scores for PRMQ-measured PM, RM, Virtual Week-measured PM and MMSE scores are reported in Table 3.3. The mean PRMQ scores are presented in Figure 3.1 as a function of source (self-report, informant-report), domain (PM, RM) and group (control, MCI, dementia).

PRMQ scores were separately using a three-way mixed ANOVA with between subject variables of memory domain (PM, RM) and respondent (self, informant) and the between-subjects independent variable of group (control, MCI, dementia). The 3-way interaction was not significant $F(2, 114) = 1.35, p = .264, \eta_p^2 = .02$. The two-way interaction of memory domain by group was significant $F(2, 114) = 4.51, p = .013, \eta_p^2 = .14$, with PM complaints being more common than RM complaints. The two-way interactions of respondent by group $F(2, 114) = 1.72, p = .184, \eta_p^2 = .03$, and of memory domain by respondent $F(1, 114) = 0.16, p = .686, \eta_p^2 < .01$, were not significant. Main effects were significant for memory domain $F(1, 114) = 18.67, p < .001, \eta_p^2 = .14$, with PM errors being more commonly reported than RM errors; for respondent $F(1, 114) = 4.09, p = .045, \eta_p^2 = .04$, with participants self-reporting more errors than their informants reported; and for group $F(2, 114) = 8.18, p < .001, \eta_p^2 = .13$. Follow-up Tukey HSD tests of the group effect indicated that the dementia group was rated as more impaired relative to both the control group ($p < .001$) and the MCI group ($p = .008$), however the MCI group were not rated differently to the controls ($p = .660$).
Table 3.3. Means scores for self-reported and informant-reported PRMQ, Virtual Week and the MMSE for participants with Mild Cognitive Impairment or dementia and healthy controls (Study 2).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>MCI</th>
<th>Dementia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
</tr>
<tr>
<td><strong>PRMQ</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-report</td>
<td>$(n = 53)$</td>
<td>$(n = 48)$</td>
<td>$(n = 37)$</td>
</tr>
<tr>
<td>Prospective memory</td>
<td>20.2</td>
<td>4.5</td>
<td>20.2</td>
</tr>
<tr>
<td>(maximum = 40)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrospective memory</td>
<td>18.8</td>
<td>4.1</td>
<td>19.3</td>
</tr>
<tr>
<td>(maximum = 40)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informant-report</td>
<td>$(n = 47)$</td>
<td>$(n = 48)$</td>
<td>$(n = 37)$</td>
</tr>
<tr>
<td>Prospective memory</td>
<td>15.6</td>
<td>4.8</td>
<td>16.9</td>
</tr>
<tr>
<td>(maximum = 40)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrospective memory</td>
<td>15.3</td>
<td>4.5</td>
<td>15.9</td>
</tr>
<tr>
<td>(maximum = 40)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Virtual Week</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number correct</td>
<td>3.5</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>(maximum = 8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MMSE</strong></td>
<td>28.7</td>
<td>1.4</td>
<td>27.9</td>
</tr>
</tbody>
</table>

Note: MCI refers to Mild Cognitive Impairment. PRMQ refers to the Prospective and retrospective Memory Questionnaire. MMSE refers to the Mini Mental State Examination.
**Figure 3.1.** Mean score for participants with Mild Cognitive Impairment, dementia and healthy controls, for self-reported and informant-reported impairment for each domain on the PRMQ.

*Note:* Maximum score = 40. PRMQ refers to the Prospective and Retrospective Memory Questionnaire. MCI refers to Mild Cognitive Impairment. SR = self-report, IR = informant-report, PM = prospective memory, RM = retrospective memory. Bars represent one standard error of the mean.
**Relationship of Self-Report and Informant-Report**

The correlations of self-report and informant-reported PM for each group are in Table 3.4. To test the hypothesis that the participants’ self-reported PM complaints would be higher than their informant-reported PM complaints, a paired sample $t$-test was conducted. This test showed that, on average, participants rated their own PM performance as being more impaired than did the informants, $t(116) = 4.52, p < .001, \eta_p^2 = .15$. Separate post-hoc Tukey HSD analyses of these ratings for each group confirmed this difference was true for the controls ($p < .001$) and those with MCI ($p = .005$), but not for those with dementia ($p = .798$).

**Correlations of PRMQ Reported Memory Impairment with Objective Assessment**

As Virtual Week tallies correct performance, whereas the PRMQ rates impairment, the Pearson correlations between the two scores would be expected to be negative. As seen in Table 3.4, the correlation between self-rated PM impairment on the PRMQ with performance on Virtual Week was not significant in either direction for any of the diagnostic groups ($r_s = -.010, .011$ and $.011$ for controls, MCI and dementia respectively, all $p_s > .90$). It can be seen that none of the correlations of informant-rated PM with Virtual Week were significant for any of the diagnostic groups ($r_s = -.061, -.127$ and $.288$ for controls, MCI and dementia respectively, all $p_s > .10$). Finally, self-reported PM on the PRMQ was not related to MMSE scores ($r = -.03$ to $.09$, all $p_s > .10$), whereas informant-reported total PM was associated with the MMSE in the expected direction for the dementia group only ($r = .359, p < .001$).
Table 3.4. Correlations between self-report and informant-report PM impairment ratings on the PRMQ, performance on Virtual Week and on MMSE, broken down by group (control, MCI, dementia).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>MCI</th>
<th>Dementia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-report and Informant-report</td>
<td>.011</td>
<td>.126</td>
<td>.553**</td>
</tr>
<tr>
<td></td>
<td>(47)</td>
<td>(40)</td>
<td>(30)</td>
</tr>
<tr>
<td>Self-report and Virtual Week</td>
<td>-.010</td>
<td>.011</td>
<td>.011</td>
</tr>
<tr>
<td></td>
<td>(53)</td>
<td>(48)</td>
<td>(37)</td>
</tr>
<tr>
<td>Informant-report and Virtual Week</td>
<td>-.061</td>
<td>-.127</td>
<td>-.288</td>
</tr>
<tr>
<td></td>
<td>(53)</td>
<td>(40)</td>
<td>(30)</td>
</tr>
<tr>
<td>Self-report and MMSE</td>
<td>-.038</td>
<td>-.094</td>
<td>-.076</td>
</tr>
<tr>
<td></td>
<td>(53)</td>
<td>(48)</td>
<td>(37)</td>
</tr>
<tr>
<td>Informant-report and MMSE</td>
<td>-.068</td>
<td>-.167</td>
<td>-.359*</td>
</tr>
<tr>
<td></td>
<td>(53)</td>
<td>(40)</td>
<td>(30)</td>
</tr>
</tbody>
</table>

Note: PM is prospective memory. PRMQ is the prospective and Retrospective Memory Questionnaire. MMSE is the Mini Mental State Examination. MCI refers to Mild Cognitive Impairment. Numbers in brackets refer to n contributing to each study. *p< .05, **p< .01.
Discussion

Study 2 investigated the validity of self-report and informant-reported PM and RM failures using the PRMQ. Unexpectedly, no differences emerged between the groups (dementia, MCI, controls) in self-reported PM or RM impairment. However, there was a difference between the groups in their informants’ ratings of both constructs. The dementia group were rated by their informants as more impaired than those with MCI or the controls, with the latter two groups not differing (see Figure 3.1).

Consistent with the findings of Slavin (2010), self-ratings of PM generally indicated greater impairment than informant-ratings, although this was not the case for the group with dementia: the difference between self- and informant-ratings occurred only for the MCI and controls groups. Self-reported and informant-reported memory complaints were only weakly related, with this association primarily driven by concordance of self-and informant-ratings in the dementia group only.

Taken together, these results indicate that self-reports of memory impairment are fairly consistent across diagnostic groups, whereas informants tend to rate those with dementia as having greater impairment than those with MCI or controls. This suggests that individuals are generally more concerned about their own memory lapses than other people notice. In this sample of individuals with dementia, the self-ratings were in agreement with the informant-ratings. This implies that anosognosia was not present in this group, which is consistent with their generally having mild dementia and being within two years of diagnosis. For the group with MCI, and for healthy controls, self-ratings were higher than informant-ratings. There are two possible explanations
for this pattern of results: that self-ratings are less accurate than informant-ratings in those with mild or no impairment (in other words, these are the “worried well”) or alternatively, that informants of those without dementia are not as familiar with the participants’ memory lapses, either not noticing them, or perhaps not considering them to be any worse than the informants’ own memory lapses.

The inclusion of Virtual Week was one of the key strengths of this study design which helps elucidate which of these two possibilities are correct. Importantly, self-reported complaints for PM failed to correlate with Virtual Week test performance (all rs close to zero; see Table 3.4), whereas there was a correlation of informant-reported PM with Virtual Week. This correlation was small however ($r = -.189$), and did not hold for the groups when analysed separately (although restriction of range of the correlation may have reduced the power of the correlations for each group separately). These data are consistent with those of Slavin et al. (2006; 2010) in suggesting that self-reported complaints are too common to be of practical use in diagnosing MCI, and also with Zeintl et al. (2006) who found only a limited relationship between self-reports and objective assessments.

These data also add to a growing body of evidence that informant reports may similarly be less than ideal methods of assessment. For example, Kemp, Brodaty, Pond and Luscombe (2002) assessed the accuracy of informant reports in four domains of cognition (including RM, but not PM) and found that 41% of informants gave discrepant ratings in at least one domain. Informants in that study were more likely to over-report patients’ cognitive problems if the patient
had dementia, and to under-report problems if the patient had subclinical cognitive problems.

Taken together, these results indicate that self-rated PM assessments should not be relied upon, and may in fact contribute little to the assessment of cognitive complaints. As noted previously, subjective memory complaints have been argued to be diagnostic for MCI. The present results add to growing evidence suggesting that relying on this criterion may be inadvisable. The data indicate that informant-reports have greater convergent validity with objective assessment of PM than the participants’ own self-reports of memory complaints, yet the validity of informant-reports is also low. This finding suggests the change in the revised criteria for MCI (Artero et al., 2006; Winblad et al., 2004) to include informant-reports of cognitive complaints is an improvement over relying solely on self-report; however given the low correlations found with objective assessments, all self- or informant-reported subjective cognitive complaints may be best considered to be an indicator for further assessment of cognition rather than of diagnostic significance.

In conclusion, Study 2 found that in all three groups (dementia, MCI, controls), both self-reports and informant-reports of PM performance have poor validity, at best correlating only weakly with objective assessments. Self-reported impairments are equivalent across groups, and informant-reports of impairment, while higher for those with dementia, do not appear to distinguish MCI from cognitively healthy controls. These data question the utility of self- or informant-reported cognitive complaints in the diagnostic criteria for MCI. Such reports are clinically perhaps best considered as an indicator for further assessment using more objective measures.
In the case of PM, Virtual Week has been identified in Study 1 as being a useful measure to quantify impairment. However its length may limit its usefulness as a part of a comprehensive neuropsychological assessment. Self-reports and informant-reports of PM were shown in Study 2 as not strongly associated with objective assessment of PM or a dementia screening measure (the MMSE). Therefore, from a clinician’s perspective, there is still a need for brief, valid and reliable performance-based test of PM. Study 3 will attempt to address this gap by trialling a brief assessment of PM, conducted as a part of a larger neuropsychological assessment.
Clinical assessment of memory typically focuses on RM rather than PM. Common test batteries such as the Wechsler Memory Scale do not include PM in their battery of subtests (Wechsler, 1997b; Wechsler & Stone, 1974). As found in Study 2, self-reports or informant-reports have only limited value as indicators of this construct, and there is consequently a clear need for objective performance-based measures that can be used in clinical settings. The type of computerised PM assessments that are a common feature in experimental research are not typically used in a clinical setting (Fish, Wilson, & Manly, 2010).

**PM tests in clinical use**

There are very few standardised measures of PM available for use in clinical assessment (Thöne-Otto & Walther, 2008). Whilst some more recently developed tests do include PM, there is typically little normative information available. For example, the Rivermead Behavioural Memory Test (RBMT; Wilson et al., 1989) includes PM tasks, but does not calculate any type of PM summary score: PM is included in the total memory score, but subtotal means and standard deviations for PM are not published. Moreover, Maylor (1995) disputes the message subtest as a true measure of PM because retrieval is not self-initiated. Instead, the examinee is cued by the instructions given by the examiner to perform the task of delivering the message. Equally, the appointment
subtest could be argued not to be a true measure of PM because the response is prompted by an alarm rather than being self-initiated.

A more recent development is the Cambridge Prospective Memory Test (CAMPROMPT; Wilson et al., 2004; Wilson et al., 2005), which contains six PM tasks: three are time-based and three are event based, and all are completed over approximately 25 minutes with “distraction” or “filler” tasks in between. The test has excellent inter-rater reliability, estimated to be .99 (Wilson et al., 2005). As expected, a practice effect was detected on test-retest reliability studies, with Kendall’s Tau-b of .64. No significant differences were found between performances using the two parallel forms. No confirmatory factor analysis has been reported, thus it is unknown whether the six tasks load onto a unitary PM factor, or whether time-based and event-based tasks load as separate factors (Albanese & Brody, 2007). The lowest 5% of the normed sample is defined as being impaired, thus specificity is fixed at .95, but sensitivity is not reported. As with the RBMT, the construct validity of the CAMPROMPT is arguable, with two tasks prompted by a timer, one by a verbal prompt from the examiner and another by a beeper followed by a verbal prompt. Thus it is ambiguous as to whether the tasks are truly self-initiated. Further, the test allows use of any memory aids desired, again potentially reducing the self-initiated retrieval that is generally a core component of PM tasks.

A variety of more ad-hoc brief measures of PM are sometimes used in both clinical and research assessments which involve one-off assessment trials (e.g., telling an examinee to ask for a red pen when next given a questionnaire). However these typically lack any published norms or reliability and validity information and do not have any standardised instructions, despite the
specificity of instructions being a factor known to influence PM performance in MCI (Blanco-Campal et al., 2009). The present study seeks to explore the utility of one such measure.

Study 1 discussed the discrepancies in prior studies comparing PM in groups with MCI and dementia and concluded that method variance was likely to be a contributing factor. In particular, the absence of a difference in PM performance between groups with MCI and dementia in Kazui et al.’s (2005) study may reflect fewer opportunities for performing the PM task in that study (three) relative to Troyer and Murphy’s (2007) study (eight). As noted earlier, Study 1 used Virtual Week, which offered participants eight opportunities to execute the PM task, and found group differences between the clinical states of MCI and dementia. The half hour required to complete Virtual Week makes it well suited to situations where quantification of PM performance is the main purpose of the assessment, as in Study 1. However if clinicians are to assess PM as part of a comprehensive neuropsychological assessment battery for cognitive impairment, then given the number of neuropsychological domains to be assessed, brief but sensitive tests are required.

Study 1 explored the impact of task type (regular, irregular) and cue type (time-based, event-based) on PM performance on Virtual Week. One important further dimension of PM cues that is not evaluated by Virtual Week is the distinction between focal versus non-focal cues.
The Cognitive Capacity Consuming Nature of Prospective Memory and the Multi Process Model of PM

There is debate as to the extent to which attentional resources are taken up by maintaining a prospective intention and attending for the cue to perform the PM task. The Multi Process model (Einstein et al., 2005b; McDaniel & Einstein, 2000) proposes that not all PM tasks are capacity consuming in this way. Einstein, McDaniel and colleagues (Einstein et al., 2005b; McDaniel & Einstein, 2000) argue that both constant monitoring for PM cues and the spontaneous noticing of PM cues may occur, depending on the parameters of the PM task plus the nature of the ongoing task. Automatic retrieval of the cue is more likely to naturally occur as part of the ongoing task in focal PM tasks, whereas effortful and capacity consuming noticing of the cue is required in non-focal PM tasks. In the context of this framework, focal cues are regarded as imposing no demands on self-initiated retrieval processes. In support of this model, Einstein et al., (2005b) point out that delays between a PM intention and action are often lengthy, and not all ongoing tasks are affected by the addition of a PM intention.

As a mechanism to explain spontaneous PM response to focal cues within the Multi Process model, the “reflexive associative theory” was proposed (Einstein, McDaniel, Thomas, Mayfield, Shank, Morissette, & Breneiser, 2005a). This theory states that when forming a PM intention, an association between the cue and the action is created. When the cue is encountered, the automatic associative-memory system triggers retrieval of the PM intention. If the association is strong enough and the PM cue is processed, retrieval will occur.
without the need for constant monitoring (Einstein et al., 2005b). Thus responding to focal PM cues is less capacity consuming than responding to non-focal PM cues.

This distinction between focal and non-focal cues may be relevant with respect to understanding the relative demands imposed by constant monitoring, versus automatic associations, in specific tests of PM. In Study 3, a non-focally cued task will be compared with a focally cued task. Reflexive associative theory suggests that the focal cue is more likely to be spontaneously noticed, whereas the non-focal cue will require strategic monitoring. This strategic monitoring requires increased cognitive capacity. The Multi Process model would predict that the higher cognitive capacity consuming demands of monitoring for a non-focal cue (compared to the spontaneous noticing without monitoring for a focal cue) would result in PM performance being more impaired when the cue is non-focal than when the cue is focal.

Consequently, MCI and dementia-related difficulties may be anticipated to be greater on a non-focal task than on a focal task. This follows because both of these groups are known to be disproportionately impaired on measures that heavily load strategic resources and are thus capacity consuming, with a relative sparing of cognitive measures that load more automatic processes (Amieva, Lafont, Auriacombe, Le Carret, Dartigues, Orgogozo, & Fabrigoule, 2002).

Cognitive capacity consuming tasks have been shown to lead to more impaired performance in MCI and dementia than in cognitively healthy controls. For example, a meta-analysis of studies of cognitive inhibitory processes (the capacity to suppress unwanted or irrelevant information or actions) showed that inhibitory processes which are consciously controlled are
disrupted in Alzheimer’s disease, as opposed to automatic cognitive inhibitory processes which remain intact (Amieva et al., 2004). Tasks requiring divided attention have been found to be more frequently impaired than tasks of cognitive inhibition or manipulation in both MCI and Alzheimer’s disease, and this is thought to be due to the capacity consuming nature of divided attention tasks (Belleville et al., 2007). In MCI, attentional deficits have been shown to be differentiated by the extent to which tasks are cognitive capacity consuming, with simple attention being less affected than divided attention, which is in turn less affected than selective attention (Okonkwo et al., 2008).

Similarly, the *flanker effect* (where responses to the direction of a target arrow are influenced by flanking congruent or incongruent distractor arrows) produced greater performance deficits where the distracter was incongruent with the target (and therefore stronger controlled inhibition was required), and this effect was larger in those with MCI than in controls (Wylie et al., 2007). In another study, participants with both MCI and Alzheimer’s disease showed a decrement in performance of simple arithmetic tasks when the order of arithmetic operations was mixed so that shifting operations were required. Performance then declined further in a Stroop-like condition (where problems with an addition sign had to be solved as multiplication and vice versa) which required effortful cognitive inhibition (Zamarian et al., 2007).

Further, aspects of executive functioning requiring conscious resolution of competing response tendencies showed greater deficits than tasks of sustained or divided attention, with this effect being greater for participants with MCI than for controls (Traykov et al., 2007). Taken together, these studies indicate that more capacity consuming cognitive tasks suffer greater decrements in
performance than more automated processes, and that these decrements are proportionately greater for participants with MCI and dementia.

**The Preparatory Attentional and Memory processes model of PM**

In contrast to the Multi Process model, the Preparatory Attentional and Memory processes model (Smith, 2003) points to the impact of a PM task on an ongoing task and asserts this is due to the capacity consuming nature of all PM tasks. In this model, the individual must constantly monitor for any PM cue, and thus PM is considered to be always capacity consuming, regardless of specific task features.

Smith’s (2003) model would predict that PM task performance should be disrupted for those with MCI and dementia, irrespective of cue focality (although the magnitude of group effects may be greater for the non-focal cue condition). Although the Preparatory Attentional and Memory processes model differs from the Multi Process model on the question of whether monitoring for PM cues is always capacity consuming or can ever be an automatic process, the two models both support the hypothesis that MCI and dementia effects on PM performance would be greater on non-focal than on focal tasks.

**Cue focality and ageing**

The few studies of cue focality in PM that specifically focus on ageing have consistently found that age effects do occur in focal-cued tasks, but are weaker than in non-focal tasks. A meta-analysis of PM studies of ageing which re-analysed all available studies of age-effects on event-based PM and classified the cues as focal or non-focal confirmed this pattern of results (Kliegel et al.,
2008a). However all studies included in this meta-analysis were studies of normal ageing. To date there are no studies comparing focal to non-focal PM in MCI or dementia.

The dual task trade-off

The addition of a PM task may result in decreased performance on the ongoing task (Smith, Hunt, McVay, & McConnell, 2007), particularly when the importance of the PM task is emphasised (Kliegel, Martin, McDaniel, & Einstein, 2001). In contrast to Kliegel's (2001; 2004) studies in which the cognitive load of the PM task was manipulated, Marsh and colleagues manipulated the cognitive load (Marsh & Hicks, 1998) and required effort (Marsh, Hicks, & Cook, 2005) for the ongoing task. The results indicated that increasing the attention required for the ongoing task had an adverse impact on PM performance. Taken together, these results suggest the existence of a dual-task trade-off (Marsh et al., 2005).

Brief assessment task design

While dual task trade-off research has helped clarify the apparent inconsistencies between the MultiProcess and the Preparatory Attentional and Memory processes models of PM, the implications for clinical practice is that adding a PM task to a standardised neuropsychological test may limit the validity of both assessments by dividing cognitive resources in a dual task trade-off. Therefore, in designing a brief PM task for inclusion in a comprehensive neuropsychological evaluation, the impact on the test being used as the ongoing task, as well as the impact of the ongoing task on the PM task, must be considered. One task that
shows no theoretical or empirical reason to be affected by the addition of a PM task involves olfactory judgements. Olfactory impairments are prominent in dementia (Gray, Staples, Murren, Dhariwal, & Bentham, 2001; Kjelvik, Sando, Aasly, Engedal, White, Kjelvik, Sando, Aasly, Engedal, & White, 2007; Westervelt, Carvalho, & Duff, 2007) but importantly these difficulties appear to be unrelated to cognitive difficulties (Kjelvik et al., 2007). Thus a test of olfaction is a suitable ongoing task to which a PM task can be added in order to minimise the risk of capacity-consuming PM affecting performance on another neuropsychological test (or vice versa).

A related issue in the designing of a novel PM task is the level of difficulty and consequent rates of success of the task, particularly for populations with cognitive impairment. In Study 1, some participants, particularly those with dementia, performed at zero per cent correct. Similarly, quite low success rates have been found in large-scale studies of PM in older adults. For instance, Huppert et al. (2000) found that in a community based sample aged 65 and above \((N = 11,956)\), with moderate to severe dementia as an exclusion criteria, using an event-based task with a ten-minute delay between instructions and the cue, only 34% of the sample were fully successful at self-initiating completion of all task components.

More recently, Logie and Maylor (2009) used the internet to gather data in what is probably the largest PM study conducted \((N = 73,018)\) aged 18 and above, of which 2126 were aged 60 and above). For the older age groups, the mean success rate for the PM task varied across encoding conditions between approximately 26% to 40% for the 60–69 year olds, and 10% to 38% for the 70-79 year olds. While exact rates of success at a PM task undoubtedly vary with
conditions of encoding, retrieval, and setting (Einstein, Smith, McDaniel, & Shaw, 1997; Henry et al., 2004), the above studies, taken together, suggest that up to two-thirds of an older aged sample are likely to fail at a single-item PM task. Therefore, Study 3 aimed to use an ongoing task that is minimally cognitively demanding, thus minimising the effects of the dual task trade-off (Marsh & Hicks, 1998).

**Summary and aims**

Study 3 aimed to address the need for a brief assessment of PM of the type that is often used (although unvalidated) in clinical practice. A brief measure was administered to a large number of individuals in a standardised manner, with general cognition also indexed using the MMSE. The PM task had instructions which emphasised the importance of the task and differentiated a key task dimension (focal, non-focal). This design tests a prediction derived from the Multi Process model of PM (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000). It was hypothesised that the effects of MCI and dementia on PM performance would be more evident on the non-focally cued task than on the focally cued task, due to the relatively heavier cognitive load of monitoring for a non-focal cue compared with retrieval of a focal cue (which would be either automatic according to the Multi Process model, or less capacity consuming according to the Preparatory Attention and Memory processes model).

These data will also be important clinically in determining whether brief, unstandardised tasks are valid for use in clinical practice (Thöne-Otto & Walther, 2008). Given the time requirements for a comprehensive test of PM such as Virtual Week (30 minutes for the adapted version used in Study 1; see
Rendell & Henry, 2009), a measure that takes only a few minutes would offer a distinct advantage in terms of test fatigue and time constraints of clinical practice. An overlap of participant sampling with Study 1 will allow a comparison of group differences between those with MCI or dementia and cognitively healthy controls on a brief PM task, and an estimate of test validity based on convergence with the scores from Virtual week obtained in Study 1.

**Method**

**Participants**

The participants were included as part of their ongoing participation in the University of New South Wales, Department of Psychiatry’s “Memory and Ageing Study”, an epidemiological study of ageing (Kochan, Brodaty, Trollor, Draper, Wen, Slavin, Reppermund, Crawford, Kang, Broe, Schofield, & Sachdev, 2009b). This project involved 1000 participants initially seen over a two year period (September 2005 to October 2007). Following this initial assessment, each participant was diagnosed by a consensus case conference as having MCI, dementia or no cognitive impairment (i.e., controls) using the methods and criteria as described in Studies 1 and 2. The current data were collected as part of the participants’ two year follow up assessment with the Memory and Ageing Study, over a two year period (November 2007 to October 2009). During this time, 727 participants were seen. Participants were aged from 72.3 to 92.7 years ($M = 80.4, \text{SD} = 4.8$) with 3.0 to 24.0 ($M = 11.7, \text{SD} = 3.5$) years of education. There were 401 females (55.2%). Diagnoses were of dementia ($n = 43$), MCI ($n = 279$), and normal controls ($n = 405$). The three groups did not differ in age, $F(2, 724) = 1.56, p = .211, \eta^2_p < .01$, education, $F(2, 724) = 1.78, p$
=.169, \eta^2_p<.01, \text{or gender}, \chi^2(2, N = 727) = 1.49, p = .475; \phi = .05), \text{but MMSE scores differentiated the groups, } F(2, 722) = 54.86, p < .001, \eta^2_p = .13). \text{ Follow-up Tukey tests indicated that participants with dementia had lower scores on the MMSE relative to controls and to the MCI group and the MCI group also had lower scores than the control group (all } p_s < .001). \text{ The demographic data for each group are presented in Table 4.1.}

Of these 727 participants, 120 were also participants in Study 1, and were assessed for that study using Virtual Week.

**Materials**

A brief measure of PM was used with all participants during their scheduled Memory and Ageing Study assessment. The PM task was embedded in an ongoing task, the Brief Smell Identification Test (B-SIT; Doty, Deems, & Stellar, 1988). The B-SIT is a 12-item “scratch and sniff” test of smell. On each page of the booklet the participant scratches a label that contains microcapsules of an odour in order to release the odour. The participant is asked to identify the smell and match it with one of four multiple choice alternative answers. The booklet is printed on coloured paper, with two pages in each of six colours (see Figure 4.1). The B-SIT test is not timed, but usually takes about three to five minutes to complete.
Table 4.1. Demographic characteristics of the control, Mild Cognitive Impairment (MCI), and dementia participants (Study 3).

<table>
<thead>
<tr>
<th>Participant characteristics</th>
<th>Control (n = 384)</th>
<th>MCI (n = 265)</th>
<th>Dementia (n = 43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>80.6 4.95</td>
<td>80.1 4.42</td>
<td>80.8 5.21</td>
</tr>
<tr>
<td>Education (years)</td>
<td>11.9 3.51</td>
<td>11.4 3.44</td>
<td>11.62 3.67</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>43.0</td>
<td>47.7</td>
<td>44.2</td>
</tr>
<tr>
<td>MMSE</td>
<td>28.6 1.40</td>
<td>27.7 1.94</td>
<td>25.9 3.26</td>
</tr>
<tr>
<td>B-SIT score</td>
<td>9.46 2.21</td>
<td>9.20 2.20</td>
<td>7.98 2.63</td>
</tr>
</tbody>
</table>

(maximum = 12)

Prospective memory task

| Number correct | 1.56 0.71 | 1.26 0.82 | 0.88 0.93 |

(maximum = 2)

Retrospective memory for PM task

| Task correctly recalled (%) | 85.9 | 72.4 | 48.8 |
| Task incorrectly recalled (%) | 8.9 | 12.9 | 16.3 |
| No recall of PM task (%)     | 5.2  | 14.4 | 34.9 |

Note: MCI refers to Mild Cognitive Impairment; MMSE refers to the Mini-Mental State Examination; B-SIT refers to the Brief Smell Inventory Test; PM refers to prospective memory.
The measure of PM consisted of a one-sentence instruction to the participant to perform a simple task when a specific cue was encountered in the B-SIT. The instructions for the focal task (given to the first 263 participants) were: “This is important. As well as the smell test, we’re going to do something else. Whenever you see that one of the possible answers is smoke, I want you to put an ‘X’ on that page.” The participant is required to read all answers before making a decision about each B-SIT item, thus meeting the definition for a focal task, in that the ongoing task involves processing the defining features (names of odours) of the PM cue (Kliegel et al., 2008a). The cue appeared on pages 4 and 9 of the 12 page booklet, thus the possible scores were 0, 1 and 2.

The instructions for the non-focal task (given to the latter 464 participants) were: “This is important. As well as the smell test, we’re going to do something else. Whenever you see that one of the questions is on green paper, I want you to put an ‘X’ on that page.” This is a non-focal task as the PM cue
(green paper) is not part of the information being processed in the ongoing activity (Kliegel et al., 2008a). The cue appeared on pages 3 and 10 of the 12 page booklet. As in the focal task, the possible scores were 0, 1 and 2.

**Procedure**

This task was initially a focal PM task, with a switch to a non-focal task midway through the data collection period. Each participant completed only one PM task. The focal and non-focal tasks were administered in blocks, with earlier participants \( n = 263 \) being given the focal task. The task was switched at a point of operational convenience (along with other changes to the data collection of the Memory and Ageing Study) to the non-focal task \( n = 464 \). In both conditions (focal and non-focal), the B-SIT was explained and demonstrated, after which the PM task instructions were provided. As a manipulation check to disentangle whether failures to execute the task reflected RM difficulties instead of PM difficulties, upon completion of the B-SIT, participants were asked whether there was anything additional they were supposed to do in addition to the smell test. The examiner recorded whether the participant reported back the instruction correctly or incorrectly, or had no recall of the PM task.

**Results**

The PM task was performed correctly on both presentations (i.e., a score of 2 out of 2) by 422 (58%) of the 727 participants. A further 158 (22%) were successful on only one occasion (a score of 1 out of 2) and the remaining 147 (20%) missed both PM responses (a score of 0 out of 2). The mean number of correct PM responses for each group is presented in Figure 4.2. A paired samples \( t \)-test
showed that on average, participants were more successful on the first occasion that the PM cue appeared (mean 75.4% correct) than on the second occasion (mean 61.3% correct), $t(726) = 8.50, p < .001, \eta_p^2 = .09$.

**Figure 4.2.** Mean number of correct responses on the prospective memory brief task as a function of focal versus non-focal cue type for controls and participants with Mild Cognitive Impairment (MCI) and dementia. Maximum score = 2. Bars represent one standard error of the mean.

These data were analysed using a 3 x 2 between-subjects ANOVA with the variables of *PM cue* (focal, non-focal) and of *group* (control, MCI, dementia). There was a main effect of PM cue $F(1, 721) = 21.78, p < .001, \eta_p^2 = .03$ and of group, $F(2, 721) = 26.44, p < .001, \eta_p^2 = .07$. As suggested by Figure 4.2, the group by cue interaction was not significant, $(F = 1.72, p = .181, \eta_p^2< .01)$. 
Counterintuitively, the main effect of PM cue indicated better performance in response to the non-focal than the focal cue. Follow-up Tukey HSD tests of the group main effect indicated that the dementia and MCI groups were each impaired relative to the control group (both $p < .001$) and the dementia group in turn performed more poorly than the MCI group ($p = .017$).

The RM component of the PM task (i.e., correctly recalling the task that needed to be done) was scored 2 points for correct recall, 1 point for partial but incorrect recall (e.g., put an “X” on orange paper, or circle answer ‘smoke’) and 0 points for no recall. These data were cross-tabulated with diagnostic category (dementia, MCI, controls). A chi-square test was significant, $\chi^2(4, N = 726) = 51.94, p < .001; \phi = .27$, with the correct task recall being proportionately less frequent in the more impaired participants (see Table 4.1). A one-way ANOVA was conducted with the between-groups independent variable of group (dementia, MCI, controls) and the dependent variable of task recall. The results indicated a main effect of group on task recall score, $F(2, 723) = 27.34, p < .001, \eta^2_p = .07$. Post-hoc Tukey tests showed that recall was better in the controls than in the MCI or dementia groups, and that the MCI group also had better recall than the dementia group (all $ps < .001$). A follow-up $t$-test comparing recall of the PM task indicated that of the two cue types (focal and non-focal), the non-focal cue was more likely to be recalled following completion of the B-SIT, $t(724) = 3.41, p = .001, \eta^2_p = .02$.

To explore the contribution of the RM component to PM performance, an analysis of covariance (ANCOVA) was conducted with the dependent variable of PM Total Score, and recall score entered as covariate. Following the entry of the covariate, the group effect size ($\eta^2_p$) was reduced from .07 to .01, but
remained significant, $F(2, 722) = 3.591, p = .028, \eta^2_p = .01$). As discussed in Study 1, the interpretation of ANCOVA requires caution (Miller & Chapman, 2001) especially as the sample was large and the effect size very small, yet these data suggest that difficulties with the retrospective component of the task contributed to performance on the PM task, but significant residual variance is attributable to a small but separable prospective component. Consistent with this interpretation, the correlation between the PM task and group status ($r = -.25, p < .001$) was reduced but remained significant after partialling out the score for correct task recall ($r_p = -.09, p = .015$).

For the whole group ($N = 727$), the scores on the B-SIT PM task correlated with MMSE scores ($r = .331, p < .001$). Of the 727 participants, 120 were also participants in Study 1 and therefore completed Virtual Week. For these participants, the scores on the B-SIT PM task correlated significantly, but relatively weakly, with their Virtual Week scores, $r = .224, p = .014$.

**Discussion**

Study 3 sought to develop a brief measure of PM and administer focal and non-focally cued versions to the three groups of interest in this research program (dementia, MCI, controls). As in Study 1, these data show that individuals with MCI and dementia exhibit PM difficulties relative to demographically matched controls, and that group differences also exist on measures of this construct between those with MCI and dementia. As noted in Study 1, previous research has been divided as to whether those with dementia are more impaired in PM function than those with MCI (Kazui et al., 2005; Troyer & Murphy, 2007). The present data from Study 3 are important in adding to the growing evidence
that there is indeed a difference in PM function between these two clinical states. Furthermore, these findings also indicate that the group differences do not simply reflect difficulties with the RM component of the task. Rather, the ANCOVA and (and partial correlation) analyses show that a small but significant group effect remains even after RM has been covaried.

The other main aim of this study was to examine the effects of a focal, compared to a non-focal, cue to perform the PM task. It was predicted that of these two cue types, non-focal cues impose greater demands on self-initiated retrieval, and thus MCI and dementia effects would be greater for non-focal target cues. Contrary to expectations, the data show that participants were more successful at the non-focal cued task than at the focal cued task. These data therefore do not align with the prediction based on the Multi Process model, but do add to growing evidence indicating that different cognitive resources are implicated in response to different cue types in various tasks. Specifically, it seems likely that other features of the particular cues used in this study potentially overrode the focal versus non-focal distinction.

For instance, an instruction to monitor for a particular colour of paper (the non-focal cue) may stand out to the participant as being a more unusual request, and thus more transparently a memory test, than to monitor for a certain smell (the focal cue) in the context of a smell assessment. The salience of the instruction may have contributed to an increased awareness that successful strategic monitoring would be required to perform the task correctly in the non-focal condition. Indeed, it has been suggested that cue distinctiveness promotes attentional switching from the ongoing activity (McDaniel, Guynn, Einstein, & Breneiser, 2004). One possibility, therefore, is that in the present study the cue
distinctiveness at encoding has increased participants’ awareness that strategic monitoring would be required for successful task completion. Consistent with this interpretation, the post-hoc analysis of retrospective recall of each cue type showed that the non-focal cue (green paper) was more likely than the focal cue (the word ‘smoke’) to be correctly recalled after the conclusion of the smell test.

For the subgroup of participants who were also participants in Study 1, the brief task in Study 3 showed convergent validity with performance on Virtual Week with a correlation of $r = .224$, which is in the small to moderate range using Cohen’s (1988) criteria. The differences between these tests are also important. The B-SIT PM task used in Study 3 is brief and easy to administer: attributes likely to hold appeal for both clinicians and examinees. However the Cohen’s $d$ effect size of .07 indicates this PM test is less sensitive to group differences than Virtual week (which had a partial eta squared effect size of .25). Indeed, it should be noted that the group effect size found in Study 3 is small, and possibly only attained statistical significance owing to the large sample size and consequent high power to detect effects.

It is also important to acknowledge limitations of the current research design. In particular, the design of the assessment task was determined largely by the need to avoid interference with performance on the ongoing task, thus a non-cognitive ongoing task was selected. This is not a common paradigm for PM research and the impact of a non-cognitive ongoing task remains to be clarified. The success rate for the PM task in this study was much higher than the predicted success rate of around 33% seen in Huppert’s (2000) and Logie and Maylor’s (2009) studies. Indeed, given that the participants in the present study were older than those of Huppert’s (65 and above) or Logie and Maylor’s (60
and above) studies, the success rate is even more remarkable. These data affirm the importance of an appropriate norm database if such assessments are to be validly used to inform clinical judgements. Additionally, as noted, the operationalisation of the focal and non-focal conditions may not have accounted for other possible systematic differences between the focal-and non-focal cue-types, such as target cue distinctiveness, thus making interpretation of the unexpected result more difficult.

In conclusion, Study 3 has shown that a brief, unstandardised assessment of PM of the type that is used by clinicians is capable of detecting differences in PM between groups with dementia, MCI and healthy controls. However the effect size is very small, and therefore unlikely to be of practical use in clinical assessments. Study 1 showed Virtual Week to be a valuable but lengthy tool to quantify the magnitude of PM impairments in MCI and dementia. Given that the effect size of the brief task used in Study 3 is small, there remains still a need to find a brief but valid measure of PM that will be a useful part of a comprehensive neuropsychological assessment. One approach employed in studies of PM in ageing is *naturalistic assessment*, in which the task is performed in the examinee’s day to day life. Thus Study 4 will explore a task with ecological validity and examine its ability to detect group differences in PM performance.
The importance of naturalistic, or ecologically-valid, measurement of memory function has long been recognised (Bruce, 1985; Koriat & Goldsmith, 1994; Latham, 1978) and seems particularly pertinent to PM (Kliegel et al., 2008b). Naturalistic tasks are carried out in the everyday environment of the participants and so may more truly reflect participants’ task motivation and level of busyness. PM is memory for future intentions, and is an important function in everyday life. It is especially important in late adulthood, when functional independence is contingent on the ability to remember activities such as taking medication, turning off appliances and paying bills. An important aspect of PM is that the PM cue is embedded within an ongoing task, and consequently situational demands are a crucial determinant of PM recall. In naturalistic PM tasks, the ongoing task tends to be the participants’ usual daily activities and is therefore under the control of the participant. This contrasts with laboratory based assessment, where the experimenter controls the setting and the ongoing task (Bailey et al., 2010). This is an important distinction in the assessment of PM, and contrasts with RM, which is not embedded in an ongoing activity and consequently is equally effortful and difficult across laboratory and naturalistic settings (Kliegel et al., 2008b).

Early PM studies used measures with high ecological validity, such as asking participants to return postcards on certain days or telephone the experimenter at certain times (Harris, 1984). A shift towards controlled laboratory studies then ensued, typically involving computer-based tasks, such as
pressing a specified button in response to a cue on screen (e.g. Einstein et al., 1997). While undoubtedly important in clarifying the key characteristics and correlates of PM function, the ecological validity (and real-life generalisability) of such tasks is questionable (Kliegel, McDaniel, & Einstein, 2000). The contrast between findings from laboratory and naturalistic settings was strikingly illustrated in a meta-analysis which revealed that older adults performed substantially worse than younger people in laboratory settings, but substantially better than their younger counterparts in naturalistic studies (Henry et al., 2004; Phillips et al., 2008). A recent study showed that for the age advantage in naturalistic PM to occur, the task had to be embedded in the participants’ real-world activities and not in an experimenter controlled ongoing task (Bailey et al., 2010).

Naturalistic assessment of PM is therefore essential to ascertain the degree to which any effects observed in laboratory settings generalise to everyday life, and to assess the validity of existing laboratory assessments (Phillips et al., 2008). This is particularly relevant for late life cognitive disorders such as MCI and dementia, because PM lapses are considered to be amongst the most distressing and disabling features of both disorders. For example, it has been found that PM failures cause more difficulties in daily living and caregiver burden than do RM failures (Smith et al., 2000).

Only one study to date has examined cognitively impaired older adults using both laboratory and naturalistic measures of PM (Will et al., 2009). In that study cognitively impaired older adults performed more poorly than age-matched controls on both measures, with the magnitude of the deficit comparable across settings. This implies that PM deficits observed in laboratory
settings may be a valid indicator of PM difficulties in everyday life. However the sample size in that study was relatively small \((n = 15\) per group), and the classification of cognitive impairment was based on self-report and the MMSE only, with no formal diagnostic criteria applied for MCI or dementia.

The first aim of Study 4 was therefore to assess empirically whether a naturalistic measure of PM differentiates between participants who meet formal diagnostic criteria for MCI and dementia, relative to age-matched controls. The second aim was to assess the convergent validity of naturalistic and laboratory-based PM assessments in MCI and dementia: specifically, whether performance on a naturalistic PM measure is related to a validated laboratory measure of this construct that has documented sensitivity to MCI and dementia (Virtual Week; Rendell & Craik, 2000; Rendell & Henry, 2009), as well as the Mini Mental State Examination (MMSE; Folstein et al., 1975), a widely used screening tool for dementia. Accordingly, the hypotheses were that the group with dementia would show more impairment on the naturalistic PM task than the group with MCI, who would in turn show more impairment on the task than controls. It was also predicted that scores on the naturalistic PM task would be positively correlated with scores on Virtual week and the MMSE.

**Method**

*Participants*

Participants were recruited into a PM study \((N = 140\); Thompson, Henry, Rendell, Withall, & Brodaty, 2010) from either a large epidemiological study of ageing which commenced two years prior to the current study, or from a Memory Disorders Clinic in Sydney, Australia. All participants were assessed
and diagnosed by consensus conference of either the epidemiological study or the memory clinic (using identical criteria) in the two months prior to recruitment. All participants were community dwelling, had adequate eyesight, hearing and English language ability to complete assessments, and had regular contact with an informant. Participants with previous psychiatric or neurological illness were excluded. Of 140 recruited participants, 98 (70%) accepted the naturalistic PM task. Of these, 22 met the DSM-IV criteria for dementia, 31 met the modified criteria for MCI (Artero et al., 2006; Petersen, 2007) and 45 were controls without cognitive impairment.

**Materials and Procedure**

Ethics approval was obtained from South-Eastern Sydney Illawarra Area Health Service – Eastern Section. After providing informed consent, participants completed measures for Study 1 (Thompson et al., 2010) and Study 2, including the MMSE and Virtual Week.

Naturalistic assessment of PM was conducted using Palm® Z22 handheld electronic organisers, with Experience Sampling Program software (ESP; Barrett & Barrett, 2001). The task was designed to be simple enough to be achievable by all participants. It involved turning the Palm device on once per day for two days at an agreed upon, pre-specified time, and tapping a response box that automatically appeared on the screen. A time-stamp function ensured accurate temporal recording of responses. The task met established criteria for a naturalistic task, in that it was embedded into participants’ everyday lives and executed over an extended (two-day) time frame (Bailey et al., 2010; Phillips et al., 2008).
Participants were given a choice of six times to complete the task. A choice element was considered important to allow participants to fit the task into their daily routine. This choice of times was not expected to interfere with the construct being assessed since it has previously been found that time schedule does not affect the magnitude of age effects on a similar time logging task (Rendell & Thomson, 1999). Participants were given a demonstration and allowed to practice the task. The demonstration and practice were repeated as many times as the participant needed to complete the task with confidence. The device automatically records all buttons pressed, thus the number and timing of rehearsals was recorded. Participants were instructed not to use any written or other reminders to do the task. Postage-paid envelopes were provided for return of the device.

Responses were scored as follows: Correct indicated the response was remembered at the correct time (defined as within five minutes before or after the agreed-upon time) and scored three points; Little Late responses were remembered more than five minutes but within 20 minutes after the correct time and scored two points, Late responses were more than 20 minutes late and scored one point. Little Early (two points) and Early (one point) items were the converse of late items. Missed indicated the participant did not remember to respond at any time and scored zero points. Each participant received a score for each of the two days.
Results

There was a group bias in task acceptance, with controls more likely than participants with MCI, $\chi^2(df = 1, N = 101) = 5.59, p = .018, \phi = .24$, or dementia, $\chi^2(df = 1, N = 92) = 9.22, p = .002, \phi = .32$, to accept the task whilst those with MCI and dementia were equally likely to accept $\chi^2(df = 1, N = 87) = .60, p = .437, \phi = .08$. Those who refused had lower performances than those who accepted on Virtual Week, $t(138) = 3.71, p < .001, \eta^2_p = .09$, and on the MMSE, $t(138) = 2.64, p = .009, \eta^2_p = .05$. Reason for refusal did not interact with group, with most refusals indicating that they didn’t want to do the task (59% of refusals), were too busy (12%) or gave other reasons (20%). Technical problems with the device that were unrelated to the participant’s task acceptance accounted for 10% of non-participation.

As found in the larger sample (Thompson et al., 2010), the groups did not differ demographically; age, [dementia $M (SD) = 79.1 (5.68)$, MCI = 78.8 (5.48), controls = 77.7 (4.86); $F(2, 95) = 0.70, p = .505, \eta^2_p = .01]$; years of education, [dementia $M (SD) = 11.14 (3.71)$, MCI = 11.19 (3.48), controls = 11.53 (3.25); $F(2, 95) = 0.18, p = .835, \eta^2_p < .01$, and sex, [dementia = 50.0% male, MCI= 58.1%, controls = 37.8%, $\chi^2(df = 2, N = 98) = 3.14, p = .208; \phi = .12]$]. MMSE scores differentiated the groups [dementia $M (SD) = 26.8 (2.53)$, MCI= 27.7 (1.50), controls = 28.7 (1.34); $F(2, 95) = 8.82, p < .001, \eta^2_p = .16$]. Post-hoc Tukey tests indicated that the dementia and MCI groups’ MMSE differed from controls ($ps < .001$ and .026 respectively), but that the MCI and dementia groups did not differ ($p = .283$). Virtual Week differentiated the groups [$F(2, 95) = 10.81, p < .001, \eta^2_p = .19$, with the dementia and MCI groups’ performance
lower than controls ($p_s < .001$ and .006 respectively), but the MCI and dementia groups not differing ($p = .356$).

A $3 \times 2$ mixed ANOVA with the between-subjects variable of group and within-subjects variable of time (day 1, day 2) identified main effects of both group, $F(2, 92) = 4.90, p = .009, \eta^2_p = .10$, and time, $F(1, 92) = 5.03, p = .027, \eta^2_p = .05$, with this latter effect indicating better performance on the first day than the second day (see Figure 5.1). The interaction between group and time was not significant, $F(2, 92) = .29, p = .75, \eta^2_p < .01$. Post-hoc Tukey tests of group showed that the PM performance of the dementia group was impaired relative to both controls ($p = .002; \text{Cohen’s } d = .81$), and MCI ($p = .025; d = .66$). MCI and control groups did not differ ($p = .377, d = .21$). Number of task rehearsals ($M = 3.68, SD = 1.36$) was not related to performance on day one ($r = .021, p = .840$) or day two ($r = -.018, p = .861$), nor was there any relationship with age (day one $r = -.064, p = .538$; day two $r = -.092, p = .369$). Finally, performance on the naturalistic PM task was positively correlated with both laboratory-measured PM (Virtual Week; $r = .31, p = .002$), and scores on the MMSE ($r = .37, p < .001$).
Figure 5.1. Mean score on the naturalistic prospective memory task for controls and participants with Mild Cognitive Impairment (MCI) and dementia. Maximum score = 3. Bars represent one standard error of the mean.

Discussion

While the finding that dementia is associated with greater PM difficulties than non-clinical controls is well established using laboratory measures (Livner, Laukka, Karlsson, & Backman, 2009; Troyer & Murphy, 2007), these data are novel in identifying this impairment using a naturalistic measure in a sample classified as MCI or dementia using formal diagnostic criteria. Naturalistic PM difficulties experienced in the everyday lives of older adults are greater for those with dementia. Specifically, a group difference in naturalistic PM performance was identified, with dementia participants performing more poorly relative to
both the control and MCI groups. However an important deviation from laboratory findings was the absence of any effect for the MCI relative to the control group. In contrast to laboratory PM studies of MCI (Schmitter-Edgecombe et al., 2009; Troyer & Murphy, 2007), the present study indicates that those with MCI are able to effectively implement delayed intentions in everyday life. As noted, non-clinical older adults also perform substantially worse than younger people in laboratory settings, but substantially better in naturalistic studies (Henry et al., 2004). The present data imply that MCI participants may be similar to healthy older adults in being able to compensate for memory deficits on PM tasks, when encountered in the context of their everyday lives.

Importantly, the naturalistic PM measure showed reasonable convergent validity. Performance was related to both laboratory-measured PM (Virtual Week) and scores on a dementia screening tool (MMSE). Thus traditional laboratory assessments do have clinical predictive validity of real-world PM difficulties in late adulthood. Further, the group effects and correlations identified in the present study may be under-estimates given the selection bias in uptake of the naturalistic PM task. As noted, those who refused the naturalistic task were more impaired on laboratory-measured PM.

The use of electronic data capture eliminated one major methodological difficulty identified in previous naturalistic studies. Specifically, Stone et al. (2002) found substantial backfilling (i.e., completing diary entries late or several at once) when paper diaries were used. Other limitations of naturalistic designs were more difficult to bypass. In particular, although all participants were instructed not to use memory aids, methodologically the adherence to these
instructions could not be objectively monitored. It is therefore not possible to definitely conclude whether the group effects and correlations in the present study reflected difficulties with PM\textit{per se}, or instead difficulties implementing effective strategies for PM performance. Older adults may be aware of the fallible nature of their memory, and therefore be more likely to equip themselves with external cues to prospective intentions (Craik & Kerr, 1996; Kvavilashvili & Ellis, 2004). However this rationale predicts that those with greatest concern over memory fallibility (those with dementia) would make greatest use of external memory aids. Although speculative, this again suggests that the group differences and correlations identified may reflect an underestimate of true effects. An alternative explanation is that a lack of insight in those with more impaired memories would make them less likely to use memory aids, with consequent poorer performance on the naturalistic PM task. It is important to note, however, that evidence does not support the claim that use of reminders contributes to variations in older adults’ performance on PM in naturalistic relative to laboratory settings (Phillips et al., 2008; Rendell & Thomson, 1999).

In conclusion, Study 4 has shown that relative to age-matched controls, everyday PM difficulties experienced in later life are greater for those with dementia, but not those with MCI. Evidence of reasonable convergent validity with laboratory-measured cognition supports the clinical predictive validity of traditional laboratory assessments as an indicator of real world difficulties in PM. These data are also encouraging in suggesting that those with MCI may possibly adopt compensatory mechanisms to bypass the PM difficulties exhibited on laboratory measures of this construct. However an important issue which remains unaddressed is the degree to which PM impairment progresses over
time in individuals with MCI or dementia. The aim of Study 5 therefore, is to quantify changes in PM in these groups over a one year period.
CHAPTER 6.

Study 5: Longitudinal Changes in Prospective Memory in Ageing, Mild Cognitive Impairment and Dementia.

Despite the increasing research and clinical interest in PM, to date there have been no published longitudinal studies investigating changes in this cognitive ability with age, or with MCI or dementia. Cross-sectional studies of memory in older age are known to be influenced by cohort-effects (Labouvie-Vief, 1985). While longitudinal studies are also subject to bias (such as practice effects and selective attrition), true assessment of age-related changes, as opposed to age-differences, requires longitudinal studies to be conducted. Likewise, studies of changes with clinical conditions require longitudinal studies, yet to date, every study of PM in ageing, or of MCI or dementia, has relied on cross-sectional data to estimate the effects of age (Henry et al., 2004; Uttl, 2008) or the clinical condition (Blanco-Campal et al., 2009; Duchek et al., 2006; Jones et al., 2006; Kazui et al., 2005; Kinsella et al., 2007; Martins & Damasceno, 2008; Troyer & Murphy, 2007). Collectively, these studies contribute to quantifying the nature and level of impairment in PM, but do not address the question of changes in PM with age or progression of cognitive impairment.

Although no studies of changes in PM with age are published, importantly, such longitudinal studies are underway, with PM data being collected but not yet published by the Betula Prospective Cohort Study on Memory, Health and Aging (Nilsson, Adolfsson, Bäckman, de Frias, Molander, & Nyberg, 2004; Nilsson, Bäckman, Erngrund, Nyberg, & et al., 1997), by the English Longitudinal Study of Ageing (ELSA; Llewellyn, Lang, Langa, Huppert,
Llewellyn, Lang, Langa, & Huppert, 2008), and by the *Zurich Longitudinal Study on Cognitive Aging* (ZULU; Zimprich, Martin, Kliegel, Dellenbach, Rast, & Zeintl, 2008). Published studies to date that have conducted longitudinal assessment of PM have sampled dissimilar populations of drug users (Zakzanis & Young, 2001) and depressed patients (Withall et al., 2009a). Both these studies found no change in PM over the period of follow up. One study that has retested older participants on a PM task (although not specifically designed as a longitudinal study) is Maylor (1996), who included a subgroup of participants of an earlier PM study (Maylor, 1993) and calculated test-retest reliability of the measure used over the two year period. The overall correlation was .37, suggesting that there is an association of current PM performance with performance three years earlier. However this correlation was significant only for the group aged in their 50s and 60s ($r = 0.46$) and not for those aged in their 70s and 80s ($r = .09$). Maylor (1996) reported that some modifications to the PM task made it harder in the latter study, and consequently some of the older group (aged in their 70s and 80s) performed at floor level. Maylor (1996) noted the need for further test-retest studies of PM.

The above studies do not lead to a clear prediction about changes in PM with age or in MCI or dementia. Nonetheless, given the well-documented decline in RM that is a central feature of dementia (McKhann et al., 1984; Petersen, Smith, Ivnik, Kokmen, & Tangalos, 1994) and of MCI (Petersen et al., 2001), and given that successful prospective remembering incorporates a retrospective component (Ellis & Kvavilashvili, 2000; Kliegel & Jager, 2006; Zeintl et al., 2007), there is sufficient theoretical justification for anticipating a
decline in PM in these groups that is greater than the decline seen in a cognitively healthy control group.

Therefore, this study reassessed the participants from Study 1, in order to quantify level of decline in PM function in MCI and dementia over a one-year period. Reassessment using Virtual Week also allowed another opportunity to assess the reliability of the specific findings from Study 1 relating to the absence of any effect of task regularity, and the higher performance found on time-based cues compared to event-based cues.

A related issue is whether PM has predictive validity for conversion to MCI or to dementia. Assessment of cognitive and functional status has been shown to predict dementia (Tierney, Szalai, Snow, & Fisher, 1996) and many neuropsychological domains can distinguish participants who would develop dementia from those who remain healthy up to 12 years prior to diagnosis (Amieva, Jacqmin-Gadda, Orgogozo, Le Carret, Helmer, Letenneur, Barberger-Gateau, Fabrigoule, & Dartigues, 2005; Amieva, Le Goff, Millet, Orgogozo, Peres, Barberger-Gateau, Jacqmin-Gadda, & Dartigues, 2008). Although many studies have shown PM impairments in MCI and dementia (Blanco-Campal et al., 2009; Duchek et al., 2006; Jones et al., 2006; Kazui et al., 2005; Kinsella et al., 2007; Martins & Damasceno, 2008; Troyer & Murphy, 2007) there is no study of whether PM performance predicts future cognition. In Study 1 of this research program, participants were assessed for PM performance on Virtual Week and the MMSE. A repeat assessment with both of these instruments would not only allow an evaluation of changes in PM performance, but would also allow an evaluation of the utility of PM to predict decline on the MMSE over a one-year period.
In summary, Study 5 aimed to quantify the changes over a one-year time period in PM associated with normal adult ageing, MCI and dementia. It was predicted than PM would decline the least in the control group, and decline the most in the dementia group. Consistent with Study 1, it was predicted that there would be no overall main effect of task regularity (regular versus irregular) on Virtual Week, but that there would be an overall main effect of cue type (time-based, compared with event-based cues). The predictive validity of baseline PM function at predicting cognitive decline one year later will be examined, with baseline scores on the Virtual Week assessment of PM expected to predict decline in MMSE scores over the interim year across all three groups.

**Method**

**Participants**

The 140 participants who took part in Study 1 were invited to return for a retest one year after their initial assessment was conducted. Of the original 140, 122 (87.1%) were available for reassessment. Of those who were not available, 7 (5.0%) withdrew, 5 (3.6%) were too unwell for reassessment, 4 (2.9%) had relocated or were uncontactable, and 2 (1.4%) were deceased. Those not available were more likely to be from the dementia group (11 of 39) than the MCI (4 of 48) or control group (3 of 53), \( \chi^2 (df = 2, N = 140) = 11.53, p = .003; \phi = .29 \), and had lower baseline (Study 1) MMSE scores, \( t(138) = 4.07, p > .001, \eta_p^2 = .11 \), but were not different to those reassessed in age, \( t(138) = .85, p = .395, \eta_p^2 = .01 \), or education, \( t(138) = 0.46, p = .650, \eta_p^2 < .01 \).

Demographic data for those participating in this longitudinal study are presented in Table 6.1. Of the 122 participants, 28 met the criteria for dementia,
44 met criteria for MCI, and 50 were cognitively healthy controls. Although the groups were equivalent at baseline in age (see Study 1), they were different at follow up, $F(2, 119) = 4.06, p < .020, \eta^2_p = .06$. Tukey tests revealed that the dementia group were older than controls ($p = .015$), although they were not different to the MCI group ($p = .320$), who in turn were not different to controls ($p = .282$). There was no difference between groups in gender, $\chi^2(df = 2, N = 122) = 3.39, p = .184, \phi = .17$, or years of education, $F(2, 119) = .07, p = .933, \eta^2_p < .01$. MMSE scores at follow-up differentiated the groups, $F(2, 119) = 28.24, p < .001, \eta^2_p = .32$. Follow-up Tukey tests indicated that participants with dementia had lower scores on the MMSE relative to controls ($p < .001$), and to the MCI group ($p = .012$), who in turn had lower scores than the control group ($p < .001$).

**Measures**

As detailed in Study 1, Virtual Week was administered to participants in an individual testing session. Details of the Virtual Week measure of PM are available in the *Methods* section of Study 1. The same modified computerised version of Virtual Week was used but with the content of the daily events experienced and tasks to be done in the game changed to minimise practice effects. A list of all tasks encountered in virtual week for this study is included in Appendix B. The test was administered on the same HP Tablet Notebook used in Study 1, with the same pre-game instructions and practice virtual day to familiarize participants with the test. Scoring of responses was identical to Study 1, as the number (out of 8) *Correct, Missed, Wrong, Late, Early, Little Late, Little*
In the present study, Cronbach’s alpha for the total score was estimated to be .84.

**Procedure**

Ethical approval and signed informed consent were obtained at the time of Study 1. Participants were re-contacted as close as possible to one year after their initial assessment (Study 1) and asked to participate in the longitudinal study. The follow up period averaged 13.3 months, with no significant difference in follow up period between the three groups, $F(2, 119) = 1.29$, $p = .279$, $\eta^2_p = .02$). Participants were assessed first with Virtual Week, then with the Mini Mental State Examination (MMSE; Folstein et al., 1975), a 30 point test of general cognition commonly used to screen for dementia. As noted in Study 1, despite the use of a modified version of Virtual Week in which task demands were reduced, some participants, particularly those with dementia, performed at zero. A repeated measures $t$-test showed that the MMSE scores of these participants declined from baseline to follow up $t(28) = 2.41$, $p = .023$, $\eta^2_p = .17$. To avoid the possibility of producing unnecessary distress in these participants, and given the small likelihood of any improvement in their performance, their scores on Virtual Week were imputed at zero. The analyses presented in this study do not include the baseline data for participants of Study 1 who were not reassessed, therefore the baseline data differs from that presented in Study 1.
Table 6.1. Mean demographic and clinical scores and significant differences of the control, Mild Cognitive Impairment (MCI), and dementia participants at follow-up.

<table>
<thead>
<tr>
<th>Participant characteristics</th>
<th>Control (n = 50)</th>
<th>MCI (n = 44)</th>
<th>Dementia (n = 28)</th>
<th>Control – MCI p-value</th>
<th>Control – Dementia p-value</th>
<th>MCI – Dementia p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years at Baseline)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.2</td>
<td>78.7</td>
<td>80.3</td>
<td>.282</td>
<td>.015</td>
<td>.320</td>
</tr>
<tr>
<td>Education (years)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.6</td>
<td>11.8</td>
<td>11.5</td>
<td>.961</td>
<td>.992</td>
<td>.934</td>
</tr>
<tr>
<td>Gender (% male)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40.0</td>
<td>56.8</td>
<td>57.1</td>
<td>.203</td>
<td>.352</td>
<td>.789</td>
</tr>
<tr>
<td>MMSE at baseline&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.8</td>
<td>27.9</td>
<td>26.4</td>
<td>.038</td>
<td>&lt;.001</td>
<td>.001</td>
</tr>
<tr>
<td>MMSE at follow-up&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.7</td>
<td>27.5</td>
<td>24.9</td>
<td>.012</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Prospective memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VW baseline number correct (maximum = 8)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.68</td>
<td>2.12</td>
<td>0.89</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.026</td>
</tr>
<tr>
<td>VW follow-up number correct (maximum = 8)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.78</td>
<td>1.84</td>
<td>0.71</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.085</td>
</tr>
</tbody>
</table>

Note: MMSE refers to the Mini-Mental State Examination; VW refers to Virtual Week. <sup>a</sup>indicates Tukey’s HSD; <sup>b</sup> indicates chi-square.
Results

PM: Changes on Virtual Week over one year

The number of correct PM responses are presented in Figure 6.1 as a function of group (control, MCI, dementia) and time (baseline, follow-up). These data were analysed with a 3 x 2 mixed ANOVA. There was a main effect of group $F(2, 119) = 20.02, p < .001, \eta_p^2 = .25$. Post hoc Tukey tests showed that (as in Study 1) the controls performed better than the MCI group and the dementia group (both $p$s < .001), but (unlike Study 1) the MCI and dementia group did not differ ($p = .085$). There was no main effect of time, $F(1, 119) = 0.41, p = .526, \eta_p^2 < .01$, and no interaction between time and group, ($F$s = .483, $p = .618, \eta_p^2 < .01$).

These results indicate no change in PM over time for any of the groups, and importantly, no evidence of disproportionate decline for either of the two clinical groups.

PM cue types and task types

The number of correct PM responses were analysed using a 3 x 2 x 2 mixed ANOVA with the between-subjects variable of group (control, MCI, dementia) and the within-subjects variables of PM task (regular, irregular) and PM cue (time, event).

There was a main effect of PM task, $F(1, 119) = 4.54, p = .035, \eta_p^2 = .04$, a main effect of PM cue $F(1, 119) = 15.55, p < .001, \eta_p^2 = .12$ and as identified above, a main effect of group, $F(2, 119) = 20.02, p < .001, \eta_p^2 = .25$. Neither of the two way interactions of group and task type ($F = 0.23, p = .794$), or group and cue type ($F = 1.17, p = .314$) was significant. However there was an interaction between cue type and task type, $F(2, 119) = 16.30, p < .001, \eta_p^2 = .12$. 
The main effect of PM cue indicated better performance in response to time-based than event-based cues and the main effect of task indicated better performance in irregular than in regular tasks, paralleling the results of Study 1. A novel finding to emerge was the task by cue interaction, which revealed that performance on regular tasks was superior to irregular tasks if the cue was time-based, but a smaller reverse effect occurred with performance on irregular tasks being superior to regular tasks if the cue was event-based.

**Figure 6.1.** Mean score on the Virtual Week for controls and participants with Mild Cognitive Impairment and dementia at baseline and one-year follow-up. Maximum score = 8. Bars represent one standard error of the mean.
**PM as a predictor of general cognitive decline**

A linear regression analysis was conducted to test the hypothesis that baseline scores on the Virtual Week assessment of PM would predict MMSE scores at follow up one year later (beyond that predicted by baseline MMSE), and further, whether PM would be predictive for all three groups (dementia, MCI, controls). Participants’ baseline PM score on MMSE was the first predictor variable entered and the criterion (or “outcome”) was MMSE at one year follow up. This model was significant, $R = .332$, $F(1, 120) = 59.75$, $p < .001$, and baseline MMSE explained 32.7% of the variance in follow up MMSE. In the next step, baseline scores on Virtual Week were entered into this equation, hence the criterion then reflects the additional value of PM as a predictor of change in MMSE over the one year period. The model was significant, $R = .591$, $F(2, 119) = 32.01$, $p < .001$, and explained 35% of the variance in change in MMSE from baseline to follow-up. However participants’ baseline score on Virtual Week just failed to attain significance as a predictor in this model, $\beta$ coefficient = .174, $t(120) = 1.79$, $p = .077$ (see Table 6.2).
Table 6.2. Regression analyses testing prediction of follow-up MMSE by baseline PM.

<table>
<thead>
<tr>
<th>Step</th>
<th>β coefficient</th>
<th>Standard Error β</th>
<th>B</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>5.89</td>
<td>2.79</td>
<td>.58</td>
<td>.037</td>
</tr>
<tr>
<td>Baseline MMSE</td>
<td>.77</td>
<td>.10</td>
<td>.87</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>7.76</td>
<td>2.96</td>
<td>.58</td>
<td>.010</td>
</tr>
<tr>
<td>Baseline MMSE</td>
<td>.69</td>
<td>.11</td>
<td>.52</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Baseline PM</td>
<td>.17</td>
<td>.10</td>
<td>.15</td>
<td>.077</td>
</tr>
</tbody>
</table>

This regression was repeated for each group separately, with the result being significant for those with dementia $r = .589, F(2, 25) = 6.63, p = .005$, and for controls $r = .401, F(2, 47) = 4.52, p = .016$, but not for those with MCI $r = .317, F(2, 41) = 2.29, p = .114$, yet baseline Virtual Week score was not a significant predictor in any of the groups (dementia β coefficient = .768, $\tau(26) = 1.62, p = .117$; MCI β = .088, $\tau(42) = 0.60, p = .553$; controls β coefficient = .022, $\tau(25) = 1.62, p = .117$).
Discussion

This longitudinal follow up study found no meaningful change in PM function over a one-year period for older participants with or without any cognitive impairment, and therefore does not support the original predictions. Thus, while it was anticipated that the nature of the group differences found in Study 1 would be reliable, it was not anticipated that the magnitude of the group differences would be unchanged from baseline to one-year follow up. These data imply that for those with MCI or dementia, as well as controls, PM appears to be relatively stable across a one-year time-frame. It seems likely that longer time frames may be needed to determine at what stage changes in PM become detectable in ageing, MCI and dementia.

The present data can be interpreted as encouraging news, indicating that PM may not decline as rapidly in these groups as other cognitive skills. In particular, retrospective memory has been consistently shown to decline with age in both cross-sectional normative studies (e.g. Steinberg, Bieliauskas, Smith, & Ivnik, 2005; Wechsler, 1997b) and longitudinal studies (e.g. Christensen, Mackinnon, Jorm, Korten, Jacomb, Hofer, & Henderson, 2004; Salthouse, 2003), although of course a caveat is that these longitudinal studies were conducted over substantially longer timeframes. Further, baseline PM function was not a predictor of decline in MMSE one year later (once baseline MMSE was accounted for), and a longer time period would be required to determine the predictive validity, and consequently clinical utility, of PM performance.

As in Study 1, the main effects indicated that PM performance is better when the cue is time-based (rather than event-based) and the task is irregular
(rather than regular). However the interaction of task type and cue type indicated that performance on regular tasks was superior to irregular tasks if the cue was time-based, but a smaller reversed effect occurred with performance on irregular tasks being superior to regular tasks if the cue was event-based. These data are consistent with the possibility that it is the combination of task regularity and cue-type that is important in determining task difficulty and consequently the degree to which more cognitively effortful processing is required for the cue to be successfully detected and the PM response to occur. Further, as discussed in Study 1, previous research has shown individuals with MCI to be disproportionately impaired when responding to time-based cues (Karantzoulis et al., 2009; Troyer & Murphy, 2007) but those with dementia to be equivalently impaired (Troyer & Murphy, 2007). The absence of any interaction between task parameters and group in the present data suggests that the interplay of task regularity and cue type has an equal impact on those with and without cognitive dysfunction.

Although the present results are important, being the first longitudinal assessment of PM in these populations, there are some limitations which must be acknowledged. Firstly, some of the effect sizes identified as significant are small according to Cohen’s (1988) criteria, and thus cannot be assumed to be of clinical significance. Further replication of these results is required, and a follow-up period of longer than one year is particularly important to clarify how PM function is affected in each of these groups over more extended time frames. In addition, despite use of a modified and abbreviated version of Virtual Week with reduced task demands, some participants, particularly those with dementia, performed at floor in Study 1. Given the unlikelihood of any improvement in
their performance, their scores on Virtual Week were imputed at zero. The presence of floor effects at both time-points therefore reduced the power to resolve any further decline in function across the three groups. Future research is therefore needed that uses an even more simplified version of Virtual Week, or other indicator of this construct, to increase sensitivity to potentially subtle changes in performance levels that occur as a function of time.

In summary, Study 5 found PM function, as indexed by a modified version of Virtual Week, to be stable over a one-year period in individuals with MCI or dementia, as well as in normally ageing controls. These data support the possibility that declines in this cognitive ability may only be seen over a more extended timeframe in each of these groups, and highlight the need for future research that directly tests this possibility.
CHAPTER 7.
General Discussion.

The central aim of this research program was to determine whether group differences exist in PM function between individuals with MCI, early dementia and normal controls. Additionally, this research sought to explore the impact of differing methods of assessment of PM with these populations, including manipulation of key task parameters (particularly time-based versus event-based, regular versus irregular, and focal versus non-focal tasks).

The data from Study 1 aligned with previous published research in showing that individuals with MCI and dementia exhibit PM difficulties relative to demographically matched controls (Blanco-Campal et al., 2009; Duchek et al., 2006; Jones et al., 2006; Kazui et al., 2005; Kinsella et al., 2007; Martins & Damasceno, 2008; Troyer & Murphy, 2007). However the differences on measures of PM function between MCI and dementia have not been well established to date, with differing results found in previous studies (Kazui et al., 2005; Troyer & Murphy, 2007). The findings of Study 1 showed that individuals with dementia are more impaired in PM, measured with Virtual Week, than those with MCI. As will be discussed, the differing results of previous studies are likely due to differing methods for assessment of the construct of PM function.

Study 1 also indicated that the group differences in PM function were not solely attributable to secondary task demands. Specifically, although PM performance was correlated with retrospective memory, working memory and executive function, significant group differences on Virtual Week remained even
after measures of each of these other cognitive abilities were statistically
covaried. These data are therefore important in showing that PM difficulties in
MCI and dementia are related to, but also separable from, decline in other more
general cognitive difficulties.

Although Study 1 showed group differences on Virtual Week, the time
required (approximately 30 minutes for the modified version used in Study 1)
limits the opportunities to use the test in clinical practice. Therefore, Study 2
explored self-report and informant-reports of PM impairment. However no
differences were found between the groups with dementia, MCI and healthy
controls in self-reported PM (or RM) on the PRMQ. There was a difference
between the groups in their informants’ ratings of both PM and RM, with the
dementia group being rated by their informants as more impaired than those
with MCI or the controls, with the latter two groups not differing. As expected,
and consistent with previous studies of self- and informant-reports by Slavin
(2010) and Zeintl et al. (2006), self-reported and informant-reported memory
complaints were only weakly related. However, the most important finding from
Study 2 was that neither self- nor informant-rated measures were meaningfully
related to performance on a behavioural index of PM (Virtual Week), with any
significant associations (where these were observed), small according to
conventional criteria. Therefore, Study 2 indicates that self-report and informant-
report may not represent valid methods of assessing PM, and there remains the
need to find a brief valid and reliable performance-based test of PM.

Accordingly, in Study 3, participants were given a brief assessment of PM
as a part of a larger neuropsychological evaluation. The task was designed
specifically for this study, and was based on an ongoing task with minimal
cognitive demands to which a PM component was added. Consequently, the success rate at this task was higher than previous studies with comparable populations (Huppert et al., 2000; Logie & Maylor, 2009). Study 3 confirmed the presence of differences in PM function between groups with MCI and dementia and controls, using a brief assessment of the type often used in clinical practice. However, contrary to predictions, there was a main effect of task, whereby participants performed significantly better on the non-focal relative to the focal task. There is now a large body of research showing that, where other task parameters are kept constant, focal relative to non-focal tasks impose lower demands on strategic, controlled processes (Kliegel et al., 2008a). Consequently, these data were interpreted as evidence that other factors related to the task may have played a more critical role than focality in the current manipulation. In particular, it was suggested that cue distinctiveness, or “salience”, may also be an important determinant of PM function. Prior research has shown that this variable represents an important determinant of controlled processing demands (McDaniel et al., 2004). It was suggested that further research in which task parameters such as salience are kept constant is needed to understand the role of focal versus non-focal PM cues in abnormal adult ageing.

Study 4 sought to differentiate groups with MCI, dementia and healthy controls using a naturalistic measure of PM. While the finding that dementia is associated with greater PM difficulties than non-clinical controls has been well established using laboratory measures (Livner et al., 2009; Troyer & Murphy, 2007), the results of Study 4 were novel in identifying this impairment using a naturalistic measure, and showing that naturalistic PM difficulties experienced in the everyday lives of older adults are greater for those with dementia. The
participants with dementia performed more poorly relative to both the control and MCI groups. However the MCI group were not differentiated from the controls. This suggests that those with MCI are able to effectively implement delayed intentions in everyday life, whilst showing an impairment in laboratory based PM in Study 1. Importantly, the naturalistic PM measure showed good convergent validity. Performance significantly correlated with both laboratory-measured PM (Virtual Week) and performance on a dementia screening tool (MMSE). Thus traditional laboratory assessments do have clinical predictive validity of real-world PM difficulties in late adulthood.

Study 5 sought to explore changes in PM function over a one year period. The group differences found in Study 1 were again identified, but the magnitude of the group differences was unchanged across testing occasions. This result is contrary to the decline in PM function that was hypothesised, however it is consistent with the only two previous studies that have longitudinally assessed PM, albeit in very dissimilar populations (Withall et al., 2009a; Zakzanis et al., 2003). While this finding might be interpreted as evidence that PM is quite stable, at least over the relatively short period of this study, the failure to resolve an effect of time may instead have reflected either use of an insufficiently sensitive measure (as noted, floor effects were evident at both time points), or too short a time-interval between testing occasions. Recommendations for further longitudinal research are made, which would help tease apart these competing possibilities.
Implications for the Assessment and Diagnosis of Mild Cognitive Impairment and Dementia

The present program of research has clearly shown that PM function is impaired in MCI and early dementia. This adds these two clinical conditions to the growing list of disorders that involve a PM impairment, such as multiple sclerosis (Rendell et al., 2007b), schizophrenia (Altgassen et al., 2008; Ungvari, Xiang, Tang, & Shum, 2008; Wang, Chan, Yu, Shi, Cui, & Deng, 2008), and depression (Withall, Harris, & Cumming, 2009b).

Dementia is a common disease and there are efficacious treatments available for slowing the rate of symptom progression (Birks, 2006; Mangialasche, Solomon, Winblad, Mecocci, & Kivipelto, 2010). New treatments currently being evaluated for dementia include disease modifying medications (Burns & Jacoby, 2008; Doody, Gavrilova, Sano, Thomas, Aisen, Bachurin, Seely, & Hung, 2008) and targeted training techniques have been shown to improve PM performance (Camp et al., 1996; Kinsella et al., 2007). Similarly, memory training for individuals with MCI has shown promising results, including improvements in PM (Kinsella, Mullaly, Rand, Ong, Burton, Price, Phillips, & Storey, 2009). The importance of PM function to independent living has been well-established (Chasteen et al., 2001; Smith et al., 2000). Thus early and accurate diagnosis potentially offers considerable benefit to those diagnosed with either of these conditions so that treatment can be appropriately planned. Given that PM is impaired in these conditions, a thorough assessment should include a PM component.

At present, the diagnostic criteria for dementia specify that impairment in memory must be present, but not which aspects of memory should be considered
Typically, it is only RM that is assessed during a neuropsychological evaluation for dementia. The proposed revision of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2010) proposes replacement of the diagnostic category of dementia with that of “Major Neurocognitive Disorder”. The proposed criteria specify the domain of “learning and memory”, consisting of immediate memory and recent memory, which includes free recall, cued recall, and recognition memory (APA, 2010). As in previous editions of DSM, there is no mention of PM. Yet the results of the present research program add to growing evidence that PM is impaired in dementia and that this decline is at least partially independent of other cognitive abilities, including RM.

The proposed revision of DSM-5 also includes a diagnostic category of “Minor Neurocognitive disorder” to replace MCI. Again, the criteria relating to this disorder do not mention PM. The same domain of “learning and memory” is used. The studies reported here add to the growing body of research showing PM impairment in both dementia and MCI and thus provides evidence for the inclusion of PM to be added to the RM components in the description of the domain of memory used in diagnostic criteria for both conditions.

Analogously, these results add further weight to suggestions that PM should be included in neuropsychological evaluations for MCI and dementia (Huppert & Beardsall, 1993; Thöne-Otto & Walther, 2008). The results also verify the importance of using measures of PM that have documented reliability and validity. The clearest group differences were found using Virtual Week, and this result likely reflects the good reliability of this measure arising from the multiple opportunities given to perform PM tasks. Further, performance on
Virtual Week was shown in Study 4 to be correlated with execution of a naturalistic task, occurring during the everyday activities of participants. It is possible that this correlation may be even higher if younger adults were included in the analysis, given that including only older adults may result in restriction of range. Consequently, these data add converging support to other evidence showing that Virtual Week is a valid indicator of real-world difficulties experienced in late adulthood (Rendell & Henry, 2009).

In contrast, self-reports of memory impairment, while included in the current DSM-IV (APA, 1994) and proposed DSM-V (APA, 2010) diagnostic criteria for MCI and dementia, appear to primarily reflect individuals’ concern about their own memory lapses. The magnitude of the associations of self- and informant-reports with objective assessments in this research program were typically not significant, and those that were, only small in practical importance. Consequently, these data suggest that subjective cognitive complaints may be best considered to be an indicator for further assessment of cognition rather than of diagnostic significance.

The implications of Study 3 are particularly important for clinicians, who require a brief test of PM to fit into a busy neuropsychological assessment (Thöne-Otto & Walther, 2008). Study 3 showed that while a brief, unstandardised PM assessment of the type that is used by clinicians is capable of detecting group differences in PM between groups with dementia, MCI and healthy controls, the effect size was very small, and therefore unlikely to be helpful as a diagnostic tool used to make decisions on an individualised level. Taken together, the results of Studies 2 and 3 indicate that brief assessments (self-reports, and informant reports and objective measures that include very few
PM trials) do not appear to be valid diagnostic tools, and instead more comprehensive, validated tests are required. There are many laboratory based paradigms in use in PM research that could be evaluated with these clinical groups.

**Implications for Task and Cue Manipulation in Prospective Memory Research.**

The results in this research program of the manipulations of time-based versus event-based cues, regular versus irregular tasks, and cue focality were not as expected. In fact participants’ responses to time-based cues were consistently superior to event-based cues (Studies 1 and 5), with performance on irregular tasks being either equivalent to (Study 1) or superior to (Study 5) regular tasks, and non-focally cued tasks being superior to focally-cued tasks (Study 3).

As discussed in Study 1, the operationalisation of task regularity and cue type in Virtual Week may be different than other laboratory based tests of PM. However the presence of differing results when task dimensions are manipulated does suggest that the manipulations result in differing cognitive demands for differing task and cue types. Further, the interaction noted in Study 5 of task type and cue type (with regular tasks performance being superior to irregular tasks when the cue is time based, and irregular task performance being superior to regular tasks when the cue is event based) suggests that it is the combination of task regularity and cue-type which is important in terms of the reliance on self-initiated processing that is required for the cue to be successfully detected and the PM response to occur.

As discussed in Study 1, previous research has shown individuals with MCI to be disproportionately impaired when responding to time-based cues
(Karantzoulis et al., 2009; Troyer & Murphy, 2007) but those with dementia to be equivalently impaired (Troyer & Murphy, 2007). Yet the absence of significant interactions involving group in the present data suggests that the interplay of task regularity and cue type has an equal impact on those with and without cognitive dysfunction. The data show an interaction between task type and cue type, and thus suggest that the degree to which one of these dimensions affects the reliance on self-initiated processing may be offset by the other of these dimensions. Therefore, these dimensions must be considered together in the design of PM assessments.

Likewise, the data in Study 3 were contrary to expectations in showing that participants were more successful at the non-focally cued rather than the focally cued task. Given that the distinction between focal and non-focal cues has been identified as robust in the research literature (for a meta-analytic review, see Kliegel et al., 2008a), with focal consistently identified as less demanding than non-focal, it is suggested that differences in other task parameters likely influenced these findings. In particular, other factors such as cue distinctiveness could possibly have increased successful strategic monitoring to perform the task correctly in the non-focal condition. Cue distinctiveness has been suggested to promote attentional switching from the ongoing activity (McDaniel et al., 2004). Indeed, the Multi Process model of PM asserts that the automaticity of cue-detection is driven at least partially by cue-salience (McDaniel & Einstein, 2000; McDaniel et al., 2004). Additionally, PM performance is known to be affected by the cognitive load of the ongoing task (Smith, 2003). In Study 3, the ongoing task was selected specifically for its minimal cognitive load. Thus sufficient cognitive resources may still be
available for monitoring for the PM cue, regardless of whether that cue is focal or non-focal.

Importantly, there may be alternative interpretations of this data that could be explored. One such possibility is that the tasks may differ from each other on some important dimension that has not been assessed in this thesis. For example, tasks may vary in interest level, perceived importance and pleasantness or positive valence. Each of these could be evaluated in future research by having the participants rate the tasks on each dimension.⁴

**Limitations of This Research**

A strength of this 5-study research program is the recruitment of participants diagnosed via application of consistent diagnostic criteria for MCI and dementia. Importantly, diagnostic assessments were completed prior to the participants’ recruitment into the present studies. PM was not included in the diagnostic classification process, thus avoiding the issue of circularity that may occur in clinical research where the assessment of the construct of interest is often used in selection or classification of participants. Further, all examiners in these studies were blind to the participants' diagnostic status at the time of the assessments.

However some limitations of this research must be acknowledged. The subtype of dementia was not known in all cases, and where known, the cell sizes were too small to allow detailed analysis of results by dementia subtype. Subtypes of MCI, while analysed in Study 1 with no significant results, were not

⁴ I would like to acknowledge and thank the anonymous reviewer who suggested this idea.
available for the larger sample used in Study 3. The very mild status of the
group of dementia participants (typically within two years post-diagnosis) makes
group differences harder to detect. This reduces the effect size, and consequently
also reduces the power of the studies. However, one aim of this research
program was to detect subtle changes that occur early in the disease process, and
this is achieved by studying individuals who are in the very early stages of
illness.

A floor effect was evident in the data in Studies 1 and 5, with a
proportion of participants performing at zero on Virtual Week. This occurred
despite pilot testing and modifications to Virtual Week to make it easier for the
populations of interest to contend with the task. However scores at ceiling were
quite rare in the clinical groups, thus avoiding the ceiling effects that according
to Uttl (2008) commonly reduce effect sizes in PM research.

Another limitation of these data is that while there is good evidence for
the reliability and validity of Virtual Week (see Rendell & Henry, 2009), there is
only limited psychometric information available for the modified version of this
measure used in the present research. The identification of floor effects implies
that further modification may be needed to optimise use of this measure in the
population of interest in the present study.

As is common in longitudinal studies (Labouvie-Vief, 1985), selective
attrition affects the investigation of change over time in Study 5, with the
longitudinal sample size being reduced. The lower scores on Virtual Week and
the MMSE for those who were not followed up make interpretation of the data
from this study problematic. Clearly, a follow-up period of longer than one year
would be needed to clarify the longitudinal course of PM.
The use of electronic data capture in Study 4 eliminated a common methodological difficulty identified in naturalistic studies. Specifically, Stone et al. (2002) found substantial backfilling (i.e., completing diary entries late or several at once) when paper diaries were used. However other limitations of naturalistic designs were more difficult to bypass. In particular, adherence to instructions not to use memory aids could not be monitored. Older adults may be aware of the fallible nature of their memory, and more likely to equip themselves with external cues to prospective intentions (Craik & Kerr, 1996; Kvavilashvili & Ellis, 2004). Although evidence does not support the claim that use of reminders contributes to older adults’ performance on PM in naturalistic settings (Phillips et al., 2008; Rendell & Thomson, 1999) it is not possible to definitely conclude whether the group effects found in Study 4 reflected difficulties with PM per se, or instead difficulties implementing effective strategies for PM performance. However this rationale predicts that those with greatest concern over memory fallibility (those with dementia) would make greatest use of external memory aids. Although speculative, this suggests that the group differences and correlations identified may reflect an underestimate of true effects.

Some of the dementia group were taking dementia medication, but it was not possible to conduct formal analyses assessing medication status and cognitive performance due to the differing medication types and dosages participants received. The role of medication status in understanding PM function in this group remains an important issue for future research. However, given that the purpose of such medication is to improve cognition, one
possibility is that use of such medication may serve to attenuate dementia effects on PM.

**Future Directions of Prospective Memory and Cognitive Impairment Research**

This research explored several dimensions of PM (time versus event based cues, regular versus irregular tasks, focal versus non-focal cues, laboratory versus naturalistic settings). The findings of superiority of performance on non-focal over focally cued tasks, and time-based tasks over event-based tasks, combined with the interaction of time versus event based cues with task regularity were unexpected. The data suggest that different features of the PM task and cue exert influences of varying strength under different assessment conditions. To further elucidate the influences on PM performance and the interactions among them, studies are required that systematically manipulate each dimension of the PM task in the same sample of participants.

Further, there are other dimensions of PM not manipulated in this research program that appear worthy of empirical investigation in those with MCI and dementia. In particular, the impact of a PM task on the ongoing task, and the effect of the perceived importance of a PM task were not specifically manipulated in the present body of research.

With respect to the impact of PM on an ongoing task, a recent theoretical issue of contention is whether PM task performance is invariably capacity consuming, and thereby will always incur ‘costs’ with respect to performance on the ongoing task. McDaniel and Einstein (2000) argued in their Multi Process model of PM that the target cue for a PM task can reach awareness through either constant strategic monitoring for the cue, or by attention being
spontaneously attracted to a novel or unusual stimulus serving as a PM cue. If the ongoing task requires focussing on the PM cue (i.e., a focal cue) then the cue is likely to automatically produce retrieval of the intention. However if the cue is not a part of the ongoing task that is the focus of attention (i.e., a non-focal cue) then more strategic attention is needed to monitor for the PM cue (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000).

The Preparatory Attentional and Memory processes model proposed by Smith (2003) instead suggested that this shift of attention from the ongoing task always requires use of cognitive resources for the constant monitoring for PM cues, and thus all PM tasks may be regarded as “capacity consuming” (Smith, 2003). Consistent with this model, redirection of cognitive resources in the context of a PM task has been shown to negatively impact ongoing task efficiency (Smith, 2003). Other studies, however, have failed to show performance decrements on the ongoing task when a PM event occurs (Einstein, McDaniel, Manzi, Cochran, & Baker, 2000).

Although the Multi Process model and the Preparatory Attentional and Memory processes model differ on the key issue of whether monitoring for cues may ever be an automatic process, both models accommodate the prediction of Study 3 that MCI and dementia effects on PM performance would be greater on tasks where the cue is non-focal (and therefore more effortful) than where the cue is focal.

Although the impact of PM on the ongoing task is the key issue on which the Multi Process model and the Preparatory Attention and Memory processes model differ, this point is not directly addressed in the research studies within this research program. However this evidence of the impact of a PM task on the
ongoing task suggests a dual-task trade off (Marsh et al., 2005) may occur, where limited cognitive capacity is confronted with two simultaneous tasks. This key difference between these two theoretical models was not explored in the present research. In practical terms, this difference highlights the importance of selecting an appropriate ongoing task for a PM assessment paradigm, given that any normative information regarding the ongoing task may be invalidated. The ongoing task for Study 3, in which focal and non-focal cues were compared as a part of a broader neuropsychological and clinical evaluation, required minimal cognitive demands, and therefore did not directly compare these two models.

Another dimension of PM that was not explored in this body of research is the effect of the perceived importance of a PM task. Importance effects have been suggested as a possible reason for some of the differences in age-related PM performance (Kliegel et al., 2008a). Further, differences in the perceived importance of the PM task have been shown to have more effect on non-focal than on focal PM tasks. Research in this area to date suggests that tasks deemed to be important tend to be better performed due to more effective monitoring for the PM cue when the task requires the strategic allocation of attentional resources (Kliegel et al., 2001; Kliegel et al., 2004). Therefore, when a brief assessment is designed that involves the participant breaking attentional set from another assessment task, the degree of perceived importance of the PM task is a necessary consideration. In Study 3 an attempt was made to standardise the perceived importance on the PM task with a clear statement in the PM instructions that the participant is being asked to do two things at once, and that the PM task is important, thus ensuring that examinees are aware that they are expected to break their attention from the ongoing task in order to complete the
PM task. However this study did not specifically manipulate the perceived importance of the PM task to determine the importance effects on PM performance in participants with MCI and dementia.

The technology of the hand held “Palm” device used in Study 4 to conduct naturalistic assessment of PM could feasibly be extended to explore the potential role of these devices as electronic memory aids which may be used to support prospective remembering in day to day life. Older adults have been reported to use more memory aids than younger adults (Cavanaugh, Grady, & Perlmutter, 1983), although empirical support for this notion is mixed (Phillips et al., 2008) and there is some evidence to the contrary (Patton & Meit, 1993). Although most memory aids used by older adults are non-electronic (such as calendars, diaries and paper notes), many older adults are receptive to the idea of electronic aids if they are suitable for the purpose and affordable (Cohen-Mansfield, Creedon, Malone, Kirkpatrick, Dutra, & Herman, 2005). The most commonly cited reasons for considering the use of an electronic memory aid are in fact PM related, specifically keeping appointments and monitoring medications (Cohen-Mansfield et al., 2005).

The absence of a main effect of time in Study 5 highlights the importance of following up a group over a longer time period to further clarify the predictive validity, and consequently clinical utility, of PM an indicator of more general cognitive decline. Further, a number of participants who were categorised as being cognitively healthy were found to have PM impairments. This group would be worth monitoring to see whether they differ in their rate of future cognitive decline from controls who did not show any PM difficulties.
The major finding of this research program is that significant PM impairments are associated with MCI and dementia. Following from this, a number of further studies would be useful for determining the risk and protective factors, the relationship of PM changes to early dementia biomarkers and covariates. These include an analysis of protective and risk factors for PM impairment. A large body of knowledge has accumulated about risk and protective factors for dementia and several large-scale studies are currently being conducted to determine their impact on MCI and progression to dementia (Ellis, Bush, Darby, De Fazio, Foster, Hudson, Lautenschlager, Lenzo, Martins, Maruff, Masters, Milner, Pike, Rowe, Savage, Szoeke, Taddei, Villemagne, Woodward, Ames, & null, 2009; Kochan et al., 2009b). It would be informative to assess the role of these identified risk and protective factors as predictors of PM impairment. Factors which are being explored for their relationship to cognitive impairment and dementia, which may also play a role in PM are as varied as age (Low et al., 2004), education (Petersen, 2007), diet (Scarmeas, Luchsinger, Mayeux, & Stern, 2007), apolipoprotein E genetic status (Driscoll, McDaniel, & Guynn, 2005) and personality (Gil, Arroyo-Anllo, Ingrand, Gil, Neau, Ornon, & Bonnau, 2001; Maylor, 1993). Some of these factors may be of use in explaining individual differences in PM function within MCI and dementia populations.

Conclusions

In conclusion, it has long been recognized that deficits in the ability to implement delayed intentions are likely to lead to problems in daily functioning. Study 1 indicates that both MCI and dementia are associated with PM deficits,
and supports the use of Virtual Week in clinical practice as a tool to quantify the magnitude of these impairments. It is suggested that while failures of RM, working memory and executive functioning each potentially contribute to PM difficulties in each of these groups, they are not sufficient to account for the magnitude of the PM impairment observed.

Study 2 found that in participants with MCI or dementia and in cognitively healthy controls, both self-reports and informant-reports have poor validity, at best correlating only weakly with objective assessments. These results question the presence of self- or informant-reported cognitive complaints in the diagnostic criteria for MCI. Such reports are clinically perhaps best considered as an indicator for further assessment with objective measures.

Study 3 indicated that a brief, unstandardised assessment of PM of the type that is used by clinicians is capable of detecting group differences in PM between groups with dementia, MCI and healthy controls. However the effect size is very small, implying such measures may not be suitable for clinical use.

Study 4 showed that relative to age-matched controls, everyday PM difficulties experienced in later life are greater for those with dementia, but not those with MCI. Evidence of convergent validity with laboratory-measured cognition supports the clinical predictive validity of traditional laboratory assessments as an indicator of real world difficulties in PM. These data are also encouraging in suggesting that those with MCI may possibly adopt compensatory mechanisms to bypass the PM difficulties they exhibit on laboratory measures of this construct.

Study 5 showed that PM function is remarkably stable over a one-year period in individuals with MCI or early dementia, as well as in normally ageing
controls. However, the presence of selective attrition in the longitudinal study renders interpretation of these findings problematic. These data also highlight the need for longitudinal assessments over more extended time periods.

Overall, this research program has found evidence for the existence of group differences in PM between participants with MCI and dementia, and cognitively healthy controls. The strongest effect was found using a sensitive laboratory measure. Self-report was not a valid measure and informant-report showed only weak validity, as did a brief but unstandardised clinical measure. Naturalistic assessment suggests that those with MCI are less affected by PM failures in everyday life than in the laboratory. PM appears stable over a one year period. While RM, working memory and executive functioning were shown to be cognitive correlates of PM, there is still a separate component of PM once these correlates have been accounted for, adding weight to the argument that these are overlapping but distinct cognitive abilities. Further research is required to monitor the progression of PM impairment, and also to explore the impact of PM on an ongoing task and the effects of manipulations of the importance of a PM task in groups with MCI and dementia. Ongoing research into the determinants and longitudinal course of PM performance in these groups has the potential to inform compensatory rehabilitation strategies, thereby enabling ongoing functional independence for individuals with MCI or dementia.
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APPENDIX A.

Participant Information and Consent Forms
Prospective Memory Study

Participant Information Statement

We are conducting research to investigate the prevalence of problems with prospective memory in older adults. Prospective memory is the ability to remember to do things you intend to do in the future, such as taking medication or stopping at shops on the way home. We hope to learn about how best to assess prospective memory.

This research is being conducted to fulfill the requirements of the degree of PhD at the University of New South Wales, and is supported by the UNSW Primary Dementia Collaborative Research Centre PhD Scholarship. It has been approved by the Research Ethics Committees of the Prince of Wales Hospital and the University of New South Wales.

You have been asked to participate because you attended either the UNSW Memory and Ageing Study or the Euroa Centre Memory Disorders Clinic. Should you agree to participate, you will be asked to complete a number of assessments. These will mostly take place at one single appointment which will take approximately one and a half hours. The results will be analysed along with some of the results of your assessment by the UNSW Memory and Ageing Study or the Euroa Centre Memory Disorders Clinic.

1. At an appointment at a time and location convenient to you, you will be asked to complete some computerised tasks.

2. You will be asked to complete a brief questionnaire about your memory. You will also be asked to nominate an informant who knows you well, to complete a brief questionnaire about your memory. This will ordinarily be the same person who provided information for your assessment by the Memory and Ageing Study or Memory Disorders Clinic.

3. At the conclusion of these tasks, you will be offered a further assessment task involving use of a portable, handheld electronic organiser device (a “Palm”) over the next two days. Arrangements will be made to collect or post the “Palm” device after the two days of the task.

4. If you wish, you may receive feedback on your performance.

5. You will be contacted again one year later and offered the opportunity to repeat some of the assessments.

Participation is entirely voluntary. You may refuse to complete any part of the project. You are permitted to withdraw from the project at any time without penalty or prejudice. Declining or withdrawing from the study will in no way affect your treatment at the Euroa Centre or any other part of the Prince of Wales Hospital or the University of New South Wales.
Benefits and Risks
We do not anticipate any risks or side effects from participating in this study. We aim to minimise inconvenience to you by arranging your assessment appointment at a time and place suitable to you. Assessments are supervised by a fully trained and qualified Clinical Psychologist. The length of the assessment is limited to reduce fatigue. We do not claim that you will receive any benefits from this study.

If you have questions or require information, please telephone Claire Thompson at POHW on 9382 3736, email thompsoncl@sesahs.nsw.gov.au, or telephone Dr Julie Henry on 9385 3936, email jhenry@unsw.edu.au. Complaints may be directed to the Research Ethics Secretariat, South Eastern Sydney and Illawarra Human Research Ethics Committee – Eastern Section, Room G71, Edmund Blackett Building, Prince of Wales Campus, Randwick NSW 2031. Phone 9382 3587, Fax 9382 2813.

Confidentiality
Any information about you that is obtained in connection with this study will remain confidential and be stored in locked filing cabinets in locked offices or on a secure computer hard drive or university computer drive with access only via login and password. Information will be disclosed only with your written permission or as required by law. Information will be retained for a period of 7 years and be disposed of by shredding or erasure.

Yours sincerely,

Claire Thompson
DA(Hons) MPsyCh(Clin) MAPS
Clinical Psychologist.
Prospective Memory Study

Participant Revocation of Consent

Please keep this form and mail it back only if you wish to withdraw from the study

I hereby wish to withdraw my consent from the Prospective Memory Study. I understand that such withdrawal WILL NOT make any difference to my medical care or my relationship with the Prince of Wales Hospital or my medical attendants, or with the University of New South Wales.

Signature __________________________ Please print name __________________________ Date ________________

This form for Revocation of Consent should be forwarded to:
Claire Thompson
Dementia Collaborative Research Centre
Level 2, Building CC4
Cliffbrook Campus, UNSW
45 Beach St
Coogee, NSW, 2034.
Prospective Memory Study  
Participant Consent Form

1. I _______________________________ of _______________________________
   _______________________________, aged ________ years,
   agree to participate in the study described in the Prospective Memory Study
   Information Statement.

2. I acknowledge that I have read the Participant Information Statement, which explains
   why I have been selected, the aims, nature and the possible risks of the study, and the
   statement has been explained to me to my satisfaction.

3. I agree that I have been given the opportunity to ask questions relating to any
   possible physical and mental harm I might suffer as a result of my participation and I
   have received satisfactory answers.

4. I understand that I can withdraw from the study at any time without prejudice to my
   relationship with the Prince of Wales Hospital and South East Sydney Illawarra Area
   Health Service or the University of New South Wales.

5. I agree that research data gathered from the results of the study may be published
   provided that I can not be identified.

6. I understand that if I have any questions relating to my participation in this research,
   I may contact Claire Thompson at PWPH on 9382 3736, Dr Julie Henry on 9385 3936,
   who will be happy to answer them.

7. I have been given the telephone number for an Executive Officer of the Internal
   Ethics Committee (Research Ethics Co-ordinator, telephone number: 9382 3587) should I
   wish to make a complaint about the conduct of this research.

8. I acknowledge receipt of this consent form and the Participant Information
   Statement.

Signature __________________________ Please print name __________________________ Date __________________________
Prospектив Memory Study
Informant Information Statement

You have been identified as the spouse, relative or friend of

who has agreed to take part in the Prospектив Memory Study, and to us approaching you to be an informant. For this study, an informant is someone who knows the participant well enough to answer questions about their day to day memory.

Thank you for agreeing to take part in this research study. We are conducting this research to investigate the prevalence of problems with prospective memory in older adults. Prospective memory is the ability to remember to do things you intend to do in the future, such as taking medication or stopping at shops on the way home. We hope to learn about how to best assess prospective memory. As part of this study, you will be asked to complete a single brief questionnaire about the participant's memory. This will be posted to you and returned by reply-paid mail. You will be contacted again one year later and asked to complete another brief questionnaire.

This research is being conducted to fulfill the requirements of the degree of PhD at the University of New South Wales, and is supported by the UNSW Primary Dementia Collaborative Research Centre PhD Scholarship. It has been approved by the Research Ethics Committees of the Prince of Wales Hospital and the University of New South Wales.

Participation in this study is entirely voluntary, and you and the participant are free to withdraw at any time without prejudice. The decision not to participate or to terminate participation will in no way affect your or the above named person's current or future care at Prince of Wales Hospital or your relationship with the hospital or the University of New South Wales. Information which is obtained and that can be identified with you personally or with the above named person will be kept confidential as required by law. Your responses will remain confidential and will not be disclosed to the participant. All information collected will be stored in locked filing cabinets in locked offices or on a secure UNSW computer drive with access only via login and password. The results will be analysed along with some of the results of the participant's assessment by the UNSW Memory and Ageing Study or the Euroa Centre Memory Disorders Clinic.
Benefits and Risks
We do not anticipate any risks or side effects from participating in this study. We do not claim that you will receive any benefits from this study. There will be no remuneration for your time.

If you have questions or require information, please telephone Claire Thompson at POHW on 9382 3736, email thompsoncl@sesahs.nsw.gov.au, or telephone Dr Julie Henry on 9385 3936, email jhenny@unsw.edu.au. Complaints may be directed to the Research Ethics Secretariat, South Eastern Sydney and Illawarra Human Research Ethics Committee – Eastern Section, Room G71, Edmund Blackett Building, Prince of Wales Campus, Randwick NSW 2031. Phone 9382 3587, Fax 9382 2813.

Confidentiality
Any information about you that is obtained in connection with this study will remain confidential and be stored in locked filing cabinets in locked offices or on a secure university computer hard drive with access only via login and password. Information will be disclosed only with your written permission or as required by law. Information will be retained for a period of 7 years and be disposed of by shredding or erasure.

Yours sincerely,

Claire Thompson
BA(Hons) MPsyCh(Clin) MAPS
Clinical Psychologist.
Prospective Memory Study

Informant Revocation of Consent

Please keep this form and mail it back only if you wish to withdraw from the study

I hereby wish to withdraw my consent to participate in the Prospective Memory Study as informant for ________________________________ (Participant's name)

I understand that such withdrawal WILL NOT make any difference to my medical care or my relationship with the Prince of Wales Hospital or my medical attendants, or with the University of New South Wales.

Signature __________________ Please print name __________________ Date ____________

This form for Revocation of Consent should be forwarded to:
Claire Thompson
Dementia Collaborative Research Centre
Level 2, Building CC4
Cliffbrook Campus, UNSW
45 Beach St
Coogee, NSW, 2034.
PRIMARY DEMENTIA COLLABORATIVE RESEARCH CENTRE

Prospective Memory Study

Informant Consent Form

1. I ________________ of ________________

__________________________, aged __________ years,

agree to participate as informant for ________________

in the study described in the Prospective Memory Study Information Statement.

2. I acknowledge that I have read the Informant Information Statement, which explains
why I have been selected, the aims, nature and the possible risks of the study, and the
statement has been explained to me to my satisfaction.

3. I agree that I have been given the opportunity to ask questions relating to any
possible physical and mental harm I might suffer as a result of my participation and I
have received satisfactory answers.

4. I understand that I can withdraw from the study at any time without prejudice to my
or the above named participant's relationship with Prince of Wales Hospital and South
East Sydney-Ilawarra Area Health Service or the University of New South Wales.

5. I agree that research data gathered from the results of the study may be published
provided that I can not be identified.

6. I understand that if I have any questions relating to my participation in this research,
I may contact Claire Thompson at POHW on 9382 3736, Dr Julie Henry on 9385 3936,
who will be happy to answer them.

7. I have been given the telephone number for an Executive Officer of the Internal
Ethics Committee (Research Ethics Co-ordinator, telephone number: 9382 3587)
should I wish to make a complaint about the conduct of this research.

8. I acknowledge receipt of this consent form and the Informant Information Statement.

Signature Please print name Date

Relationship to Participant

Signature of Witness Please print name Date

Signature of Investigator Please print name Date

Page 4 of 4 Informant Information and Consent 8 April 2003
Propective Memory Study

Participant Information Statement - Caregivers Version

We are conducting research to investigate the prevalence of problems with prospective memory in older adults. Prospective memory is the ability to remember to do things you intend to do in the future, such as taking medication or stopping at shops on the way home. We hope to learn about how best to assess prospective memory.

This research is being conducted to fulfil the requirements of the degree of PhD at the University of New South Wales, and is supported by the UNSW Primary Dementia Collaborative Research Centre PhD Scholarship. It has been approved by the Research Ethics Committees of the Prince of Wales Hospital and the University of New South Wales.

Your relative or friend (the participant) has been asked to participate because they attended either the UNSW Memory and Ageing Study or the Euroa Centre Memory Disorders Clinic. Should you agree to their participation, they will be asked to complete a number of assessments. These will mostly take place at one single appointment which will take approximately one and a half hours. You are welcome to stay with your relative or friend during this appointment. The results will be analyzed along with some of the results of the assessment by the UNSW Memory and Ageing Study or the Euroa Centre Memory Disorders Clinic.

1. At an appointment at a time and location convenient to you and the participant, they will be asked to complete some computerised tasks. They will be asked to complete a brief questionnaire about their memory.

2. They will also be asked to allow you or another informant who knows them well, to complete a brief questionnaire about their (the participant's) memory. This will ordinarily be the same person who provided information for the assessment by the Memory and Ageing Study or Memory Disorders Clinic.

3. At the conclusion of these tasks, they will be offered a further assessment task involving use of a portable, handheld electronic organiser device (a "Palm") over the next two days. Arrangements will be made to collect the "Palm" device after the two days of the task.

4. If they wish, the participant may receive feedback on their performance.

5. They will be contacted again one year later and offered the opportunity to repeat some of the assessments.
Participation is entirely voluntary. You or the participant may refuse to complete any part of the project. You are permitted to withdraw the participant from the project at any time without penalty or prejudice. Declining or withdrawing from the study will in no way affect your or the participant's treatment at the Euroa Centre or any other part of the Prince of Wales Hospital or the University of New South Wales.

Benefits and Risks
We do not anticipate any risks or side effects from participating in this study. We aim to minimise inconvenience to you and the participant by arranging the assessment appointment at a time and place suitable to you. Assessments are supervised by a fully trained and qualified Clinical Psychologist. The length of the assessment is limited to reduce fatigue. We do not claim that the participant will receive any benefits from this study.

If you have questions or require information, please telephone Claire Thompson at POHW on 9362 3736, email thompsoncl@sesahs.nsw.gov.au, or telephone Dr Julie Henry on 9365 3936, email jhenry@unsw.edu.au. Complaints may be directed to the Research Ethics Secretariat, South Eastern Sydney and Illawarra Human Research Ethics Committee – Eastern Section, Room G71, Edmund Blackett Building, Prince of Wales Campus, Randwick NSW 2031. Phone 9362 3587, Fax 9362 2813.

Confidentiality
Any information about you or the participant that is obtained in connection with this study will remain confidential and be stored in locked filing cabinets in locked offices or on a secure computer hard drive or university computer drive with access only via login and password. Information will be disclosed only with your written permission or as required by law. Information will be retained for a period of 7 years and be disposed of by shredding or erasure.

Yours sincerely,

Claire Thompson
BA Honours, MA Psych (Clin) MAPS
Clinical Psychologist.
Prospective Memory Study

Participant Revocation of Consent – Informant Version

Please keep this form and mail it back only if you wish to withdraw the participant from the study

I hereby wish to withdraw my consent for my relative/friend from the Prospective Memory Study. I understand that such withdrawal WILL NOT make any difference to their medical care or their relationship with the Prince of Wales Hospital or their medical attendants, or with the University of New South Wales.

Signature __________________________________________
Please print name __________________________________
Date ________________________________________________

This form for Revocation of Consent should be forwarded to:
Claire Thompson
Dementia Collaborative Research Centre
Level 2, Building CC4
Cliffbrook Campus, UNSW
45 Beach St
Cooee, NSW, 2034.

Page 3 of 4 Participant Information and Consent, Caregiver version, 08 April 2003
Prospective Memory Study
Participant Consent Form – Informant Version

1. I __________________________________________ of __________________________
__________________________________________, aged __________ years,
agree to the participation of __________________________________________
in the study described in the Prospective Memory Study Information Statement.

2. I acknowledge that I have read the Participant Information Statement, which explains
why the participant has been selected, the aims, nature and the possible risks of the
study, and the statement has been explained to me to my satisfaction.

3. I agree that I have been given the opportunity to ask questions relating to any
possible physical and mental harm the participant might suffer as a result of
participation and I have received satisfactory answers.

4. I understand that I can withdraw the participant from the study at any time without
prejudice to their relationship with the Prince of Wales Hospital and South East
Sydney Illawarra Area Health Service or the University of New South Wales.

5. I agree that research data gathered from the results of the study may be published
provided that the participant can not be identified.

6. I understand that if I or the participant have any questions relating to my participation
in this research, I may contact Claire Thompson at POHW on 9382 3736, Dr Julie
Henry on 9385 3936, who will be happy to answer them.

7. I have been given the telephone number for an Executive Officer of the Internal
Ethics Committee (Research Ethics Co-ordinator, telephone number: 9382 3567)
should I wish to make a complaint about the conduct of this research.

8. I acknowledge receipt of this consent form and the Participant Information
Statement.

________________________________________
Signature

________________________________________
Please print name

________________________________________
Date
APPENDIX B.

Tasks encountered in Virtual Week in Study 1 and Study 5.

Study 1: Baseline

Trial Day
- Take favourite children's book when you visit a school
- Phone plumber at 4 p.m.
- Take medication at 12 noon
- Take vitamins with dinner

Monday
- Drop in dry cleaning when you go shopping
- Phone bank at 10 a.m. to arrange an appointment
- Take medication at 12 noon
- Take vitamins with dinner

Tuesday
- Pick up your pool membership pass when at the swimming pool
- Get a hair cut at 1 p.m.
- Take medication at 12 noon
- Take vitamins with dinner

Study 5: 1-year Follow Up

Trial Day
- Phone Julie at 10 a.m. to invite her to lunch
- Buy new batteries when you go to the supermarket
- Take antibiotics with dinner (6 p.m.)
- Check your blood pressure at 11 a.m.

Monday
- Physiotherapy appointment at 10 a.m.
- Pick up your new reading glasses when you go to the shopping centre
- Take antibiotics with dinner (6 p.m.)
- Check your blood pressure at 11 a.m.

Tuesday
- Phone the dentist at 12 noon to change you appointment
- Take snacks for the movies when you leave home to go to the cinema
- Take antibiotics with dinner (6 p.m.)
- Check your blood pressure at 11 a.m.