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An investigation into prospective memory performance in normal ageing and dementia

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An investigation into prospective memory performance in normal ageing and dementia.

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Abstract

Prospective memory is the implementation of a previously formed intention, or the ability to remember to do something at some designated point in the future. It is a ubiquitous feature of everyday living (e.g. remembering to take medication, buying supplies when necessary), and accordingly, has important implications for independent living, particularly for vulnerable groups. The motivation for this dissertation was to explore prospective memory in persons with dementia, a relatively under-investigated field of prospective memory. The study achieved this using a number of methods including training, self-report measures, and controlled experiment. The findings demonstrated a significant deficit in prospective memory for persons with dementia, which could not be accounted for by simple retrospective failure.

Additionally, the research hoped to identify the everyday circumstances that give rise to failure for older persons, and to investigate prospective memory systematically, under controlled conditions.

The study aimed to develop the prevailing research paradigm of Einstein and McDaniel (1990) to include aspects of multiple response, and ecological validity. The study also considered the effect of target-task relationship, learning, and the demands of the ongoing task on prospective performance. The findings suggest that processing demands made by the on-going task have a significant negative effect on prospective memory. This reduction in performance is greater for the older group. Further, the nature of the target-task, in conditions of multiple-response, has a significant effect on prospective performance; both old and young benefit from a congruent target-task pairing.

The findings are discussed in relation to prospective memory theory, and processing theories of ageing.

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One

Ageing and Memory

Defining Ageing

Ageing is a fundamental part of human life. It is an inevitable process affecting biological, social, and psychological aspects of the individual. Despite the ubiquity of the term, its definition is fraught with ambiguity. Birren & Cunningham (1985) point out "few researchers using the term aging define what they mean by it." (Birren & Cunningham, 1985 p.5)

With regards to psychological research, ageing is generally treated as an independent variable, and characterized in terms of an individual's chronological advancement. In accordance with this view, the term *old* usually refers to individuals aged 60 years and older (Craik, 2000). Still, there is no definitive agreement on what it means to be 'old' and a chronological cut-off point tends to be arbitrary. For instance, some studies (Maylor, 1993; Tombaugh, Grandmaison, Lawrence, Schmidmt and James, 1995) have included individuals as young as 50 years in the 'old' group. Thus, the vagueness of the idiom "old-age" surrounds even the apparently quantifiable variable of chronological age, and has led to the emergence of terminology such as: *young-old* and *old-old* (Neugarten, 1975; Soldo, 1980; Suzman & Riley, 1985.)

Age-related changes in Cognitive Function

Age-related changes in cognition have been a central focus for psychologists interested in adult development for both theoretical and practical reasons. From a theoretical view, it is important to understand how the processes of storage, transformation, and recall of information change because of age, and if this change can be correlated with age-related changes in brain structure and function. From a practical view, it is important that age-related decline in cognition does not threaten the individual's safety, independence, and well-being. Both approaches are particularly relevant in contemporary, industrial societies where ageing of the population is increasing and age-associated problems must be managed.

Before discussing patterns of age–related change in cognition, it is important to highlight methodological issues in age-related research generally. The predominant data collection strategy used in age-related research is a cross-sectional design, presumably because this design is more efficient (in terms of both time and cost) than the longitudinal approach (Salthouse, 2000). However, it is widely accepted that cognition can be influenced by a variety of variables, in addition to age. Notable examples include educational status, socio-economic status, gender, health status, and even time of day. As a result, cross-sectional studies, comparing individuals from different age-groups, may be prone to bias. To illustrate, on a number of neuropsychological tests the average score for older people is typically lower than that for younger people.

However, such findings frequently underestimate the variability in performance by the older group. As a sample, older people tend to demonstrate wider variance in performance than a younger population, with some members of the older group performing as well, or better than younger individuals, and some older persons performing at a level associated with a clinical dementia (Lindenberger, Mayr & Kliegl, 1993).

In view of this caveat, it would seem that the best way to understand how cognitive function changes over time is by adopting a method that entails each individual acting as their own control at various ages; i.e. longitudinal studies. However, although longitudinal research controls for variation in individual performance, therefore allowing direct measurement of change in specific cognitive functions as the ageing process occurs, it is not without its limitations. In particular, the time-consuming nature of the research, higher cost, and operational complications are accepted restrictions to this type of research. Furthermore, interpretation of the findings from longitudinal studies can be hampered by subject attrition[1], floor or ceiling effects, and the ambiguity of analytical measures employed (with particular reference to research published before the 1980's) (McArdle & Anderson, 1990; Rogosa,

[1] In particular, positive selection bias. This underestimates age-related decline because individuals who are retested are often superior in terms of demographics and baseline cognitive function than those who fail to return (Hultsch et al. 1998; Schaie 1996) Additionally, Perls et al. (1993) examined influence of selective survival on cognitive function. Found group of 90-99 year olds performed better than 80-89 yr old group due to selective survival. Also Sieglar and Botwinick (1979) found individuals who were able to complete 5 longitudinal test sessions were 15 points higher on baseline WAIS than remaining sample.

1988). Nonetheless, in terms of controlling confounding variables inherent to age-related research, longitudinal studies provide one of the best approaches to understanding how cognition changes due to the ageing process.

Cross-sectional studies have the advantage over longitudinal studies in terms of addressing the need to examine the effect of age on cognition in a relatively short time. The cross-sectional approach involves comparing samples of individuals from various age ranges. Substantial numbers can be studied over a (reasonably) short time and variations in performance according to age group can be compared. However, it is then important to control for other factors such as educational level.

These variations in cognitive performance are perhaps most clearly demonstrated in large-scale studies that have included a broad range of ages. For example, Schaie (1996) demonstrated a linear age-related decline in a number of aspects of cognition, including: inductive reasoning, spatial tasks, perceptual speed, and episodic memory, but not vocabulary. The decline in these areas appears to be monotonic, slowing decreasing from about age 30, falling below the standard score around age 60, and continuing to significantly decline to age 80.

This pattern of age-related decline has been found in similar cross-sectional studies (e.g. Park, Smith, Lautenschlager, Earles, Frieske, Zwahr & Gaines, 1996; Woodcock & Johnson, 1990). It would appear therefore that the ability to perform certain cognitive tasks (in particular, measures of processing speed) deteriorates with age, but this impairment is not uniform across all cognitive domains. Moreover, there is no general consensus regarding which aspects of cognitive decline are a result of normal ageing, and which are due to the onset of a pathological process, such as a dementia (Wilson, Bennett and Swartendruber, 1997).

Age-Related decline and sparing in memory function:

To a great extent, the majority of research conducted in the field of memory and ageing has been motivated by the question of which memory tasks show a decline, and which are spared. Additionally, enquiry into memory and ageing appears to reflect common trends and approaches in psychological theory, for instance, cognitive neuroscience perspective, cognitive theory, and processing theory.

Overview of Theoretical Approaches to Ageing and Memory

Information Processing Theories

One of the most influential theories of age related decline in cognition is the *processing resource hypothesis* (Craik, 1986; Craik & Bryd 1982; Salthouse, 1982, 1991). This view proposes that processing capacity (or the related concepts of 'processing resources' or 'mental energy') diminishes with age, and produces a deficit in cognitive tasks. This deficit is greatest in tasks that require some degree of manipulation, for example high-load working memory tasks, since they place excessive demands on the available processing resources.

Another variant of the processing resources approach to memory is Craik's (1986) *environmental support hypothesis*. This is a functional account of memory that considers memory in terms of an interaction between external and internal factors. In proposing this model, Craik (1983, 1986) drew attention to the fact that models of memory were too concerned with internal processes and mechanisms, and as a result, neglected the influence of the environment on the individual. Craik proposed that models of cognition should move away from the view that all processes and mechanisms operate internally within the individual. Instead, he advocated that a theory of cognition should consider the interaction between both internal processes and external influences. Craik asserted that cognitive performance is determined by an interaction between processes that are driven by external influences (for example environmental support such as context and retrieval cues) and processes that originate within the individual (mental processes and operations). Craik termed this self-initiated activity and predicted that since processing resources declines with age, older adults would be more impaired on tasks requiring a higher degree of self-initiated activity (such as retrieval). In support of this view, Craik (1986) reported findings demonstrating a pattern of performance in which performance on recognition memory (which has a high degree of environmental support) is better than performance on free-recall (which is predominantly self-initiated and resource-demanding).

In line with this hypothesis, it is predicted that age-related decrements in memory can be reduced by the availability of greater environmental support at the time of encoding and retrieval, or by encouraging deeper levels of processing to provide internal support. However, experimental support for this hypothesis is mixed (Light 1991) with some studies showing older people benefit more from encoding support than the young (e.g. Rabinowitz, Craik & Ackerman, 1982), some showing equal benefits for young and old (e.g. Bäckman & Mantyla, 1988; Nilsson & Craik, 1990) and some demonstrating disproportionate benefits in favour of the young (Perlmutter 1979).

Speed of Processing

A number of cognitive theorists (e.g. Cerella, 1985; Salthouse, 1991, 1996) have proposed that age-related decline in memory performance is a result of reduction in processing speed. It is argued that cognitive processes slow down as an individual ages, and this slowing can account for the age-related variance in a number of cognitive tasks. In support of this view, Salthouse (1991, 1992) found that age-related variance on working memory tasks are significantly decreased when the variance attributed to speed of processing (as measured by perceptual speed tasks) is partialled out. Furthermore, the variance in performance is typically greater for speed of processing than other processing indices, for example working memory capacity.

Salthouse (1996) proposes that the relation between speed of processing and age-related changes in memory can be explained in terms of two mechanisms: the *limited time mechanism* and the *simultaneity mechanism.* According to the *limited time mechanism*, age-related decline occurs because the older individual runs out of the time needed to complete complex tasks, with the available time having been used up during the completion of early processes. Whereas age-related decline is explained by the *simultaneity mechanism* in terms of early processing outcomes being lost before they can be used for later processes.

Inhibitory Control

Age-related decline in cognition has been explained in terms of a deficiency in inhibitory control (Hasher & Zacks, 1988; 1999). This view predicts that as individuals age, the ability to inhibit irrelevant material declines. The consequence of which is a "mental clutter" of superfluous material that reduces the functional size of working memory.

Hasher, Zacks & May (1999) propose three components of inhibitory control: *access, deletion,* and *restraint.* When functioning properly; the access function prevents goal-irrelevant material from gaining access to working memory; the deletion function suppresses any irrelevant material that has been inadvertently activated, and the restraint function prevents strong, but situationally inappropriate responses from gaining control of thought/action. Accordingly, when the mechanisms of inhibitory control are operating efficiently, only relevant responses are allowed for consideration.

Hasher, Zacks & May (1996; 1999) hypothesise that these mechanisms do not work together effectively in older adults, resulting in more extraneous information in working memory during encoding. In terms of cognitive performance, the inefficient inhibition of irrelevant information interferes with the processing of relevant material, leading to slower and more error prone retrieval of the task information. In support of this view, experimental studies of directed forgetting (Zacks et al., 1996) found that older adults were less able to suppress items that were cued as, 'to be forgotten', implicating a difficulty with disinhibition in older adults.

Cognitive Neuroscience perspective

This perspective hopes to identify age-related changes in behaviour with corresponding changes in brain structure. In particular, the decline in learning and memory function and the corresponding changes to the prefrontal cortex and hippocampus.

It is well documented that an older brain differs from a younger brain on a number of global and physiological measures, and it is probable that such differences account for some of the cognitive changes that accompany ageing. However, it is only relatively recently that the field of cognitive neuroscience has attempted to directly correlate such structural change with behavioural measures of cognition.

Age–related physical changes in the brain: Global changes in Neuroanatomy and physiology

The following subsection is a cursory appraisal of the main structural and neurochemical changes in the ageing brain. It is beyond the scope of this review to evaluate all physiological changes that occur in the ageing brain along with any corresponding changes in cognitive function. Instead, the focus will be upon structural and neuronal changes in the brain and their implication in age-associated declines in memory.

Structural Changes

A fundamental aspect of age-related change in the brain is shrinkage; throughout adulthood, the brain reduces in both weight and volume. Tissue loss is evident in the gyri, which demonstrate shrinkage, and the sulci, which widen and become more prominent with age (Haug & Eggers, 1991; Stafford, Albert, Naeser, Sandor & Garvey, 1988). This decline approximates to about 2% per year (Kemper, 1994). However, the decrease is not uniform; some structures for example, the hippocampus and dorsolateral prefrontal cortex, exhibit greater atrophy compared with others, e.g. the cerebellum (Coffey, Wilkinson, Parashos, Soady, Sullivan, Patterson, Figiel, Webb, Spritzer & Djang, 1992). There is also some debate whether this decline occurs from early adulthood (about age 20) and continues in stable linear rate (Mueller, Moore, Kerr, Sexton, Camicioli, Howieson, Quinn & Kaye, 1998); or if this decline accelerates after middle to late adulthood (about age 50). (Salonen, Autti, Raininko, Ylikoski & Erkinjuntti, (1997)).

A possible reason for the apparent late-life accelerated deterioration could be the inclusion of individuals with preclinical conditions, such as Alzheimer's disease in the sample. In support of this theory, Fox, Crum, Scahill, Stevens, Janssen & Rossor (2001) examined the rates of atrophy over 5 years in individuals with a genetic predisposition to AD, who were not exhibiting clinical symptoms of the disease at the beginning of the study and compared them with healthy controls. The results revealed a significant atrophy in the medial temporal lobes of the patient group. Thus suggesting that disease may be responsible for the structural alterations seen in the ageing brain, and consequently, large changes seen in cross-sectional studies may reflect the presence of preclinical dementia in the older sample. In view of this explanation, the general consensus seems to be in the healthy older brain; the rate of decline occurs from young adulthood and continues at this pace, although the cumulate effects are not generally noticed until older age.

Neuronal changes

The main reason for brain shrinkage is the loss or atrophy of neurons. Originally, it was thought the reason for brain shrinkage was the reduction of neurons with advancing age. Past studies (Brody 1955) estimated that the loss was up to 100,000 neurons per day, or a decline of about a 50% of neurons per gram of tissue from age 20 to 80 years (Devaney & Johnson, 1980[2]; Henderson, Tomlinson & Gibson, 1980[3].) However, evidence from more recent studies, using more precise techniques (Mouton, Pakkenberg, Gundersen & Price, 1994[4]; West, 1994) suggest that the magnitude of neuronal loss may have been exaggerated due to the inadequacies of previous measurement techniques (Long, Mouton, Jucker, & Ingram 1999). Instead, it has been proposed (Katzman 1995; Long et al., 1999; Terry, DeTeresa & Hansen, 1987) that shrinkage, synaptic (or receptor) loss, and signal deficits, rather than neuronal death may be a more decisive age-related change. Furthermore, neuronal loss is regional and selective rather than global (West, 1993).

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[2] This method adopted the technique of using a hemacytometer and was restricted to the visual cortex. However, the findings were consistent with the results of other studies using different techniques.

[3] Adopted the technique of computer image analysis.

[4] In response to the controversy surrounding the degree of age-related neuron loss, a new generation of stereological techniques were developed to produce more accurate estimates of total neuron number.

Neurochemical Changes

A related issue of neuronal atrophy is the change in the network of communication among the cells. In particular, some regions for example the hippocampus experience an age-related reduction in dendritic branching (Haug & Eggers 1991). A significant reduction of dendritic branching in this structure is also associated with Alzheimer's disease (Teri, Masliah, Salmon, Butters, DeTeresa, Hill, Hansen & Katzman 1991). Conversely, normal age-related cell loss in the hippocampus appears to be more region-specific and distinct from the pattern of loss seen in AD. For example, in normal ageing, the brain exhibits no reduction in dendritic length or cell loss in the CA1 field of the hippocampus (Sommer's sector). By contrast, in Alzheimer's disease, the brain displays a significant loss of neurons in this region (Price, Ko, Wade, Tsou, McKeel & Morris 2001; West, Coleman, Flood, & Troncosos, 1994.)

Reduced dendritic branching is presumed to affect both efficiency and strength of inter-neural communication by reducing the concentration of certain neurotransmitters. With normal ageing, a number of changes have been documented in neurotransmitter systems (enzymes, receptors, and neurotransmitters). For example, choline *O*-acetyltransferase levels tend to decrease; the number of cholinergic receptors tends to decrease; and g-aminobutyric acid, serotonin, and catecholamine levels usually decrease (Poirier & Finch, 1994).

A profound decrease in Choline *O*-acetyltransferase (CAT) levels is also found in persons with Alzheimer's disease.

The cholinergic system is of particular relevance since it is believed to play a vital role in memory (Bartus, Dean, Beer & Lippa, 1982; Gold, 2003; Whitehouse, 1998).

The cholinergic hypothesis evolved in the early 1970's as a result of biochemical research into learning and memory (Drachman & Leavitt, 1974) and Alzheimer's disease (Bowen, Smith & White, 1976; Davies & Maloney, 1976; Perry, Gibson & Blessed, 1977). The incentive of such investigations was to identify a specific neurochemical abnormality in Alzheimer's disease, and subsequently develop a pharmacological treatment. Since this time, numerous studies have provided support for the cholinergic hypothesis (for reviews see Francis, Palmer, Snape & Wilcock, 1999; Muir, 1997; Terry & Buccafusco, 2003). For example, research has identified a wide range of cholinergic abnormalities known to exist in both ageing and Alzheimer's disease, including a significant correlation between the reduction of Choline acetyltransferase activity in cerebral cholinergic neurons, and the severity of cognitive impairments observed in both Alzheimer's disease and ageing. However, despite these findings, and the development of cholinomimetic drugs officially approved for treatment (e.g. acetylcholinesterase inhibitors such as donepezil, rivastigmine, and galantamine) the promise of a pharmacological remedy based on the cholinergic hypothesis remains unfulfilled (for reviews of clinical trials see Kaduszkiewicz, Zimmermann, Beck-Bornholdt, & van den Bussche, 2005; Ritchie, Ames, Clayton, & Lai, 2004). As such, at the present time, there remains no 'cure' for Alzheimer's disease (Desai & Grossberg 2005; Francis et al., 1999).

Nevertheless, the body of evidence indicating that the memory deficits evident in both advancing age and Alzheimer's disease are attributable to a dysfunction of the central cholinergic system would defend the cholinergic hypothesis as a functional theory of abnormal ageing.

Neuropsychology and Neuroscience of Memory

The previous sections presented evidence for physiological changes in the ageing brain. The following section will consider the significance of these changes in relation to the cognitive function of memory.

Several dissociable types of memory exist, and these are mediated by different neurological structures and subsystems. In view of the known physiological changes associated with ageing, an important issue to be addressed is the extent to which memory performance is affected by ageing. For instance, are age-related changes selective, with some memory systems showing more impairment than others? Alternatively, are age-related changes equivalent, affecting different memory processes in a uniform manner?[5]

This issue can be tackled in two ways, firstly by drawing upon neuropsychological evidence from people with amnesic syndrome (with known damage to particular brain regions) and comparing patterns of performance with that of older adults. The expectation from this perspective would be that a qualitatively similar pattern of memory performance, differing in degree of severity, should emerge.

[5] For more detailed review of age-related behavioural performance on memory function, see section: Patterns of change in memory.

The second, and more current, approach is with the use of neuroimaging techniques, in this way the relation between structural damage and memory performance can be directly explored (Raz 1998).

Structures Associated with Memory: Medial temporal lobe

Neuropsychological evidence

The hippocampus and associated cortex in the medial temporal lobes are most widely identified as mediating memory function (Kapur, 1999; Press, Amaral & Squire, 1989; Squire, 1992; Squire & Zola, 1998; Vallar & Shallice, 1990). Damage to this region (displayed in amnesia cases) leads to a profound loss of memory for new episodic and semantic memories, despite intact perception, intelligence, and motivation (Press et al., 1990; Vargha-Khadem et al., 1997).

In general, most cases of amnesia follow insult to the medial temporal lobes or diencephalon (Cohen & Squire, 1980; Kapur, 1999; Squire et al., 1992; Wheeler & McMillian 2001). However, the medial-temporal lobe system consists of a number of structures, including the hippocampus, parahippocampal gyrus, and entorhinal cortex. Accordingly, both the degree of damage, and the severity of amnesia vary considerably. For example Zola-Morgan, Squire & Amaral, (1986) cite cases of anterograde amnesia resulting from damage limited to the CA1 field of the hippocampus. In comparison, when damage extends to other structures (e.g. the entorhinal cortex) the anterograde amnesia is more severe and the temporal extent of the retrograde amnesia is extended by one or two decades prior to injury (Corkin, Amaral, Gonzalez, Johnson & Hyman, 1997).

The pattern of amnesia also varies according to the laterality of the damage. For instance, unilateral lesions to the left temporal lobe can lead to specific deficits for verbal information, whereas unilateral lesions to the right can lead to specific deficits for non-verbal material (Milner 1971) By contrast, bilateral medial lobe damage results in global impairment and an inability to form any new memories (Scoville & Milner, 1957; Viskontas, McAndrews & Moscovitch,2000).

Perhaps the foremost example of this is characterised by Milner's work on H.M. (Scoville & Miller 1957). After bilateral resection of his medial temporal lobe structures (hippocampus, entorhinal cortex, parahippocampal gyrus and portions of the temporal cortex), H.M. suffered a global amnesia, affecting several classes of information, (semantic and episodic). He also experienced retrograde amnesia for the 10 years prior to surgery.

H.M. was unable to form any new explicit long-term memories; being equally impaired on both recall and recognition tasks. However, H.M.'s immediate and implicit memory was relatively intact.

This profile of memory dysfunction provides evidence in support of the role the medial-temporal lobe and diencephalon play in memory storage and retrieval. However, as highlighted in other cases of amnesia (Zola-Morgan, et al., 1986; Corkin et al., 1997; Viskontas et al., 2000), variation exists both in severity of memory dysfunction, and location and size of the lesion (Kapur 1999)

Neuroimaging Evidence

The emergence of functional neuroimaging technology has greatly advanced understanding of the ways in which neural systems mediate memory. This 'on-line' technique allows changes in cerebral activity to be measured as a cognitive task is being performed. In this way, the brain regions recruited for different memory processes may be identified.

Functional neuroimaging studies have shown that the medial-temporal lobe is implicated during encoding and retrieval of information (Gabrieli, Brewer, Desmond & Glover, 1997). The medial-temporal lobe activations are greater during the encoding of initial material than previously seen material, implying an effect of novelty, or familiarity, on encoding (Tulving, Markowitsch, Kapur, Habib & Houle, 1994).

In line with neuropsychological evidence, imaging evidence also reveals a laterality effect in metabolic activation. During the encoding of verbal material, activations are left-lateralized, and are right-lateralized for non-verbal stimuli (Kelley et al., 1998).

Level of activation during encoding has also been identified as predictor for successful recall. Event-related fMRI studies, which record separate activation values for each stimulus, have reported a relationship between the level of parahippocampal activation during encoding and the probability of successfully recalling the stimulus (Brewer, Zhao, Desmond, Glover & Gabriele, 1998; Wagner, Schacter, Rotte, Koutstaal, Maril, Dale, Rosen & Buckner, 1998). Thus, suggesting greater activation levels during encoding predict successful recall.

The medial-temporal lobes also participate in retrieval of information. Hippocampal activation levels are greater for well-remembered material than poorly remembered material (Schacter, Savage, Alpert, Rauch, & Albert, 1996). Additionally, the magnitude of activation observed in the anterior hippocampus is reported to be positively correlated with retrieval accuracy (Nyberg, McIntosh, Houle, Nilsson & Tulving, 1996).

Findings from fMRI research (Gabrieli et al., 1997) confirm the role medial-temporal lobe structures play during encoding and retrieval of information. Different structures appear to play distinct roles in mediating memory performance, with parahippocampal activations occurring during encoding, and activation in the sublicuum occurring during retrieval.

In conclusion, evidence from both neuropsychological cases and neuroimaging suggests that medial temporal lobe plays a significant role in successful explicit memory, in terms of both storage, and retrieval.

Medial temporal lobes, ageing and memory

The basic profile of individuals with damage to medial-temporal structures is one of an inability to form or retain new episodic long-term memories, together with relatively spared immediate, implicit, and remote memory. In view of this conclusion, the question arises as to whether a medial temporal lobe dysfunction characterizes the pattern of memory performance for older adults. Obviously, the physical effects of normal ageing are less dramatic than in cases of amnesia, where extensive damage has occurred, so it would be expected that the deficits shown in normal ageing should be less severe. However, what is of interest is the similarity in pattern of memory impairment between older adults and neurological groups.

Experimental evidence

Consistent with a medial temporal-lobe dysfunction in ageing, older adults perform less well than young adults on delayed recall tests of newly learned material for both recognition and recall (Craik & Jennings 1992; Craik, 2000; Zacks, Hasher & Li, 1999). Furthermore, ageing effects are not generally found for immediate memory, as measured by digit span (Gregoire and Van der Linden 1997) and most measures of implicit memory (La Voie & Light 1994). This pattern of impairment is similar to the memory deficits observed in amnesia, and would imply that medial temporal lobe dysfunction is implicated in age-related decline of memory performance. However, in contrast to amnesic performance, older adults demonstrate a marked improvement in performance for cued-recall and recognition compared to free recall of material (Smith, 1996). Additionally, unlike the amnesiac profile, ageing effects have been reported for priming tasks, for example word stem completion (Davis, Cohen, Gandy, Colombo, Van Dusseldorp, Simolke & Romano, 1990; Titov & Knight, 1997). The discovery that such priming effects are consistent for people with amnesic syndrome, but not for older adults would indicate that the medial-temporal lobe is not involved in implicit memory. At the same time, it would suggest that this task might engage other cognitive processes (for example strategic processing) that recruit other brain regions, more susceptible to ageing effects. Moscovitch & Winocur (1995) propose that word stem completion studies engage frontal lobe mechanisms, which decline with age, selectively reducing priming on tests demanding strategic searches. However, this theory does not explain why patients with direct lesion to the frontal lobes are unimpaired on word-stem completion (Shimamura, Gershberg, Jurica, Mangels & Knight, 1992).

It would appear that some aspects of age-related memory loss exhibit amnesiac-like patterns of memory impairment, and can be linked to medial-temporal lobe dysfunction. However, such medial-temporal dysfunction is variable among older adults.

Structural Evidence

In an attempt to address the question whether age-related memory impairment arises from medial-temporal dysfunction, as opposed to a generalized neural decline, structural and imaging evidence will be considered.

As previously noted, some studies report medial-temporal lobe atrophy with age, in particular declines in hippocampal volume (Coffey, Wilkinson, Parashos, Soady, Sullivan, Patterson, Figiel, Webb, Spritzer & Djang, 1992; Jack et al., 1997). Yet other studies (Sullivan, Marsh, Mathalon, Lim & Pifferbaum, 1995) have found that hippocampal volume does not significantly change with age (although temporal grey matter does decline). In an effort to address the relationship between hippocampal volume and memory performance in ageing studies (Golomb, Kluger, de Leon, Ferris, Convit, Mittelman, Cohen & George1994; O'Brien, Desmond, Ames, Schweitzer & Tress, 1997) have examined individual hippocampal volume rates along with memory performance. Overall these studies have reported a correlation between hippocampal volume and performance on recall accuracy, with low volume associated with poor recall performance. Additionally, in a follow-up study four years after the original test, Golomb et al., 1996 reported that hippocampal formation size significantly predicted the magnitude of memory decline. This finding was robust even when demographic variables and general cortical atrophy (measured by cerebral volume estimates) were controlled.

Thus, in support of the medial temporal lobe dysfunction theory, the findings would suggest that hippocampal volume is not only correlated with current memory performance, but predicts the rate of decline over time. However, a caveat exists in the dysfunction theory: The evidence reviewed suggests a great deal of variability among older adults, not all older adults exhibit a decline in hippocampal volume, and accordingly not all older adults display poor recall.

Functional Evidence

Evidence from neuroimaging studies seems to support this conclusion. The findings from imaging studies comparing older and younger adults are currently inconclusive. For example, Grady et al., (1995) report a reduction in hippocampal and parahippocampal activations during encoding for older adults. In contrast, other studies (e.g. Madden et al., 1999; Schacter, Savage, Alpert, Rauch, & Albert, 1996) report equivalent activation for both age groups during successful recall. However, it ought to be noted that numerous differences in procedure and stimuli exist among these studies, (e.g. Grady et al. used faces; Madden et al. & Schacter et al. used words). Such a discrepancy in procedure makes it difficult to draw any firm conclusions relating to the effects of ageing on medial-temporal lobe activation.

It would appear therefore that the medial–temporal lobe dysfunction hypothesis is useful for explaining poor memory performance, but it is not an inevitable part of the ageing process. Moreover, it would appear that other brain structures (e.g. the frontal lobes) play a significant role in mediating memory performance.

Structures Associated with Memory: Frontal lobes

Neuropsychological studies of patients with focal brain lesions have highlighted the importance of medial temporal lobe and diencephalic structures in the formation and retrieval of long-term episodic memories (Scoville & Miller 1957; Squire and Cohen, 1980).

Generally, Frontal lobe lesions do not cause the same global amnesia that can result from medial temporal lobe lesions; recent and remote memories have been found to be intact after insult (Hecaen & Albert 1978; Janowsky, Shimamura, Kritchevesky, & Squire, 1989). However, frontal lesions are associated with impairments in memory tasks with more strategic demands, i.e. tasks in which the retrieved memories must be evaluated, manipulated, and transformed.

The frontal lobes occupy a substantial area of the brain, constituting approximately one third of the entire cortical mantle, and containing a number of distinct cytoarchitectonic regions. A number of reciprocal connections exist between the prefrontal cortex and the medial temporal lobe Goldman-Rakic, Selemon, & Schwartz (1984). Additionally, the prefrontal cortex has reciprocal connections with sensory association cortices including temporal and parietal regions, (Barbas, Ghashghaei, Dombrowski, &

Rempel-Clower, 1999) and many subcortical structures such as hippocampus, thalamus, and amgygdala (Thierry, Gioanni, Degenetais, & Glowinski, 2000).

The frontal lobes therefore are a heterogeneous structure, with extensive connections to other cortical and subcortical regions. Accordingly, they are thought to be responsible for a broad range of 'higher level' human behaviours, including control of social behaviour, affect, problem solving, planning, cognitive flexibility, and goal direct-behaviours. (Blumer & Benson, 1975; Luria, 1966; 1973; Stuss & Benson, 1984). These cognitive processes form the basis of what is referred to as; *executive functioning* (Goldman-Rakic 1987, Milner 1963).

The frontal lobes consist of a number of distinct regions, and it is hypothesised that each region is functionally specialized, as well as neuroanatomically dissociated (Petrides: 1998). However, these specialized regions may be recruited simultaneously, as a network, in order to solve cognitive problems (Duncan & Owen 2000).

One approach to differentiating aspects of frontal lobe functioning is based upon fundamental neuroanatomical distinctions. Traditional classification divides the prefrontal cortex into four distinct areas: The anterior, dorsolateral, ventrolateral, and medial regions. (Fuster, 1980; Goldman-Rakic, 1984; 1987).

The Dorsolateral Prefrontal cortex (DLPFC) is part of the archicortical trend originating in the hippocampus. At least four rather distinct regions have been identified within the DLPFC: the region surrounding the principle sulcus, the inferior convexity, the region surrounding the accurate sulcus, and the frontal eye field (Goldman-Rakic, 1987[6]).

Much of what is known about frontal cognitive function in neuropsychological studies is based on patients with DLPFC dysfunction. Lesion evidence suggests the DLPFC is involved in reasoning, memory and other executive functions. Table i.i summarises the main characteristics of memory performance in human neuropsychological cases.

[6] These functional distinctions are based on the non-human primate brain. The human equivalents are somewhat less clear (Kertesz, 1994.)

Table i.i Summary of memory Impairment after lesion to prefrontal cortex: Neuropsychological Evidence.

Memory Process	Performance relative to controls	Study
Meta memory	Impaired	Janowsky et al. (1989)
Remote memory	Normal	Janowsky et al.(1989)
Recency discrimination	Impaired	Landavas, Umilta& Provinciali, (1979); Milner (1971)
Contextual detail: *source*	Impaired	Schacter, Harbluk & McLachlan (1984)
Contextual detail: *Temporal order*	Impaired	McAndrews & Milner, (1991); Shimamura, Janowsky & Squire, (1990)
Short term retention	Normal	Stuss& Benson (1984)
Spatial span	Normal	Owen, Downes, Sahakian, Polkey & Robbins, (1990)
Short term retention with Proactive interference	Impaired	Milner, (1964); Stuss & Benson, (1984); Incisa Della Rocchetta and Milner, (1993).
Visuo-spatial Short-term working memory	Impaired	Gron, (1998);Owen, Sahakian, Semple, Polkey & Robbins, (1995)
Auditory working memory	Impaired	Gron, (1998)
Executive functions *e.g. attentional set shifting Planning ability*	Impaired	Owen, (1991)
Recognition	Normal	Janowsky et al (1989)
Delayed recall	Impaired	Janowsky et al. (1989)
Prospective memory	Inconclusive, but generally some impairment	Shallice & Burgess, (1991); Cockburn(1995)

Neuropsychological evidence for the role of the frontal lobes in memory performance.

Clinical studies of patients with brain lesions have made a significant contribution to our understanding about the functional organization of human memory processes. Lesions, predominantly in the medial-temporal lobe (discussed earlier), and the frontal lobes have resulted in memory deficits that provide indicators about what brain regions are involved in which memory processes.

Table i.i summarises the pattern of deficits shown in frontal lobe patients. In general, the role of the frontal lobes in memory appears to be one of control and direction rather than true amnesia.

Frontal lobe lesions are shown to compromise performance on strategic memory tasks, despite normal performance on recognition tests. This pattern is in contrast to medial-temporal lobe amnesia where performance on both strategic and non-strategic memory tasks is equally severely impaired. Patients with frontal-lobe lesions have disproportionate impairments on tests of free recall (Janowsky et al., 1989), recency, or temporal order judgments (Milner 1971), frequency judgments (Stuss & Benson, 1984), and recollection of the source of information (Landavas et al., 1979; Janowsky et al., 1989).

The observation that patients with prefrontal cortex damage usually perform poorly at discriminating the source of information, yet remain relatively unimpaired at recognition, has led to the view that the prefrontal cortex is crucial for retrieval, but less important for familiarity-based memory (Schacter et al., 1984; Simons et al., 2002). However, recollection and familiarity tasks are not always matched for difficulty; consequently, it is possible that patients with frontal lobe perform more poorly at source recollection because it is more difficult and requires greater cognitive resources than item recognition (Simon & Spiers, 2003).

Frontal patients also perform poorly on problem-solving or reasoning tasks that require the generation, flexible maintenance, and shifting of plans, such as the Wisconsin Card Sorting Test and the Tower-of-London Test (Owen, 1991) as well as working memory based tasks (Owen et al., 1995).

In accordance with this, prospective memory is shown to be impaired in the tasks requiring executive elements, and a high degree of self-initiated activity. In particular, poor performance seems to be a failure of initiation and the inhibition of on-going behaviour, rather than memory. (Shallice & Burgess, 1991; Cockburn, 1995).

Additionally, similar patterns of deficit in strategic memory tasks are demonstrated in patients with degenerative or developmental diseases of the basal ganglia, such as Parkinson's disease (PD) and Huntington's disease (HD) (Gabrieli 1996). Furthermore, such strategic memory and reasoning deficits are correlated with working memory capacity, which is also significantly reduced in PD and HD patients. Since PD patients have severely reduced dopamine functioning, and dopamine treatment can enhance working memory performance in PD patients (Cooper, Sagar, Doherty, Jordan, Tidswell, & Sullivan 1992), this would imply the neurotransmitter dopamine might play an essential role in mediating working memory.

The overall pattern of deficit suggests that fronto-striatal lesions reduce working memory capacity, limiting reasoning ability, which results in impaired strategic memory performance.

Thus, it may be concluded frontal-lobe contribution to memory may be one of manipulation, reasoning, and control processes that serve to facilitate memory encoding and retrieval, rather than one of an automatic storage process.

However, whilst lesion studies are a valuable source of information regarding the role of brain structure in cognitive function, the conclusions drawn are limited by the inexact nature of the insult. Naturally occurring lesions (e.g. disease or TBA) often impair multiple brain systems, either by direct insult, or by severance of the interactive connections to other brain regions. It is therefore difficult to ascertain which deficit is the consequence of which part of a lesion. Furthermore, compensatory processes, reorganisation, and adjustments in strategy may atone for any deficits arising from regional damage.

Therefore, when considering the evidence provided by lesion studies, it should be borne in mind that the performance of memory-impaired patients does not clarify what process is sub-served by the damaged region, but rather it reflects what intact brain regions can accomplish after the lesion (Gabrieli, 1998).

Although lesion studies continue to be a valuable source of evidence, it is important that conclusions drawn are corroborated by functional imaging techniques in order to identify the brain regions recruited for different memory processes. In the past decade, functional neuroimaging studies (Cabeza & Nyberg 2000) have greatly enhanced understanding of the role of the frontal lobes in memory, in ways not possible with lesion-only research. In particular, it is possible to identify more precisely which specific regions are involved in which memory processes as they occur.

Neuroimaging evidence for the role of the frontal lobes in memory performance.

A number of theories or models have been proposed in an attempt to unite localisation and function. These are largely based upon findings from neuro-imaging and neuropsychology, but are also inspired by predictions from general cognitive theory.

HERA Model: Hemispheric Encoding/Retrieval Asymmetry

Neuroimaging studies have consistently reported engagement of the prefrontal cortex during episodic memory performance (Desgranges, Baron & Eustache 1998; Gabrieli, 1998). Moreover, the two hemispheres of the prefrontal cortex exhibit different roles in the processes of encoding and retrieval (Nyberg, Cabeza & Tulving 1996; Tulving, Kapur, Craik, Moscovitch& Houle, 1994).

Encoding is associated with activation of the left pre-frontal cortex, (Brodmann's areas 45/46, 47/10) whereas retrieval is associated with activation of the right prefrontal cortex (Brodmann's areas 10, 46, 44, 6).

This pattern of findings led Tulving et al. (1994) to propose the hemispheric encoding/retrieval asymmetry (HERA) model. This contends that the two hemispheres are functionally separate; in that, the left prefrontal cortex is implicated in the encoding of episodic information, and processing of semantic information, whereas the right prefrontal cortex is concerned with the retrieval of episodic memories.

More recent evidence, (Kelley et al., 1998; Simmons, Graham, Owen, Patterson, & Hodges, 2001) however, indicates that lateralization within the prefrontal cortex might depend as much on the type of material being remembered as on the memory process being undertaken, for example verbal or non-verbal material (Kelley et al., 1998;) or familiarity of objects and faces Simmons et al., 2001). Right prefrontal activations have been consistently found for words (Schacter et al., 1996a; Shallice et al., 1994; Squire et al., 1992; Tulving et al., 1994), faces (Haxby et al., 1996), scenes (Tulving et al., 1996), or meaningless objects (Schacter et al., 1995b). This pattern of activation is unusual in that it applies to both to verbal and nonverbal memories, (usually the expectation is that verbal material would show a left hemisphere lateralization).

In addition, right frontal lesions do not result in dramatic negative effects on declarative memory.

A possible interpretation for this pattern of activation is that right frontal retrieval activations reflect working memory processes that guide episodic retrieval (Hartley and Speer, 2000; Gabrieli, 1998). If right-frontal activation were necessary for retrieval, patients with right-frontal lesions would be globally amnesic because they would be unable to retrieve memories. Instead, however, deficits after right-frontal lesions are limited to more subtle impairments in strategic memory. For example, a right-frontal lesion in some cases can result in a tendency for false recognition responses (Schacter et al., 1996b).

Thus, it is more likely that right-frontal activation during retrieval reflects strategic monitoring or executive functions of memory retrieval. It would seem that this view goes some way toward explaining the counter intuitive nature of right frontal activations for some materials, as well as the dissociation between recognition and retrieval shown in patients with right-prefrontal lesions.

Therefore, the right prefrontal cortex does appear to play a crucial role in the strategic or executive aspects of retrieval. Accordingly, at least in healthy young brains, the HERA model seems to be a convincing model of brain localization and function.

CARA Model: Cortical Asymmetry of Reflective Activity

Despite the focus of studies concerning the role of predominantly right-frontal activations during retrieval, the HERA Model is not without criticism. Buckner (1996) argued that the HERA model underestimates the role of the left prefrontal cortex in the retrieval of episodic information. A number of studies have reported bilateral prefrontal activation during retrieval tasks (e.g. Bäckman et al., 1997; Buckner et al., 1995), indicating that the Left prefrontal cortex is regularly activated during both encoding and retrieval.

Such observations have led Nolde, Johnson & Raye (1998) to propose the cortical asymmetry of reflective activity (CARA) model. This model suggests that, as well the right prefrontal cortex, the left Prefrontal cortex is activated during remembering, dependent upon the demands of the task. In the case of simple memory tasks requiring *minimal* processing (e.g., temporary storage of activated information, or the comparison of two stimuli on some dimension) the right prefrontal cortex is sufficient to mediate this activity. However, in more complex memory tasks, requiring *reflective* processes (e.g. deliberate analysis of activated information, or more complex evaluation, or the initiation of self-cueing to retrieve information), additional processes mediated by the left prefrontal cortex are required, and left prefrontal activity is more likely to occur. Hence, the pattern of asymmetry as opposed to lateralization seen during complex tasks.

This view is also consistent with PET studies of prospective memory (Burgess, Quayle & Frith 2001; Okuda, 1998). Prospective memory involves a number of reflexive processes (planning, self-initiation, and maintaining intentions) and predictably, bilateral activation of the prefrontal lobes is exhibited during the maintenance period of the task. However, prospective memory is not exclusively a frontal task; during the realization period (carrying out the intention) activation is seen in the thalamus, along with a corresponding drop in right frontal activation. This suggests that the thalamus is involved in the recognition of the prospective cue and the retrieval of the intended response, whereas the 'working' or 'reflexive' elements of prospective memory; i.e. maintaining the intention in awareness whilst carrying out the secondary task, are mediated by the prefrontal cortex (particularly Bodmann's area 10).

The HERA and CARA models afford a greater understanding of the localisation and function of memory processing in the frontal lobes. However, both models are based on evidence derived from healthy young individuals. In terms of ageing research, this poses the question; do ageing brains exhibit the same or dissimilar pattern of findings?

Frontal lobes, ageing and memory

Structural Evidence

There are a number of reasons to suppose that age-related neurobiological changes that occur in the frontal lobes may account for the normal age-related decline in memory performance (Gabrieli 1995). It is well documented that working memory, reasoning, and strategic memory performance decline linearly across the life span (Park, et al., 1996; Schaie, 1996; Woodcock and Johnson, 1990).

At the same time, ageing is associated with structural deterioration of the frontal lobes, which begins earlier, and is more acute than other brain areas (Haug & Eggers, 1991). For example, a greater reduction in brain volume (mainly from cell shrinkage) is seen in the frontal cortex, than in other region across the cortex. This atrophy is particularly marked in the dorsolateral prefrontal cortex (Haug & Eggers, 1991; Terry, DeTeresa, & Hansen, 1987).

Functional evidence

Furthermore, functional changes are evident in the brains of older individuals. In particular, a state of hypofrontality has been reported (Gur, et al., 1987; Shaw, 1984). This refers to the state in which a there is a selective reduction in blood flow to the frontal cortex, and is in marked contrast to the state of hyperfrontality seen in young and early middle-aged individuals.

HERA model and Age-related findings: The HAROLD model

The HERA model proposed by Tulving et al., (1994) argues that the left prefrontal cortex is functionally distinct from the right. Whereas activation in the left PFC is prominent during the *encoding* of episodic information, the right prefrontal cortex is activated during the *retrieval* of episodic memories. For young adults, this pattern of activation is generally consistent (Nyberg et al.,1996; Tulving et al., 1994). However, for older adults, a number of studies (Cabeza, Grady et al., 1997; Grady 1995) have demonstrated a departure from the HERA model, and instead prefrontal cortex (PFC) activity tends to be less asymmetric for older adults than younger adults, and has been described by Cabeza, (2002) as the Hemispheric Asymmetry Reduction in Old Adults model (HAROLD).

The HAROLD model has been observed in a number of cognitive processes. For example, the domains of episodic retrieval (Bäckman et al., 1997; Cabeza, Grady et al., 1997), episodic encoding and semantic retrieval (Stebbins et al., 2002; Logan & Buckner 2001), working memory (Dixit et al., 2000; Reuter-Lorenz et al., 2000), perception (Grady et al., 2000) and inhibitory control (Nielson et al., 2002).

The dissimilarity in frontal activity between older and younger adults raises some interesting questions regarding age-related decline and sparing in cognitive function. One explanation for the bilateral (as opposed to asymmetrical) activation of older brains during retrieval is the *compensation* hypothesis. This theorizes that older adults attempt the asymmetrical right frontal activation used by younger adults during retrieval, but must additionally recruit left frontal sites to counteract, or compensate for age-related neurocognitive decline.

An alternative hypothesis is the *dedifferentiation* hypothesis; this proposes that the decrease in asymmetrical activity reflects an age related difficulty in spontaneously recruiting the regions that aid memory processing. This may be due to under-recruitment, in which the critical frontal region is not recruited as effectively, or non-selective recruitment, in which inappropriate brain regions are recruited and performance is disrupted (Logan, Sanders, Snyder, Morris & Buckner, 2002).

Recent research (Cabeza 2002; Logan, et al., 2002) comparing the activity patterns in young adults, low-performing older adults, and high-performing older adults, seems to favour a compensation hypothesis for high-performing older adults. The patterns of activity revealed a hemispheric asymmetry reduction in high-performing, but not in low-performing older adults. Thus suggesting that low-performing older adults recruited a similar network as young adults but used it inefficiently, whereas high-performing older adults compensated for age-related neural decline by reorganization of neuro-cognitive networks to recruit extra regions.

CARA Model and Age-related findings

The CARA model (Nolde et al., 1998) proposes that demanding, or complex retrieval tasks are more likely to elicit activation from the left, as well as the right prefrontal cortex. This pattern is evident in both younger and older adults for demanding retrieval tasks, such as contextual detail (Cabeza, et al., 2000; Schacter et al., 1996). However, on less demanding retrieval tasks, the younger adults show activity the right prefrontal cortex only (HERA model), whereas the older adults need recruit both hemispheres (HAROLD model). These findings are consistent with the CARA model, which would predict that older adults would have difficulty in spontaneously processing retrieval cues (usually for younger adults, right-prefrontal regions are sufficient to mediate this) and instead need to engage in more strategic retrieval processes, mediated by the left prefrontal cortex. As a result, there would be an increase in left prefrontal activation during retrieval, accounting for the asymmetrical pattern of activity exhibited by older adults during retrieval.

Both the CARA and HAROLD models are consistent with the predictions made by theoretical approaches to cognitive ageing discussed earlier. Whilst such cognitive theories do not explicitly make predictions regarding neurobiological basis of ageing, expectations can be inferred. For instance, both Processing Resource and Speed of Processing hypotheses discuss age-related cognitive decline in relation to inefficient processing resources. In terms of neuroscience, it can be inferred that such processing resources are a property of neural units, and accordingly, both cognitive theory and neurobiology may be linked to gain a better understanding of age–related cognitive decline.

For example, the Processing Resources view (Craik, 1986, Craik & Bryd 1982) proposes that processing capacity diminishes with age, and this reduction in resources produces a deficit in demanding cognitive tasks. In order to compensate for some of the mental declines that come with age, older adults need to recruit more neural units to attain the same level of resources generated by young adults. According to Reuter-Lorenz et al. (1999), older adults activate both hemispheres of the brain to remember what younger adults can remember using just one hemisphere.

However, such a compensatory process also is not without costs, (Bäckman & Dixon, 1992; Reuter- Lorenz et al., 1999). Whilst engaging additional regions of the brain is beneficial for older adults during basic memory storage tasks, the strategy is not as successful for more complex processing tasks. Reuter-Lorenz (1999) suggests that by recruiting regions for the simple memory tasks, it leaves them unavailable for the more complex tasks, in particular handling additional, or distracting, information. This prediction is consistent with cognitive resource theory, and experimental data, indicating that older adults' performance is impaired on tasks divided attention (Anderson, Craik & Naveh-Benjamin, 1998).

A similar line of argument can be applied for the linking of the cognitive theory of Speed of Processing and the HAROLD model.

Speed theories of ageing (Cerella, 1985; Salthouse, 1996) hypothesise that age-related deficits in cognitive performance are result of a generalised slowing in processing speed. This view predicts that older adults are slower to process information than younger adults, and this difference is exaggerated in difficult tasks, which require more cognitive procedures. Once more, it is feasible to assume that processing speed may be a function of the amount of neural activity. In order to counteract deficits, and increase the speed of processing, older adults need to recruit additional neural units, obtained by engaging both hemispheres. Therefore the Speed of processing theory is consistent with the HAROLD model, in that for older adults, the level of activity required for optimal performance is higher than for younger individuals, and consequently bilateral activity is seen. In contrast, younger adults are able to attain this speed of processing through unilateral activity.

Another cognitive theory of age related decline is the Inhibitory control theory (Hasher & Zacks, 1988; Hasher, Zacks & May, 1999). This view attributes age-related decline in cognitive performance to a corresponding decline in the ability to inhibit irrelevant material. The consequence of a deficient inhibitory control system is a 'mental clutter' of irrelevant material that gains access to working memory, reducing its functional capacity, and impairing encoding and retrieval operations.

Since it can be assumed that the PFC is implicated in inhibitory functions (D'Espotito, Postle, Jonides & Smith, 1999; Jonides, Smith, Marshuetz, Koeppe & Reuter-Lorenz, 1998; Shimamura, 1995), this view is consistent with the HAROLD model in that older adults need to recruit supplementary PFC regions involved in inhibitory processes in order to attain the same level of inhibitory control as young adults. In support of this perspective, Jonides et al. (1999) reported that inhibitory processes were not only associated with left ventrolateral prefrontal cortex activity, but also, age-related underperformance was associated with weaker activity in this region (Jonides et al., 2000).

This structural and functional evidence would imply that the frontal lobes are particularly sensitive to the deleterious effect of ageing. Accordingly, support is provided for a number of cognitive theories of ageing, as well as the neuropsychological models that deem frontal-lobe deterioration as directly accountable for age-related changes in cognition (Moscovitch & Winocur, 1995; West, 1996).

It would appear therefore that the PFC not only plays a critical role in the strategic elements of memory, but the susceptibility of this region to the deleterious effects of ageing may be accountable for an age-associated decline in cognition. A position supported by studies of cognitive ageing (Mittenberg, Seidenburg, O'Leary, & DiGiulio, 1989; Moscovitch & Winocur, 1995) in which age effects are most evident on the cognitive tasks and memory measures thought to be sensitive to frontal-lobe dysfunction.

Patterns of change in Memory

It is widely acknowledged by cognitive theorists (e.g. Baddeley, 1990,1995; Craik, as cited in Park 2000; Cohen, as cited in Squire and Butters 1984; Eysenck, 1993) that memory is not a unitary construct, but rather "an alliance of inter-related subsystems" (Baddeley, as cited in Baddeley, Wilson and Watts, 1995, p.9). Accordingly, what is of interest in terms of ageing research is which types of memory are vulnerable to decline, and which are spared in old age.

Short term memory

Short-term memory (STM), also described to as *primary memory* (Waugh & Norman, 1965) refers to a limited storage capacity memory system. The defining features of STM are the limited capacity, typically about seven plus or minus two units (Miller 1956), and the brevity of storage; information is rapidly forgotten. STM on average has a maximum retention of about 19 seconds (Peterson & Peterson, 1959). STM usually is measured using span-paradigms.

In terms of ageing research, short-term memory span shows a small, but reliable decline with age. The average digit span for young adults is about six or seven items whereas for older adults, this average declines to five or six items (Parkinson, 1982). However, the age-related deficit in span is exacerbated if the task requires some kind of manipulation, e.g. backward span (Babcock & Salthouse, 1990; Gick and Craik, 1988).

Thus, it would appear, that whilst STM is not entirely spared the effects of ageing, the deficit is minimal

Working memory

The concept of short-term memory has been extended into what is now described as working memory (Baddeley, 1986, 1992; Baddeley and Hitch, 1974). Working memory is conceptualised as an active system that encompasses not only the temporary storage of information, but also the processing operations needed to make use of this information.

In essence, the working memory model is composed of two basic mechanisms: *storage* and *central executive functions* (Baddeley, 1986). The storage systems are comprised of two sub-systems. The Articulatory loop, responsible for the temporary storage of verbal information, and the Visuospatial sketchpad, responsible for the temporary storage visual information. Both sub-systems are seen as relatively passive slave systems, controlled by the central executive.

Arguably, the most important aspect of Working Memory is the Central executive. The Central executive is presumed to have limited storage capacity, but its main function is that of an active processor of information. It regulates how attention is directed, and which slave and strategy is utilised for the task.

The central executive is therefore conceptualised as a co-ordinator of the slave systems, as well as being responsible for the manipulation and transformation of information held in short-term memory.

Damage to the frontal lobes frequently results in impairments in central executive functioning (Gron, 1998; Owen, 1991). Baddeley (1986) conceived the term dysexecutive syndrome (DES) to describe dysfunctions of the central executive. The classic dysexecutive syndrome is characterized by; an inability to maintain attention, increased distractibility, a lack of flexibility including preoccupation with habitual actions and an inability to forward plan.

Ageing and working memory

Working memory is typically measured using a dual-task paradigm. This usually involves asking participants to simultaneously store and process information (Daneman & Carpenter, 1980). The idea is that working memory represents a negotiation for storage capacity between storage and processing components. Accordingly, resources allocated to the processing component, compromise information held in storage by making fewer resources available for the refreshing of this information.

There is a general consensus that working memory declines with age (Craik & Byrd, 1982; Moscovitch & Winocur, 1992; Park, 1996; Salthouse, 1994;

Salthouse & Babcock, 1991; Verhaeghen, Marcoen & Goosens 1993). Furthermore, this age-related deficit appears to reside in the processing, rather than storage, component of working memory (Gick, Craik & Morris, 1988; Salthouse & Babcock, 1991; Van der Linden, Brédart & Beerten 1994).

Thus, an age related deficit in working memory is generally a robust finding; however, the reasons for this are subject to debate. In line with the perspectives considered earlier, each theoretical model has discussed the deficits in relation to their respective views. For instance, Resource Processing theories (Craik, 1986) argue that WM deficits are the result of an age-related depletion in mental energy or attentional resources. In effect, older adults are not as effective processors as younger adults are. Along similar lines, Speed theories (Salthouse, 1996) account for WM deficits in terms of older participants not being able to process information as quickly as younger adults, resulting in a generalized slowing of cognitive processing for the older adults. Accordingly, in a working memory task involving a series of stages (or operations) older adults' performance may be compromised, since outcomes from early operations may be lost before they can be used in later stages of the WM task.

The inhibitory Control view (Hasher & Zacks, 1988; Zacks and Hasher 1997) attributes age-related deficits in WM to an age-related decline in inhibitory control over the contents of working memory. According to this view, the older individuals are more prone to distractions and as such, the contents of the older person's working memory are more likely to contain a mixture of both relevant and irrelevant information. This in turn, leads to contradictory trains of thought, slowness in response and problems in retrieval.

Finally, the cognitive neuroscience perspectives, for example the frontal deficit hypothesis, (West, 1996) attributes age related decline in working memory to a corresponding decline in prefrontal cortex function, i.e. structural and neurochemical changes. In addition, this perspective views age-related decline as resembling the performance (in nature, rather than degree) of patients with frontal lobe damage (Daigneault & Braun, 1993; Veroff 1980).

In conclusion, the evidence suggests that working memory is a domain that is particularly sensitive to the deleterious effect of ageing

Long-Term Memory

Long-term memory (also referred to as secondary memory) encompasses an immense number of memory functions. In contrast to short-term or working memory, long-term memory has an unlimited capacity and storage duration. A number of taxonomic distinctions have been made in an attempt to differentiate the various types of memory systems within long-term memory. Such a modular view of LTM is not without criticism (Howe, 2000; Gorfein, 1987; Ratcliff & McKoon, 1986) nevertheless it serves as a useful heuristic for understanding and investigating the different memory processes.

Hypothetical Organisation of Long-term memory and age-related sparing/decline.

Perhaps the fundamental division of LTM is Tulving's (1972) distinction between episodic and semantic memory. In crude terms, episodic memory refers to memory for personally experienced events and information (varying from the last book we read, to recalling a list of words after a few minutes delay in an experiment).

Semantic memory, on the other hand, refers to memory for general facts (for example that a cello is a musical instrument). It differs from episodic memory in that it is not associated with specific learning contexts or events. Both episodic memory and semantic memory are consciously and intentionally recollected. Although the boundary between episodic and semantic memory can sometimes be blurred, particularly since semantic knowledge frequently interacts with episodic recall. In view of this, Tulving (1984; Tulving, Markowitsch, et al., 1998) later revised the original distinction between the two systems, suggesting that, despite having features that semantic memory does not, episodic memory developed from semantic memory and is not an entirely independent memory system.

Episodic memory and Ageing

Age-related declines in episodic memory are observed using materials that range from the meaningless (e.g. images of unfamiliar, novel objects, Cooper & Valdisseri, 1992) to the highly meaningful (e.g. information on labels of medicine bottles, Park & Poon, 1990). Findings (see Spencer & Raz, 1995; Verhaaeghen & Salthouse, 1997 for a meta-analysis) indicate age-related differences are smaller in recognition than in recall, presumably because recognition makes fewer demands of self-initiated retrieval operations than recall (Bäckman, Mäntylä, & Herlitz, 1990;Craik & McDowd, 1987).

This general pattern of age- related decline in episodic memory has been found both in cross-sectional (Nilsson et al., 1997) as well as a longitudinal design (Hultsch, Hertzog, Dixon, & Small, 1998.)

Semantic memory

The existing evidence for age-related differences in episodic and semantic memory implies that age-related deficits are robust for episodic memory. In contrast, for semantic memory, age-related differences are attenuated or in some cases non-existent (for reviews, see Bäckman, Small, Wahlin, & Larsson, 1999; Craik & Jennings, 1992). Some research (e.g. Balota & Duchek, 1988; Laver & Burke, 1993) report no significant age-related difference in the structure of the semantic network; although other studies (e.g. Au et al., 1995; Maylor, 1990; and for review see Light, 1992) suggest older adults have problems in rapidly accessing lexical information. Additionally, age-related deficits have been observed in tasks tapping semantic knowledge with limited speed demands, such as vocabulary (e.g., Gilinsky & Judd, 1994; Lindenberger & Baltes, 1994). In a recent study, Nyberg, Maitland, Rönnlund, Bäckman, Dixon, Wahlin & Nilsson (2003) examined age-related performance on a number of episodic and semantic measures. The findings revealed significant age-related differences in episodic memory, and some age-related variation within the semantic domain of memory. Specifically, the performance on knowledge-based tests showed little decline in old-old age relative to middle age. By contrast, fluency performance showed a significant decrease in old-old age. Although verbal fluency is not generally considered a memory task, [category fluency] tasks require self-initiated retrieval as in free recall, but from semantic rather than episodic memory (Rosen & Engle, 1997 as cited in Trey, Hedden, Lautenschlager & Park 2005).

Thus, it would appear that although age-related differences do exist in certain aspects of semantic memory (e.g. category fluency) in general, and in comparison to episodic memory, semantic memory shows minimal age-related decline.

Declarative (explicit) and non-declarative (implicit) memory

Another principal classification in Long-term memory system is the distinction between Declarative (explicit) and non-declarative (implicit) memory. Declarative memory (explicit memory) accounts for the conscious recollection of facts and information acquired through learning, (including episodic and semantic memory.) Non-declarative memory (procedural memory and implicit memory) is the non-conscious influence of past experience on current performance or behaviour (Schacter, 1992). It is usually assessed by way of indirect tests, during which no reference is made to the learning episode or context, for example, word fragment tests.

An implicit memory effect, or priming, is evident in older adults as well as younger adults, occurring on a range of tasks using both word and non-word stimuli (e.g. Light et al., 1995; Maki et al., 1999). Another aspect of implicit memory that is relatively spared the effects of ageing is Procedural memory. This is demonstrated by improved speed or accuracy across trials of a repeated challenging task. The findings indicate that whilst older adults may be somewhat slower or less accurate on procedural tasks overall, with practice, they often show similar levels of improvement as the young (e.g., Howard & Howard, 1992, 1997).

In conclusion, although implicit priming effects are occasionally smaller for older adults than for younger adults, these differences are not as pronounced as those obtained with tests of explicit memory (La Voie and Light, 1994). This Suggests that non-declarative memory is relatively spared in ageing.

Prospective memory and Ageing

Prospective memory may be defined as, 'remembering to remember' (Mantyla, 1994; Stone, Dismukes & Remington, 2001); or the ability to perform an intended action at some designated point in the future

(Brandimonte, Einstein, & McDaniel, 1996). Prospective memory is a relatively new addition to the taxonomy of human memory (see Ellis, 1996; 2000 for reviews), and whilst there is an abundance of studies demonstrating an age-related decline in performance for many other aspects of memory (for reviews see Craik et al., 1995; Zacks, Hasher and Li, 2000, as well as above chapter sections) the impact of ageing on prospective memory is less clear.

Age-related changes in prospective memory may be considered from the perspective of theoretical models developed to explain age-related decline in other areas of memory. For example processing theories, (Craik; Hasher & Zacks, 1999; Salthouse, 1988). In particular, Craik (1986) proposed a framework that has often been cited as instigating investigations into age-related decline (see Maylor, 1993; 1996; Maylor, Darby, Logie & Della Sala, 2002).

Craik (1983; 1986) proposed that memory processes can be arranged along a continuum, or in a hierarchy, according to the extent to which performance depends on the availability of processing resources. Further, Craik predicted that older adults, because of a decline in processing resources, would have particular difficulty in performing tasks requiring a high degree of self-initiated activity, and low on environmental support. This assertion is substantiated by greater age-related reductions in free-recall tasks, where self-initiation requirements are high, in comparison to recognition tasks, where information is organized to provide external support (Craik, 1986; Craik & McDowd, 1987).

Prospective memory tasks are viewed as low in environmental support, and requiring a high degree of effortful self-initiated activity (remembering to remember). In the hierarchy of memory, Craik (1986) characterises prospective memory as being the most resource demanding, since it is comparable to free recall, but without the external prompt to initiate the recall. Thus, Craik predicts prospective memory is more vulnerable to age-related impairment than retrospective memory.

However, Craik's theory was based upon retrospective memory research, and accordingly, such generalizations may under-estimate the influence of the other cognitive processes involved in prospective memory, as well as the extent to which external environmental support may be available in real-life situations.

Age-related differences in prospective performance

Contrary to Craik's prediction, research on prospective memory and ageing has yielded mixed findings. Some earlier studies have reported older people outperforming the young (e.g. Devolder, Brigham & Pressley, 1990; Martin, 1986; Moscovitch 1982). Other studies found no age differences (e.g. Einstein and McDaniel 1990; Einstein, Holland, McDaniel & Guynn, 1992; Maylor 1990), and other research reports an age-related decline in performance (Cockburn and Smith 1988; Cockburn & Milne, 2000; Dobbs and Rule 1987; Einstein et al., 1992; Maylor 1993,1996; Park, Hertzog, Kidder, Morrell & Mayhorn, 1997 Uttl & Graf, 2000). Additional studies (e.g. Martin & Schumann-Hengsteler 1996; Rendell & Thomson, 1999) have reported equivocal findings; with some conditions demonstrating no significant age difference, some demonstrating superior performance for the older group, and others demonstrating an age-related decline.

These conflicting findings may arise from the differing methodologies used to investigate prospective memory. For instance, the studies reporting superior performance by the older participants were all naturalistic, with prospective memory being measured by the execution of a task at some point during the daily life of the participant: for example telephoning the experimenter at a specific time (Devolder et al., 1990; Maylor 1990; Moscovitch 1982).

Further, early studies in prospective memory (e.g. Martin, 1986) used self-report as a measure of prospective memory. Such measures included rating memory for keeping appointments and paying bills on time, etc. The findings revealed that the older people participating rated their prospective memory better than did the younger group.

However, a possibility could be that the older participants 'forget that they forget.' In an attempt to objectively validate the self-assessment results, Martin, (1986) conducted a second, naturalistic, study that involved examining attendance records for appointments. The findings of this study confirmed the self-rating assessments of appointment keeping, suggesting that the self-rating was essentially accurate. However, though this study has high ecological validity, it does not explain why older people report better performance.

Additionally, in naturalistic studies, no control is possible over the use of external aids, such as reminders or notes, which might serve as prompts to perform the task (thus serving as external support and reducing the demands on self-initiated activity). Moscovitch (1982) suggested the superior performance by older individuals in his experiment was because the older adults were more likely to set up their own external aids or cues, e.g. note in diary. Controlling for this is particularly important since Harris (1983) argues that if individuals feel that the environment might not successfully cue them to perform some task, they will go to great lengths to form their own external cues, such as writing notes on hands and sticking post-it notes in bizarre places. Indeed, Maylor (1990) found that prospective memory performance in older participants was positively correlated with making use of external aids and negatively correlated with relying on internal, self-generated mental strategies. Thus, suggesting that the use of external reminders is beneficial to successful prospective performance, presumably because they lighten the cognitive load. This is consistent with the findings of Rendell and Thomson (1999) where differential age effects occurred as a result of the testing environment, either naturalistic or laboratory-based.

This idea of external cues mediating the effects of age is consistent with the results of laboratory studies, both naturalistic (Cockburn and Smith 1988; Maylor, 1993, 1996) and experimental (Einstein et al., 1992; Mäntylä 1994; Park et al., 1997) that have reported some age-related decline. These findings illustrating the beneficial effect of external support can be interpreted within Craik's framework, in that the use of external reminders would obviate the need for resource demanding self-initiated activity, and accordingly older individuals would no longer be disadvantaged in these conditions.

The mixed findings in the prospective memory literature therefore may be explained in part by the difference in methodology. Prospective memory tasks not only vary in terms of being naturalistic or laboratory-based (the former probably being higher in external support), but also according to the demands placed on processing during the secondary task. The secondary task refers to the activity performed by the participant between receiving prospective memory instruction and performing the action (Burgess & Shallice, 1997; Einstein et al., 1997; Ellis, 1996; 2000). This task serves the purpose of a 'filled delay,' and must be interrupted in order to perform the prospective memory task.

However, the nature of this secondary task varies across studies, e.g. rating the pleasantness of words, memorising short word lists, digit monitoring (Brandimonte & Passolunghi, 1994; Einstein et al., 1992; Einstein, McDaniel, Smith & Shaw, 1997), phonological rehearsal (Stone, Dismukes & Remington, 2001) or executive functions and working memory tasks[7] (Cherry & Le Compte, 1999; Marsh & Hicks,1997).

Consistent with Craik's framework, and other processing theories of age-related decline, the general finding reveals an age-related decrement in conditions in which the on-going activity places substantial demands on

[7] For fuller discussion of factors affecting prospective memory performance, including the nature of the ongoing-task see chapter three.

cognitive resources (Cherry & Le Compte, Einstein et al., 1997, Park et al., 1997, Stone et al., 2001). However, it should be considered that this difficulty to disengage from one task in order to perform the prospective task might reflect difficulty to switch attention, or inhibit a response, or other executive skills.

In summary, it would appear that age-related changes in prospective memory are inconsistent, and vary according to the nature of the prospective task. Further, the disparity of findings within the ageing literature has highlighted the fact that prospective memory is a multi-faceted cognitive process, sharing many of the attributes of retrospective memory. These include episodic memory (recalling the intention), working memory (planning when to implement the intention, and disengaging from other tasks) attention, and inhibition. These elements vary in degree according to the prospective task, and interact in complex ways to affect prospective performance.

It would appear therefore that further investigation of these variables and their relation to age-related prospective memory performance is clearly warranted.

Two

Prospective memory and dementia

Defining Dementia

Dementia is a generic label used to describe a progressive decline of cognitive function, severe enough to impair the daily functioning of an individual (Gitelman, 2002).

A precise diagnostic definition of dementia is hampered by the heterogeneous nature of the condition. Currently, one the most widely accepted standardised guidelines for the diagnosis of dementia is the Diagnostic Statistical Manual of mental disorders, 4th edition (Kaufer & Cummings, 1997). The DSM-IV (1994) identifies a number of criteria necessary for diagnosis, see table 1. Briefly, these include: impairments in social and occupational functioning; memory impairment, and impairment in other cognitive functions. These features must not be attributable to delirium or other known medical conditions, and there must be evidence of a decline in function over time.

However, it has been suggested that the DSM criteria may be too comprehensive, leading, in some instances, to unreliability of diagnosis (Jorm & Henderson 1985, as cited by Lawrence & Sahakian, 1996).

Furthermore, Cummings and Benson (1980) argue that 'memory impairment' which is an essential component in the DSM diagnostic criteria is not an essential early feature of some forms of dementia, e.g. Pick's disease and other frontotemporal dementias. As a result, Cummings and Benson (1986) have proposed alternative criteria for defining dementia. This definition requires that the individual present an acquired, persistent impairment of intellectual function with change or loss in at least three of the following areas: language, memory, visuospatial skills, emotion or personality, and executive cognitive functions.

Table i.ii DSM-IV Criteria for dementia.

A person suffers from dementia when multiple cognitive deficits develop manifested by: Memory impairment (inability to learn new information or recall previously learned information) One (or more) of the following cognitive disturbances: Aphasia Paraxial Agonisa Disturbance in executive function. The cognitive deficits in 1 and 2-cause significant impairment in social and occupational functioning and represent significant decline from previous level of functioning. The cognitive deficits in 1 and 2 are not due to any of the following: Other central nervous conditions that cause progressive deficits in memory and cognition. Systemic conditions that are known to cause dementia. Substance- induced conditions.

The aetiology of dementia is wide-ranging and diverse, including metabolic, degenerative, and cerebrovascular causes. These disorders may produce either degenerative or non-degenerative dementias, with the degenerative disorders being the most prevalent. These can be further specified into subtypes of dementia according to the nature of the underlying pathological characteristics. As a result, it is perhaps more useful to view dementia in terms of distinct dementia syndromes rather than a singular condition. (Kaufer and Cummings, 1997)

Dementia of the Alzheimer type

The single most common cause of dementia is Alzheimer's disease (Gitelman, 2002). The onset of Alzheimer's disease (AD) can occur from the age of 45 or younger. However, it is typically an age-associated disease, with the incidence increasing markedly with age. Prevalence rates suggest that, up to the age of 65 years, only one person in 1000 is affected. This figure increases sharply to 1 in 20 over the age of 65, and rises again to 1 in 5 over the age of 80 years (Alzheimer Disease International, 2000). This equates to between 50% - 66% of patients presenting with dementia being diagnosed as having Alzheimer's disease. (Gitelman, 2000).

However, it should be noted that Alzheimer's disease frequently co-exists with other types of dementia, in particular, vascular dementia, which is seen co-occurring in about 10-15 % of AD patients (Gitelman, 2000). Alzheimer's disease is a degenerative disease characterised histologically by senile plaques and neurofibrillary tangles (Boller & Duyckaerts, 1997). Currently, Alzheimer's disease cannot be diagnosed with 100 percent certainty until a brain autopsy reveals the disease's characteristic anatomical abnormalities. These neurofibrillary tangles and plaques represent the death of nerve cells or neurons throughout the brain. The brain shrinks in size, losing as much as one-third of its normal weight. The tangles consist of tau protein that congests the insides of certain brain cells and their connections. Similar deposits of tangled tau are seen in most people as they age, but in much smaller amounts.

Diagnosing dementia of the Alzheimer type

During life, a diagnosis of Alzheimer's disease is generally clinical, based upon behavioural criteria (for example the NINCDS-ADRA, Becker et al., 1994; or the CAMDEX, Roth et al., 1986.) Additionally, assessment may incorporate structural imaging techniques (for example CT or MRI scans) and neuroimaging techniques (for example positron emission tomography PET scans) to corroborate diagnosis.

Alzheimer's disease is a progressive, dementing illness that creates severe decrements in various aspects of cognition (Nebes 1997). Clinically, there is considerable heterogeneity of symptom presentation, particularly in the early stages. Furthermore, there is no distinctive pattern of cognitive deficit that can reliably distinguish Alzheimer's from other disorders (Nebes, 1992 as cited in Craik & Salthouse, 1992). However, of the many cognitive deficits observed, memory impairment appears to be a cardinal feature of the disease (Calesimo & Oscar-Berman, 1992).

Memory function and dysfunction in Alzheimer's disease

Alzheimer's causes a reliable disruption in both short-term memory and long-term memory performance. Nevertheless the onset of memory disturbance in dementia is insidious and gradual, and often erroneously dismissed as part of growing old. The fact that AD and normal age-related senescence are related pathologically as well as clinically makes it necessary to address explanations of AD in the context of the normal aging process.

In addition, whilst AD is associated with memory loss, it is important to consider that memory is not a unitary construct, and impairment is not uniform.

Short-term memory

Short-term memory (STM) is a limited capacity system. It is used when we are required to maintain or manipulate information for brief periods of time. STM is hypothesised to be necessary for the transfer of information to long-term memory. Short-term memory is usually assessed by using the memory span procedure, which involves immediate repetition of a sequence of items. Commonly used tasks include verbal memory span tasks. Verbal memory span is measured using immediate recall of digits, letters, or words. Compared with controls, digit span in Alzheimer's patients is considered to be significantly impaired, in terms of both span and serial position (Belleville, Peretz & Malenfant, 1996; Cherry, Buckwalter & Henderson 1996). For instance, Alzheimer's patients have smaller memory spans than controls for verbal as well as non-verbal material, (Corkin, 1982). The pattern of retrieval (serial position) for Alzheimer's also differs from controls, with the greatest decrement shown in the primacy section of recall and no difference in the recency section (Wilson, Bacon, Fox and Kaszniak, 1983). This would imply that, though not normal, short-term memory is less impaired than long-term memory in Alzheimer's disease.

Working memory

Such a formation of deficits in short-term memory has been considered within the context of working memory (Baddeley, 1986). The working memory model is a three-component system that covers both storage and processing tasks. Working memory is defined by two slave subsystems, the phonological loop and the visuo-spatial sketch-pad. These sub-systems are asserted to be controlled by a central executive system.

The working memory model has been used as a theory of both normal age related deficits (Anderson & Craik, 2000; Craik, 1994; Morris, Craik & Gick, 1990) and the abnormal aging deficits demonstrated by persons with Alzheimer disease, (Kopelman, 1994). Such failings in short-term memory, demonstrated by persons with Alzheimer's disease, have been ascribed to the dysfunction of the central executive system (Morris 1986).

Experiments attempting to examine the role that the central executive plays in the coordination and allocation of attentional resources typically adopt a dual task paradigm. This involves the individual being asked to perform two tasks simultaneously (or concurrently), the idea being that the secondary task provides a distraction that makes reviewing or refreshing information held in storage difficult.

It has been widely demonstrated that dual-task performance is grossly impaired in persons with Alzheimer's disease, compared with controls (Baddeley, Bressi, Della Sala, Logie & Spinnler, 1991; Morris 1984; Vallar & Papagno, 1995.) However, a plausible explanation for this underperformance on dual tasks could be task difficulty, and not because attention is divided. Alternatively, Logie, (2001) suggests that AD patients have a specific problem with dual-task performance rather than general cognitive demand. To test this dual co-ordination hypothesis, Baddley et al. (1986) matched the difficulty level of the task for each subject and then measured the memory span. Performance on the tasks was then measured separately and in combination. Comparison with the matched control group revealed that the AD group were indeed significantly more impaired on dual task performance than controls. In a follow up study, Baddeley et al. (1991) used the participants from the first study as their own controls. Findings revealed that whilst performance on single tasks was maintained, the dual task performance had significantly decreased. These results indicate that memory deficits demonstrated by persons with Alzheimer's disease in dual task experiments are more to do with attentional control than task difficulty.

Long-term memory

Persons with Alzheimer's disease also demonstrate impaired performance on a wide range of long-term memory tasks, including recalling lists of words, sentences, stories or recognising words, faces and pictures. (Corking 1982; Nebes 1992; Spinnler 1999; Wilson et al., 1983).

Successful long-term memory is dependent upon the information being encoded, maintained in storage, and later retrieved. A break down in any one of these areas could lead to a failure of long-term memory. In a comprehensive review of the neuropsychological literature on memory deficits in Alzheimer's disease, Carlesimo and Oscar-Berman, (1992) suggested that the nature of this malfunction is most likely to be in the initial encoding of material.

Encoding

Support for this assertion comes from behavioural dissociations in performance on variables known to have an effect on encoding in controls, but which do not influence encoding in persons with Alzheimer's disease.

Examples of such variables include word familiarity. Wilson et al. (1983) established that controls demonstrate a rare-word recognition superiority, in that infrequent words are better recognised than common words. In contrast, for persons with Alzheimer's disease, performance is unaffected by word frequency.

Additional support for an encoding-deficit hypothesis in Alzheimer's disease comes from performance differences due to the imagability of the stimulus (Hart, Kwentus, Taylor and Hamer, 1987). For controls, stimuli that can be readily visualised (e.g. high-imagery nouns) have a facilitative effect on recall. The advantage of high–image stimuli is presumed to be due to the opportunity to dual-encode the stimulus in terms of both its verbal label and image, thus increasing the likelihood that it will be recalled. Conversely, for persons with Alzheimer's disease there is no difference in recall between high and low imagery stimuli, implying a dysfunction in the dual encoding process.

The dual-encoding hypothesis has been investigated comparing motor as well as verbal encoding methods. However, findings are equivocal. Karlsson, Bäckman, Herlitz, Nilsson, Winbald & Osterlind, (1989) compared performance of persons with Alzheimer's disease and controls for verbal recall of directive sentences. Each sentence consisted of a command action, (e.g. "lift the cup"). The stimuli were presented verbally; either as a sentence, or the participants was required to carry out the action (motor as well as verbal factor). Participants were then asked to recall (verbally) the sentences. Both the AD and controls demonstrated better recall for the sentences that they had enacted. Karlsson et al. concludes that motor action enriches the encoding process, which, in turn, facilitates recall. This superiority of motor encoding is consistent with the findings widely demonstrated in young populations through the subject-performed task paradigm (Cohen, 1989; Englekamp & Zimmer, 1994; Zimmer & Englekamp, 1999)

However, Dick, Kean & Sands (1989) carried out a similar study to Karlsson et al. (1989) and found no advantage of enactment in verbal recall performance for persons with Alzheimer's disease. It would appear therefore that further investigation in the area of motor encoding is warranted, perhaps also examining enactment as a method of recall.

Other evidence for encoding impairment in Alzheimer's disease comes from studies examining the effects of contextual and semantic aspects of stimulus material in encoding. Again, dissociations have been demonstrated between persons with Alzheimer's disease and controls, with stimulus variables known to facilitate recall in controls having no significant effect on the performance of Alzheimer's disease patients (Bäckman and Herlitz, 1990; Martin, Brouwers, Cox & Fedio, 1985; Weingartner, Kaye, Smallberg, Ebert, Gillin & Sitaram, 1981).

Generally, in controls, stimulus material that is salient to the individual produces better recall, presumably because the richer detail provides a stronger memory trace. However, no such advantage of context is observed in persons with Alzheimer's disease (Bäckman and Herlitz, 1990).

Additionally, in controls, lists of stimuli that are semantically related (e.g. from distinct categories, fruits, animals) are better recalled then random, unrelated stimuli. In contrast, persons with Alzheimer's disease do not demonstrate such an ability to cluster responses based upon categorical relationships, and accordingly, performance is equally poor on both types of stimuli lists (Weingarter et al., 1986.)

Depth of processing in encoding

The advantage of semantic relationships in encoding has been explained in terms of the Depth of Processing model, (Craik & Tulving, 1975.) Briefly, this model asserts that how well an item is recalled is a function of how deeply it was processed at the time of encoding. There are differing levels of processing from the relatively shallow, concerned with superficial characteristics of the item (e.g. number of consonants, or phonetic aspects such as rhyming) to the deepest level, which involves the semantic meaning of the item (e.g. category it belongs to, its definition). Craik & Tulving hypothesize that the more deeply processed an item is, the better it is recalled.

Evidence from several studies (Corkin, 1982; Cushman, Como, Booth & Cain, 1988) provides support for the levels of processing model in normal older people, with superior performance for deeply processed items. However, persons with Alzheimer's disease typically do not demonstrate any benefit from semantic (deep level processing) cues compared with sensory, or no cues, thus suggesting impairment in the ability to encode material semantically (Cushman et al., 1988.)

Contrary to the majority of the findings on this model, Martin, Brouwers, Cox & Fedio (1985) found persons with Alzheimer's disease did demonstrate a levels of processing effect, whereby persons with Alzheimer's disease were able to recall more words from the conditions requiring deeper processing than the free encoding, or shallow encoding conditions. Despite the encouraging nature of these findings, subsequent error analysis from word recognition tasks led Martin et al. to conclude that persons with Alzheimer's disease do in fact demonstrate difficulties in encoding but that these may be more to do with inadequate semantic elaboration than an inability to encode semantically.

It is also important to note that, in contrast to other studies (e.g. Corkin, 1982), the procedures involved in the Martin et al. deeper levels of processing conditions were more extensive and involved motor aspects (symbolically performing the item.) Thus, it could be argued that persons with Alzheimer's disease can demonstrate a depth of processing effect but only for conditions that involve elaborate and comprehensive encoding in different modalities.

Nevertheless, on the whole, evidence from the studies reviewed leads to the conclusion that the ability to successfully encode material into memory is severely damaged in persons with Alzheimer's disease.

Storage

Another component of long-term memory is storage. Storage refers to the formation of a comparatively stable memory trace, or record, of information (Tranel & Damasio, 1995.) The ability to maintain or store information (without conscious rehearsal) is necessary for successful remembering. Since, if the information is not stored, then there is no information to access and the resulting outcome is memory failure. Storage is frequently measured in terms of forgetting rates, or how fast information decays from memory. In general, findings comparing persons with Alzheimer's disease and controls are equivocal, with some (Kopelman, 1985) suggesting no difference in forgetting rates when the initial level of acquisition is controlled. However, in this study, control for initial learning was at the expense of widely differing encoding times for the two groups, (on average controls were exposed to the stimulus for 0.5 seconds, in comparison to the 9-second long exposure rate for persons with Alzheimer's disease.) Accordingly, this may have produced qualitative differences in encoding, which may have confounded the results. Studies that have examined the proportional forgetting rates between persons with Alzheimer's disease and controls, (e.g.

Becker, Boller, Saxton & McGonigle-Gibson, 1987; Sebastian, Menor & Elosua, 2001) have found that whilst persons with Alzheimer's disease perform less well and demonstrate a faster rate of forgetting for immediate recall, the delayed rate of forgetting between the groups is similar.

In a comparison of Alzheimer patients with vascular dementia patients, Carlesimo, Fadda, Marfia & Caltagirone, (1995) examined rates of forgetting for two types of stimuli (verbal and spatial). Carlesimo et al. found that the proportional rates of forgetting were significantly different for verbal material, but only marginally so for spatial information. This implies that even compared with other dementia sub-groups persons with Alzheimer's disease demonstrate a greater rate of forgetting. However, the rate of forgetting may be influenced by the nature of the material to be remembered.

In sum, it would appear that, on balance, persons with Alzheimer's disease do demonstrate a faster rate of forgetting than controls, particularly in the early stages of retention. However, there may be some sparing of delayed forgetting.

Retrieval

The retrieval component of memory is the process of recovering and reactivating information from memory to form a conscious response. In the vein of encoding and storage methods described earlier, experiments investigating retrieval components of memory also adopt the approach of examining behavioural dissociations in performance on variables known to have an effect on retrieval.

Typically, experiments attempting to demonstrate retrieval deficits compare conditions where support is provided at retrieval (e.g. recognition, cued-recall) with conditions where no support exists (e.g. free-recall). In accordance with Craik's (1983, 1986) environmental support hypothesis, which states that provision of cognitive supports (i.e. cues) minimizes demands placed on internal processing resources; it is predicted that a decrease in demands at the time of retrieval will lead to better recall. In populations known to show deficits in processing (e.g. older people compared with young; persons with dementia compared with controls), support at retrieval can minimize differences in performance. Subsequently, if an advantage is demonstrated by a cued-condition then it can be concluded that a retrieval deficit is present.

A number of experiments (Branconnier, Cole, Spera & De Vitt, 1982; Miller, 1977) have demonstrated poorer recognition memory for persons with Alzheimer's disease than controls. Furthermore, persons with Alzheimer's disease perform more poorly than controls on cued-recall. However, before the conclusion can be drawn that persons with Alzheimer's disease demonstrate a deficit exclusively in retrieval, findings should be able to show that persons with Alzheimer's disease benefit more from the use of cues and aids than controls. This has not been demonstrated rather, findings from studies (Grober & Buschke, 1987; Martin et al., 1985) have demonstrated that cues do not help persons with Alzheimer's disease more than controls. Although persons with Alzheimer's do benefit from cued recall, (c.f. free recall), their performance is poorer than controls (Morris, Wheatley, & Britton, 1983).

Overall, it would appear that AD patients do not benefit more than controls from the strategies or retrieval cues that assist performance in controls, suggesting that the retrieval deficit in Alzheimer's disease is not greater than that found in normal aging. However, it should not be overlooked that retrieval studies are often hampered by the confounding variable of inefficient encoding. The overall poor performance by persons with Alzheimer's disease may be due to the fact that the information was not sufficiently encoded in the first place, indicating that the memory trace was so weak, it could not be activated by retrieval aids necessary to recall information.

In conclusion, it would appear that, relative to controls, Alzheimer's disease causes impairments in all components of secondary memory (encoding, storage and retrieval). However, impairment is not universally poor for all components, and the interactive nature of memory makes it difficult to establish the exact location of this deficit.

Prospective memory

Although retrospective failure is well documented in Alzheimer's disease, experimental study of prospective memory has yet to be undertaken extensively.

Prospective memory is a crucial aspect of everyday functioning and research is of considerable practical importance. Further, anecdotal evidence indicates that prospective memory is problematic in dementia (McKitrick, Camp & Black, 1992.)

Questionnaire Reports of prospective memory failure

This is corroborated by questionnaire studies, e.g. Della Sala, Logie & Maylor, (2000), who found not only that the carers of persons with Alzheimer's disease reported more prospective than retrospective failures for the individuals with Alzheimer's disease, but that such failures were more frustrating for the carer.

The importance of an informant's rating of memory complaints in the diagnosis of dementia has been investigated by Carr, Gray, Baty & Morris, (2000). Carr et al. found informant reported memory complaints not only distinguished persons with dementia from controls, but also predicted future diagnosis of Alzheimer's disease.
Furthermore, there is evidence from questionnaire studies in the healthy elderly (Johansson, Allen-Burge & Zarit, 1997; Schofield, Jacobs, Marder,

Sano & Stern, 1997) that self-reported prospective and retrospective memory complaints in an elderly population are correlated with a pathological decline leading to dementia.

It would appear therefore that reported measures of memory complaint, including prospective memory failures, might be a useful tool in aiding the diagnosis of dementia.

Prevalence rates of Prospective memory Impairment

In an attempt to discover the prevalence of prospective memory impairment amongst older people, Huppert, Johnson & Nickson, (2000) conducted a wide scale population-based study of a large, representative sample of older people (including the old, old-old, and early stage dementia.). Prospective memory was assessed by a one-item, two-part task. The findings revealed a very high prevalence of prospective memory impairment by individuals in the early stages of dementia, with only 8% of individuals categorized as having mild dementia succeeding on the prospective memory task, (performing at least one part) and only 3% performing both parts of the prospective memory task correctly. This is in marked contrast to performance by healthy older people, where, although a distinct age-related decline was demonstrated, approximately half the sample performed the prospective task.

However, despite the merits of this epidemiological study, in terms of providing one of the first large-scale studies of prospective memory in a representative sample of older people, a number of methodological issues need to be addressed. For instance, the prospective memory measure involved a single, two-part task, with the opportunity to perform it only once. This results in categorical data and makes it difficult to assess variability in performance. In addition, it is possible that the poor performance was a result of retrospective failure, (i.e. forgetting the content of the action). This conclusion is corroborated by the finding that the majority (60%) of participants categorized as having mild dementia failed to perform the prospective action with a prompt, indicating impaired retrospective memory.

In view of the findings of this epidemiological study, it would appear that there is a real need to systematically investigate the pervasiveness and presentation of prospective memory in dementia under controlled conditions.

Experimental Studies of prospective memory

At the current time, actual experimental research examining prospective memory in dementia is sparse, with only one experimental study comparing dementia patients with healthy controls published (Huppert and Beardsall, 1993).

Before discussing the Huppert & Beardsall study, it should be acknowledged that Maylor, Darby & Della Sala, (2000) conducted a naturalistic study comparing the intention superiority effect, comparing a group of people with dementia with normal older people. The intention superiority effect refers to how easily intentions can be brought to mind. Experimental findings from young populations (Goschle & Kuhl, 1993; Marsh, Hicks & Bink, 1998) established that items relating to prospective memory tasks are recalled better than items related to past-performed memory tasks. This is presumed to be because the items relating to the to-be-performed (or prospective task) are held in a heightened state of activation in long-term memory.

In the Maylor et al. (2000) study, the intention superiority effect was assessed by comparing participants' recall for tasks that they had performed with tasks they intended to perform. The findings revealed that, in contrast to young participants, older participants and persons with Alzheimer's disease do not exhibit an intention superiority effect for prospective memory. Instead, persons with Alzheimer's disease and the older group recalled fewer prospective intentions than past intentions; or displayed an "intention inferiority effect" (Maylor et al., 2000, p.96).

However, it should be noted that this experiment does not address prospective memory in the actual, behavioural sense of the term. Additionally, the relationship (if any) between recalling intentions and actual performance remains to be established.

The dearth of prospective memory studies in populations with dementia perhaps can be accounted for by the difficulty in fractionating memory functioning in people with dementia. For instance, evidence from long-term memory research consistently illustrates deficits in almost all areas of memory. As a result, poor prospective memory performance could be due to any aspect of retrospective memory failure (failing to encode the intention, failure in storage over time, or failure to retrieve the intention in order to perform it) and ultimately may lead to floor effects. Therefore, it could be argued, any attempt to ascertain prospective memory performance in persons with Alzheimer's disease using methodologies designed for controls, would be open to a number confounding variables.

An accurate diagnosis of dementia has important implications for the prognosis and management of the individual. Since Alzheimer's disease is the single most common cause of primary dementia, and its cardinal feature is a progressive loss of episodic memory (Butters, Delis, & Lucas, 1995; Garrido, Furuie, Buchpiguel, Bottino, Almeida, Cid, Camargo, Castro, Glabus, & Busatto, 2002; Mesulam, 2000), memory assessment is considered to be a particularly sensitive way of testing for the onset of dementia.

Huppert and Beardsall (1993) investigated the possibility that prospective memory may be more vulnerable to impairment than retrospective memory. In this study, prospective and retrospective memory tests were administered to controls and patients with varying levels of cognitive impairment.The results revealed that the participants with dementia, even those with minimal dementia, were more impaired on prospective memory tasks than the control groups. Moreover, no significant difference was found between the mild/moderate group and the less severely impaired, minimal impairment group.

In contrast, performance on the retrospective tests indicated a memory gradient associated with cognitive decline: with the minimal group performing at an intermediate level between the low scoring controls and the mild/moderate dementia group.

From these findings, Huppert and Beardsall concluded, "prospective memory tasks are particularly sensitive to impairment and that impairment may be an early indicator of dementia" (Huppert and Beardsall, 1993, p.805).

However, a number of methodological weaknesses need to be addressed before accepting such a conclusion. For instance, the poor performance on prospective memory may instead have been a failure of retrospective memory. In other words, the dementia groups simply forgot what they were supposed to do.

The validity of the study is also questionable. For example the conclusion that prospective memory is more vulnerable to retrospective memory is based on performance in a test in which a prospective task (delivering a message), is embedded in a spatial memory task (recalling and retracing a route around a room). This spatial task is taken by Huppert and Beardsall to represent a retrospective task because of its recall and retrace components. This method forms the basis of the conclusion that prospective memory performance is poorer than retrospective performance and therefore a sensitive indicator of dementia.

However, an obvious caveat that applies in the acceptance of this conclusion is that prospective memory is more vulnerable than spatial memory rather than retrospective memory per se.

It is possible that the poor performance on prospective memory was due to ageing rather than dementia. This variable was not controlled, and it is instructive to note the group that performed most poorly (the minimally demented) was significantly older than the other groups.

Finally, since the prospective memory test comprised only one task, the non-significant difference in performance between the dementia groups could have been the result of a floor effect.

The methodological issues highlighted in this pioneering study identifies the need for future prospective memory studies to overcome such limitations by developing a paradigm in which prospective memory performance can be measured in a valid way, and avoids the confounding variable of spatial memory. Future research also needs to control for the confounding variable of retrospective failure (i.e. forgetting the content of the instruction).

Spaced retrieval

Controlling for retrospective failure in a population, which is by nature amnesic, is obviously a thorny problem to overcome. However, studies (Arkin 1991; Camp & Stevens 1990; Camp & McKitrick, 1992; Mckitrick, Camp & Black, 1992 Camp, 1990) have described some promising findings that suggest prospective memory of people with dementia can be improved by using the technique of spaced retrieval.

Spaced retrieval is a memory improvement technique that involves extending the retention period by testing the subject over short periods and gradually expanding upon the length of time a participant can retain the information (Laundauer & Bjork, 1978).

Schacter, Rich & Stammpp (1985), first used spaced retrieval (SR) as a rehabilitative technique in individuals with cognitive deficits. They found that although SR was successful in aiding new learning, attempts to train participants to use SR techniques spontaneously were not successful.

In a later study, Moffat (1989) modified the SR technique for clinical use as a rehabilitative method. Although the principle of expanding the interval remained the same, the behaviour to be learned was decided by the client, rather than the experimenter. In contrast to Schacter et al. (1985), the interval periods were determined by time periods, as opposed to other experimental material, and the SR was implemented with motor, rather than verbal behaviour. Moffat, (1989) termed this technique "expanding rehearsal," and described its success in rehabilitating an individual suffering from dysgraphia caused by cerebral anoxia.

Spaced retrieval has also been successful improving prospective learning in Alzheimer's disease. Camp et al. (Camp & Stevens 1990; Camp & McKitrick, 1992 McKitrick, Camp & Black, 1992) have performed a number of experiments in which Alzheimer's patients have been trained to use spaced rehearsal to remember intentions. In such studies, the period Alzheimer's patients could retain and recall a target (a coloured coupon) ranged from one day up to one week. More encouragingly, the patients could be trained to shift set and change to a different (coloured) target. Camp et al. (1992) conclude that spaced retrieval may be used to enhance prospective memory for Alzheimer's patients.

In summary, prospective memory is a crucial aspect of everyday functioning and research is of considerable practical importance. However, comparatively little research has been conducted on this topic, and models and theories remain incomplete and experimentally untested. Findings suggest that prospective memory may be a useful tool in the diagnosis of dementia, though methodological weaknesses highlighted would preclude the acceptance of this conclusion until further research has been conducted.

Three

Prospective Memory: Definitions and models.

In order to function efficiently in our everyday lives, we require more than the ability to recall information. Indeed, one of the principal functions of memory is not to recall the past, but to plan for the future, and subsequently remember to carry out these plans. This type of memory, in which the individual must remember to perform an intended action at some designated point in future, is known as *prospective memory* (Brandimonte, Einstein & McDaniel 1997; Einstein & McDaniel, 1990; McDaniel & Einstein, 1997; 2000).

A distinguishing feature of prospective memory is that it involves a time element. (Cohen, 1998) This may be a specific time (for example, appointment 9.00 a.m. tomorrow), or a less specific time (for example, next summer). However, the time to implement the plan need not necessarily refer to the temporal construct, measured by arbitrary units of days, hours, etc. Instead, it can refer to a variety of retrieval contexts that prompt the execution of the plan. For example, *when* you next see someone, or *after* you finish work. (Cohen, 1998; Dalla Barba, 1993).

In general, most prospective memory research has been concerned with either event-based contexts or time-based contexts. Event based prospective memory tasks require that the action be carried out in response to some external event (e.g. pressing a key in response to a target, Einstein, McDaniel, 1990; Cherry et al., 2001). In contrast time-based prospective requires that the action be carried out after a period of time (e.g. posting cards back to the lab after one week, Martin, 1993).

Additionally, in order for a task to be defined as Prospective memory, it must display the following characteristics (Ellis, 1996; 2001; Shallice & Burgess, 1997; Stone, Dismukes & Remington, 2001):
First, prospective memory intrinsically involves concurrent-task performance, in that the individual is engaged in other (ongoing) activities in the period between forming the intention and implementing it. To satisfy prospective memory criteria, the individual must *interrupt* their on-going activity in order to perform the prospective task at the appropriate time. Second, there must be a *delay* between the formation of the intention and the opportunity for carrying it out. It is this delay, coupled with disengagement of some other activity that distinguishes prospective memory from vigilance tasks (Brandimonte, Ferrante, Feresin & Delbello, 2001). Finally, a prospective memory task must lack an explicit prompt (e.g. from the experimenter) to perform the intention at the appropriate time. It is this absence of an explicit reminder that differentiates prospective memory from episodic retrospective memory (McDaniel & Einstein, 1992).

Accordingly, it is acknowledged (Burgess, 2000; Dobbs & Reeves, 1996; Ellis, 1996) that prospective memory involves many elements of cognition including retrospective memory, working memory, planning and monitoring. Successful prospective memory therefore involves remembering the content of the intention and keeping track of the opportunity to implement it.

Prospective memory is prevalent in the daily lives of individuals; from locking the door after leaving the house, to switching the cooker on to cook some food. Accordingly, failure of prospective memory can at best be an inconvenience (forgetting to buy milk) and at worst can seriously impair an individual's ability to live independently (forgetting to take medication, or forgetting to turn off a cooker). Prospective memory therefore is a crucial aspect of everyday functioning and research is of considerable practical importance.

In spite of its apparent importance, research into prospective memory has attracted little attention until relatively recently (Rendell and Thomson 1999). Further, at the present time, research into prospective memory is in the early stages and arguably, the term prospective memory is too broad a category to be useful (Cohen, 1989; Ellis 2000). As such, there would appear to be a need to develop and investigate theories and models of this topic.

Theoretical Approaches

It has been argued (Crowder, 1996; Roediger, 1996), the term prospective memory is 'misleading' (Crowder, 1996, p.143), and is not entirely separate from retrospective memory in that it relies upon retrospective memory to retrieve the content of an action in order to execute it. (For example, remembering the content of a telephone message in order to pass on the message.) Indeed, from this perspective Roediger, 1996, argues it appears indistinguishable from paradigmatic retrospective cued-recall tasks. In both cases, successful performance necessitates an association between cue and target to be forged and re-affirmed at retrieval.

However, Einstein and McDaniel (1997) argue that, in contrast to retrospective studies of cued-recall, which involves the experimenter presenting an external cue that directs the individual to search for and retrieve the target. On the other hand, prospective memory requires a spontaneous search, self-initiated, and often interrupting on going activities. Thus, in prospective memory, the individual must recognise that the cue is a prompt to perform an action and must disengage him or herself from their concurrent activities to execute the action.

Additionally, prospective memory differs from retrospective memory in that it involves planning and executing an action in the future. Thus, remembering the content of the message, but forgetting to pass it on is a failure of prospective memory.

Thus, in contrast to the views of Crowder (1996) and Roediger (1996), researchers (e.g. Einstein, Holland, McDaniel & Guynn, 1992; Einstein &

McDaniel, 1990, 1996; Ellis, 1996; Krishnan & Shapiro, 1999;Kvavilashvili, 1987; Uttl, Graf & Miller, 2001) have argued the case for prospective memory being a distinct aspect of cognition. Nevertheless, these experimenters have acknowledged the pivotal role retrospective memory plays in prospective memory, and accordingly have proposed that prospective memory operates within a two-component process: remembering to remember, and remembering what to remember. Remembering to remember is identified as the prospective component. It refers to the realization that some prospective action needs to be performed. Remembering what to remember is the retrospective component. This serves a complimentary function to the prospective component, in that it refers to memory for the content of the intention. Both components need to be operative for prospective memory to be successful.

Theories and Models explaining prospective memory.

Theoretical models developed to explain prospective memory have been slow to evolve, and are largely based upon the principles and models of retrospective memory research.

Craik's hierarchy of memory.

Craik, (1986) models prospective memory in terms of the amount of cognitive processing required. Craik considers memory processes to be organised in a hierarchy, ranging from processes exceedingly reliant on available cognitive resources, to minimally demanding processes supported by external factors. Remembering is viewed as an interaction between internal and external factors. Where environmental support is weak, or there are few external cues available, the individual must rely on effortful self-initiated retrieval. Since in many prospective memory tasks the individual relies on self-initiated activity, i.e. remembering to remember, this is hypothesised as requiring more effortful processing. Accordingly, Craik (1986) considers prospective memory more vulnerable to impairment than retrospective memory because it demands more cognitive resources.

However, it is questionable whether all prospective memory tasks require a high degree of self-initiated activity. Consequently, there is a very real need both to develop a theory that encompasses possible distinctions in prospective memory, and to gain more evidence highlighting the role of cognitive processing in prospective memory.

The simple activation Model

Einstein and McDaniel (1996) investigated event based prospective memory and acknowledged that, as a cognitive process, it is structurally similar to retrospective cued recall tasks. However, in line with Craik (1986) they suggest the important difference between cued recall and event based prospective memory is that, in the latter, the individual must spontaneously recognize the event as a stimulus for performing the action.

Einstein and McDaniel (1996) therefore, predict that successful prospective memory will rest heavily on the ease of identifying the cue or target event as a prompt to perform the action. Accordingly, they suggest that different properties of the target or cue, such as specificity, distinctiveness, and familiarity will affect performance.

A number of experiments, (Einstein and McDaniel 1995; McDaniel and Einstein, 1993 ;) have confirmed this prediction. For example McDaniel and Einstein (1993) varied the familiarity of the target event (either a familiar word e.g. movie; or an unfamiliar word e.g. yolif), as well as the distinctiveness of the target event (embedded in either dissimilar, or distinctive non-target words; or similar non-target words). Findings demonstrated that unfamiliar target events benefit prospective memory performance, as do target events that are distinctive relative to the local context.

These results led Einstein and McDaniel (1996) to propose the Simple activation Model. According to this framework, when presented with a prospective memory instruction, one forms an "associative encoding" of the cue and target. (Einstein and McDaniel, p.122) Unless this association is kept in heightened awareness, it will subside as one performs other activities. This decline of activation will continue until the association is below the level of conscious awareness.

However, activities that raise activation levels (for example, rehearsal of the association) make it more likely that when one is exposed to the target at the appropriate time the activation will be raised above threshold and the action executed.

Another important factor is the level of processing the target event is subjected to when it occurs. A high level of processing will influence the degree to which the cue-event association is activated, and subsequently called into conscious awareness.

Borrowing from Anderson's (1983) adaptive control of thought (ACT*) model of cognition, Einstein and McDaniel (1996) explain the effects of familiarity in terms of activation of nodes in an associative network. Spreading activation models (e.g. Anderson's Act* model) consider that activated concepts in long-term memory pre-activate other nodes in such a way that retrieval of the pre-activated concepts is facilitated.

In terms of prospective memory, Einstein & McDaniel explain that the cue will activate that item's node as well as other associated nodes, producing a "fan of association" (Einstein and McDaniel, p.122). With many associations, the activation across the fan is broadly dispersed, however an unfamiliar target has a much smaller fan of association and more concentrated activation. Consequently, Einstein and McDaniel propose that it is more likely that the unfamiliar target will receive the level of activation necessary to raise it above the unconscious threshold into awareness. Thus, it will be identified as a prompt, and will then elicit prospective memory performance.

This view is also used to explain the positive effects of cue distinctiveness. It is proposed that distinctive cues demand more processing and hence longer levels of activation. This in turn will increase the probability that the intention will receive sufficient activation to raise it into awareness in order to be performed.

However, although this model does provide an explanation for Einstein and McDaniel's (1990, 1993) findings, the limited research on prospective memory generally make it difficult to evaluate fully.
Nevertheless, the model makes testable predictions regarding the effect of different properties of the target event on prospective memory, which may be helpful in directing future research.

Ellis' Conceptual framework of memory for delayed intentions

More recently, Ellis (1996) proposed a conceptual framework of prospective memory. However, Ellis suggests that the term prospective memory is, "an inadequate description of research on the formation, retention, and retrieval of an intended action that cannot be realized at the time of encoding." (Ellis, 1996, p.3). Moreover, Ellis claims that viewing prospective memory as a distinct form of memory may be misleading. Instead, prospective memory is referred to as 'memory for delayed intentions'. The organization of future action forms the basis of Ellis' conceptual model of prospective memory.

The model states that prospective memory has five main stages, briefly, these are:

1. The *encoding* stage - or *what* you must do and *when.* This stage refers to establishing the both the content of the task to be performed and the associated time to execute it. Ellis suggests at this stage, related schematic structures may be activated. (For example if the intention was to put petrol in the car before picking children up from school, one may visualise taking a route to school which includes a garage.) Also at this stage, planning, and motivation will influence the eventual realisation of the action. (For example if the tank is half full, and it is raining, one may not be motivated and may postpone the intention; or if the plan of the action is insufficiently elaborate, then it may lead to a failure to carry out the intention, e.g. one may take alternative route to school, avoiding the garage.)
2. *Retention Interval*- This refers to the delay between encoding and performing the task. In this phase, the memory for the future action is retained until Phase 3.
3. *Performance Interval* - This has been previously referred to as the 'window of opportunity' (Harris and Wilkins, 1982). It is the retrieval of the intention as the time to execute it draws closer. I.e. during an awareness of the time to execute the action, we must retrieve the content of the action. (In the petrol example above, as

the time for picking up the child from school approaches one must retrieve the plan to stop at the garage for petrol.)

4. *Initiation and execution* of Intended action - This is the actual performance of the intended action at the correct time.
5. *Evaluation* of outcome - This involves some kind of check or mental note that the action has been performed.

These stages are themselves described in relation to two main components: the Retrospective component, which is concerned with the content of a delayed intention and consists of action, intention, and retrieval elements; and the Prospective component, which is concerned with the initiation and execution of the intention.

Ellis highlights the fact that many errors are possible. These failures can occur in almost any phase, with the ultimate error being a failure to perform the action. In the case of the final, evaluation phase, possible errors could be repetition of the action.

However, this is a conceptual framework for prospective memory and the main criticism is that Ellis does not provide any experimental evidence to support the existence of this model. In addition, it is complex and although it encompasses many of the areas and components involved in prospective memory, the comprehensiveness of such a model makes it difficult to research experimentally. Further, it does not differentiate between either the different types of intention, or the nature of the ongoing task on performance of the intention.

Multiprocess Approach

One of the challenges of prospective memory is the understanding how prospective tasks are accomplished. By definition, prospective memory tasks occur without some external prompt to stimulate retrieval. Accordingly, the intention must retained in mind until the opportunity to implement it arises, when the individual transfers attention from the secondary task to the prospective task.

Strategic Processes

One viewpoint (Burgess & Shallice, 1997; Ellis, 1996; Smith, 2000) sees the switching of attention from an on-going activity to an intended action as a strategic process. This process is considered as mediated by an executive attentional system, for instance the Supervisory Attentional system (Shallice & Burgess, 1991). Its role would involve monitoring the environment for the cue to perform, and subsequently to initiate the action.

According to McDaniel & Einstein (2000), this strategic process could operate in at least two ways, both of which involve the deployment of attentional resources. One possibility is that the executive system periodically brings to mind the intended action, which means when the target for the prospective action is encountered it is more likely to be activated and acted upon (e.g. Guynn, McDaniel & Einstein, 1998). Another possibility is that some executive resources are committed to monitoring the environment for the target associated with the intend action (e.g. Smith, 2000).

The strategic perspective, therefore views prospective memory as a intentional and planned process that includes self-reminding (Ellis & Nimo-Smith, 1993), and is demanding of processing resources (Smith, 2000).

Automatic Processes

Another viewpoint (see also the Simple Activation model) sees the prospective memory process as an automatic process. This view (e.g. Brandimonte, Ferrante, Feresin & Delbello, 2001; McDaniel et al., 1998; Moscovotch, 1994) suggests that when the target event is encountered it automatically brings to mind the intended action. Accordingly, from this perspective, there is no need for cognitive resources to be allocated for strategic monitoring, since upon encountering the target, involuntarily activation of the prospective action will occur (Brandimonte et al., 2001). Support for this view comes from the cue distinctiveness experiments (Einstein and McDaniel 1995; McDaniel and Einstein, 1993 cited earlier) and also phenomenological reports by participants that the intended action spontaneously 'popped into mind' when the target event appeared (Einstein & McDaniel, 1990).

Multiprocess Approach

At the present time, neither the strategic process nor the automatic process has been consistently supported in experimental studies. In particular, findings from the ageing & prospective memory literature are mixed, providing evidence for both views. The ageing debate is relevant because a widely held assumption is that cognitive processes decline with age (e.g. Craik, 1986; Craik & Bryd 1982; Salthouse, 1982, 1991). If this is assumption is deemed to be accurate, then according to the strategic view of prospective memory, age-related decline should be seen, because older adults cannot effectively initiate the strategic processing necessary for successful prospective memory. In contrast, according to the automatic view of prospective memory, age-related reductions should not be observed, since retrieval of the prospective task is a reflexive, involuntary process, that does not make extra demands on processing resources.

In favour of the strategic view, a number of studies have found age-related decline in prospective performance[8] (Cockburn & Milne, 2000; Dobbs and Rule 1987; Einstein et al., 1992; Maylor, 1993,1996; Park, et al., 1997 Uttl & Graf, 2000). However, counter to the strategic view, and consistent with the automatic view of prospective memory, other experimental studies have found no significant age-related decline in prospective memory performance (Cherry & LeCompte, 1999; Einstein & McDaniel, 1990; Einstein et al., 1992, 1995; Einstein, Smith, McDaniel & Shaw, 1997).

According to the evidence, it would appear that prospective memory adopts neither process exclusively.

[8] For detailed review of ageing and prospective memory see Chapter one, section*:* Age-related differences in prospective performance.

In light of the inconsistency in the findings, McDaniel and Einstein (2000) proposed the Multi-process view. They propose that prospective remembering can depend on both automatic and strategic processes, depending upon the nature of the prospective task (e.g. importance of the prospective task, target-task relatedness, the ongoing activity) and individual differences (including age and personality factors). For example, in tasks where the cue to perform the action is not particularly salient, the automatic process may be not be sufficient to bring the intention to mind, therefore a more strategic search may be initiated.

McDaniel and Einstein further propose that due to higher order nature of prospective memory as a cognitive function (involving future–oriented behaviour and planning), a multi-process is more effective for supporting prospective memory, and fundamentally humans as a species.

Methodological issues in Prospective memory research

A further factor requiring consideration in prospective memory research generally, is the methodology employed in assessing prospective performance. In the past ten years experimental studies of prospective memory have flourished (e.g. Einstein and McDaniel 1990; Einstein et al., 1991, 1992, 1995,1996; Kidder, Park, Hertzog & Morrell, 1997; Kvavilashvili 1998; Marsh & Hicks, 1998; Maylor 1993, 1996; McDaniel, Robinson-Rielger & Einstein, 1998; Rendell & Thomson, 1999). Whilst this is an important step in the empirical investigation of the area, and affords greater experimental control than the naturalistic studies of the past (Maylor

1990; Meacham 1982; West 1988), such studies have tended to compromise ecological validity. Such experimental studies have typically relied on a single repeated task (e.g. pressing a key) as an outcome measure. The main problem of such a measure is that participants may develop a response set. Thus, no matter what the target is, the participant is always required to perform the same response. As well as potentially leading to ceiling effects and fatigue, this does not assist generalization into the real world where the challenge of prospective memory lies in performing a number of different actions under different circumstances.

Laboratory studies (Cockburn & Smith 1988, 1991; Hubbert &Beardsall 1991; Dobbs & Rule, 1987) that have attempted to afford some ecological validity without compromising control have also typically used only single incidents as a measure (for example, returning a belonging; or delivering a message; or circling a word). Obviously, such limited responses means that little data can be yielded, and floor or ceiling effects are common.

Studies attempting to gain more quantitative data by employing aggregated response measures (Kvavilashvili 1998; Maylor 1993, 1996) have failed to overcome response set by using repeated responses and targets (for example, circling a target number when a face with beard or glasses is encountered, Maylor 1993, 1996; or substituting a "target" word when it appeared in prose, Kvavilashvili, 1998).

Therefore, it would appear there is a need to develop an ecologically valid methodology, which utilises multiple outcome measures of prospective performance.

It is important to consider that prospective memory does not operate in isolation from other cognitive functions, (planning, working memory, recall, etc). Accordingly, a number of variables may interact with the prospective goal and influence eventual performance. Failure could be due to retrospective memory i.e. simply failing to remember what the content of the task was. This would be less likely, of course, in tasks using repetitive outcome measures on healthy subjects, and some studies (e.g. Einstein and McDaniel 1993) have, *post hoc*, established that the participants could recall the prospective task. Nevertheless, prospective memory studies generally have failed to control the retrospective content from the outset of the experiment.

Conditions that affect prospective memory performance

Einstein and McDaniel have been instrumental in highlighting the effect different properties of the event target have on performance. In particular, they stress the importance of activation of the cue in order to elicit prospective memory performance.

On the basis of this assertion, it may prove useful to identify conditions that manipulate the level of attention the target event receives. This may be done in a positive way: for example, priming of the target event; or in a negative way, for example reducing the attentional resources available by embedding prospective memory within demanding ongoing tasks.

The role of working memory in prospective memory performance also merits examination. Cohen (1993) has discussed the role of the central executive component of working memory in the process of prospective memory.

The central executive is concerned with attentional control and the regulation of ongoing sequences of behaviour (Baddeley, 1992). Thus, it is suggested that failures of prospective memory can, in some instances, be attributed to an overload of working memory (Cohen 1993).

Experimental support for this position comes from a number of studies that have varied the demands of background tasks on event-based prospective memory (Kidder et al., 1997; Marsh and Hicks 1999), and time-based prospective memory (Einstein et al., 1997; Park et al., 1997), and both event- and time-based prospective memory (Busch 2001).

These studies have combined prospective memory tasks with verbal working memory tasks, varying the load, for example, by increasing the number of words to be recalled (Kidder et al., 1997; Park 1997), through digit monitoring tasks (Einstein et al., 1997), or a selection of working memory tasks, both executive and visuospatial (Busch, 2001; Marsh and Hicks, 1998) under different conditions. Prospective memory performance was generally reduced where the attentional resources were divided, although some exceptions have been reported (e.g. Marsh and Hicks, experiment 3, 1998; Otani, 1997).

Further investigation of the role of divided attention in prospective memory is clearly warranted, particularly in the area of ageing, where greater discrepancies in age-related performance might be expected to occur.

Conclusion of review, proposal for research.

Prospective memory is a crucial aspect of everyday functioning and research is of considerable practical importance. However, comparatively little research has been conducted on this topic, and models and theories remain incomplete and experimentally untested. Findings suggest that prospective memory may be a useful tool in the diagnosis of dementia; although the methodological weaknesses highlighted in the research in this area would preclude the acceptance of this conclusion until further research has been conducted.
The rationale for the proposed study is to evaluate models of prospective memory, (memory for future actions). Particular emphasis will be placed on investigating the circumstances that give rise to prospective memory failure.

The second objective is to establish whether prospective memory performance in persons with dementia differs significantly form healthy controls.

The third objective is to identify from self-report where and how prospective memory might fail in real life situations. This aspect of the study has the potential value to provide insight into those strategies that are relevant to independent living skills.

Four

The Experiments

Pilot Study

The aim of this pilot study is to establish a baseline level of prospective memory performance, by replicating typical single task methodology, using a passive or low cognitive demand background task.

By doing so, the experiment hopes to make the first step toward drawing attention to the following problems inherent in prospective memory research:

(i) Response set: Performance of the same response over a number of times, regardless of its relationship to the cue, will lead to a practice effect, which may have a cumulative effect on performance. In turn, this may lead to artificially inflated prospective performance or ceiling effects.

(ii) Ceiling effect: This may be a direct consequence of response set; or it may be due to a low-demand ongoing task. Such a background task would allow the participant to switch attention without great cost to cognitive resources, and consequently, neither background nor prospective performance would be compromised. Ceiling effects may also be the result of motivational factors. For instance, if the participant deems the prospective task to be more important than the secondary task, he or she may allocate cognitive resources accordingly.

(iii) Ecological validity: Whereas experimental tasks afford more control than naturalistic experiments, they do lack ecological validity. It could be argued that pressing a key in response to a word, tells us little about how an individual remembers to pass on a telephone message, or water the plants. Nevertheless, a first step in building a compromise between control and ecological validity may be by utilising everyday behaviours as part of the response.

In accordance with the methodological problems outlined, in particular the problem of response set, a *null* hypothesis predicts there will be no difference in performance between identical target and event and unrelated target and event.

Method Section (pilot study)

Ethics

This study adhered to the ethical code of conduct set out by the British psychological society (BPS). Ethical approval was granted by the school of psychology, University of Wales, Bangor ethics committee.

Participants

Twenty participants, opportunity sampled from University of Wales, Bangor, participated in this study. Nine of the participants were male and 11 were female. The mean age was 27.5 (s.d. 6.37 years). The participants were briefed about the nature of the study.

Apparatus/Stimuli/Materials

Apparatus

An Apple Macintosh computer, Performa 6200 was used to present the stimuli. The stimuli were presented centrally on screen, each image measured six inches by six inches. The rate of presentation was controlled by the participant.

A Kodak digital camera was used to take photographs of the majority of the stimuli, though some images were obtained from web sites.

Stimuli

The stimuli consisted of a 32-item picture list. Each picture was composed of a real life image. In the related target/task condition, 16 of the images consisted of a picture of a wooden container and some paperclips. The remaining half were filler items and consisted of a variety of different images (e.g. ship, fountain, books, etc). In the unrelated condition, the target image was of a pair of parrots, repeated 16 times. The remaining pictures were unrelated fillers. The stimuli were randomly presented to the subject in each condition.

Materials

A wooden container and 17 paperclips were used as part of the prospective memory task. The paperclips were arranged near the empty container and the participant was required to put one in whenever an appropriate target appeared.

Each participant completed a consent form and received written standardised instructions. Responses were recorded on a score sheet.

Design

The study employed a within subjects design. Learning effects were controlled by counterbalancing the presentation of the conditions.

The independent variable was the relatedness of the event and target (either identical or unrelated). The dependent variable was the prospective performance in each condition.

Additionally, since the aim of the study was to establish a baseline measure of prospective memory performance on a repeated single response, data was recorded for comparison with condition one of experiment one, (using multiple tasks).

Procedure

The participants were approached and asked if they would like to participate in a study concerned with prospective memory. The participant was then presented with a consent form to sign and date. Once informed consent was obtained the participant was given written instructions to read and then verbally instructed before each experiment.

Participants were randomly allocated to either the identical or unrelated condition. Once they had completed one condition they were given a short break and given instructions for the remaining condition.

On completion of the experiment, participants were asked if they had used any links to help remember the association between the target and task. A record was made of any links made. (No links were actually reported by any of the participants.)

Finally, the participants were thanked for their time and debriefed about the precise nature of the study. The entire procedure lasted on average ten minutes.

Results

The results for both conditions in the single response task showed that performance was at ceiling (Related, M=16; Unrelated, M=16). Thus there is no significant difference between related and unrelated performance in a single task methodology.

Table (a) Comparison of Prospective Performance, (Mean % Correct), according to Multiple or Single Response*.

Condition	Mean Percent correct
Single Response	
Related	100 (0)
Unrelated	100 (0)
Multiple Response	
Related	93.12 (8.57)
Unrelated	38.12, (23.81)

Table (a) shows that performance for single repeated response measure is superior to Multiple responses for both related and unrelated targets and events. This difference is much greater for unrelated performance than related. t-tests revealed the difference between Multiple and Single responses to be significant

* For ease of interpretation, it was deemed appropriate to include the prospective performance of experiment one in this table. This was to demonstrate a direct comparison between single and multiple response methods, in order to verify the claim that response set is a factor in ceiling effects.

for both related, $t(19), -3.58, p=<0.002$; and unrelated $t(19), -11.62, p=<0.0001$ conditions.

Review of Findings of Pilot study

The results support the prediction that a single task method produces maximum performance (ceiling effects) regardless of relatedness factor (of target to task). The alternative hypothesis stating there will be no significant difference in performance between related and unrelated stimuli was retained.

The findings demonstrated superior prospective memory performance when using single response rather than multiple outcome measures. However in light of the ceiling effects, this leads to the suggestion that performance may be artificially inflated in single measures, perhaps due to vigilance or the direction of attentional resources onto a single target. This is particularly salient when examining the relatedness of targets and tasks. In the multiple measures condition, performance for unrelated items is significantly poorer than for highly associated items, perhaps because of the amount of processing required to construct a cognitive link between unrelated target and tasks.

In contrast, no such difference is found within single response measures for unrelated and related items. In both conditions, performance is at ceiling. This implies that response set is occurring, thus such a method may not be a valid measure of prospective performance.

Based on these findings, experiment one will employ a multiple response methodology. This will serve the dual purpose of controlling for ceiling effects and adding an element of ecological validity. The level of the background task will remain minimal. However, in order to establish the effect background task has on prospective performance, the demand level of the background task will be manipulated in a later experiment.

Experiment one

At the present time there is no single defining methodology for studying prospective memory. However, the paradigm developed by McDaniel and Einstein (1990) has been most widely adopted in laboratory-based experiments of prospective memory.

In essence, this methodology entails the participant viewing stimuli on a computer screen (which also includes material for the secondary task) and responding to the prospective cue (usually a word) whenever it appears on screen. In general, this methodology relies on a single repeated task (e.g. pressing a key) as an outcome measure. The main problem of such a measure is that participants may develop a response set. Thus, regardless of the target, the response is invariable. Besides potentially leading to ceiling effects, this methodology fails to assist generalization into the real world, where the challenge of prospective memory lies in performing different actions, under different circumstances.

Studies (Kvavilashvili 1998; Maylor 1993, 1996) that have attempted to control for ceiling and floor effects by employing aggregated response measures have also failed to overcome response set, mainly because the same responses and targets are repeated over a number of times. It would appear therefore, there is a need to develop an ecologically valid methodology that utilises multiple outcome measures of prospective performance.

Furthermore, in many laboratory tasks, the prospective cue is embedded within relatively demanding secondary tasks. Although a prerequisite of a prospective memory task is the disengagement from a secondary task, in order to respond to the prospective cue, it is important to establish that prospective failure is not the result of a demanding secondary task, expending available cognitive resources. Thus, it is important to establish that poor prospective performance is not simply a reflection of poor dual task performance. Accordingly, in order to establish the effect the secondary task has on performance, there is a need to develop a baseline measure of prospective performance, and subsequently manipulate the level of difficulty (demands) of the background task.

Experiment One will attempt to develop a methodology that addresses some of the methodological flaws discussed. Prior to this experiment, a pilot study was conducted. This study replicated the single-task response methodology, common to prospective memory research.

The findings in the pilot study demonstrated a ceiling effect for both unrelated and related target-task items. This implies that response set is occurring, and based on these findings, experiment one will employ a multiple response methodology.

It is acknowledged that both the pilot and experiment one deviate from the majority of prospective research in that a low-load or 'passive' task is used as the secondary task. However, this methodology is not unique in this approach. McDermott & Knight (2004) conducted an experiment in which the secondary task involved the passive viewing of a video recording of a shopping trip. The prospective element required participants to recall an associated action for each cue in the film (e.g. when they saw the McDonald's on the video, participants were supposed to recall the action of buying a hamburger). Additionally, Logie, Maylor, Della Sala & Smith (2004) included the passive watching of a silent film as the 'low-load' condition in their prospective memory study. The findings showed that during the high load condition (in which participants were asked to perform arithmetic tests) prospective performance was significantly poorer.

These findings justify the need to establish that performance on the prospective task is not confounded by high cognitive demands made by the secondary task.

Experiment one: Aims

The aims of experiment one are threefold: Firstly, to investigate prospective performance using multiple-task methodology. Secondly, to directly compare retrospective and prospective memory using the same experimental methodology. Thirdly, to investigate the effect of learning on prospective and retrospective memory.

One of the aims of this study is to explore the benefit of a learning technique on prospective memory, the technique of selective reminding will be utilised to accomplish this. The other two aims of the study include comparison of retrospective and prospective memory in terms of encoding and production; and investigation of multiple prospective outcome measures.

Hypotheses:

There will be a positive gradient associated with learning for both prospective and retrospective memory: Retrospective recall and prospective performance will increase over each trial.

There will be a significant difference between retrospective and prospective memory in each trial, with participants showing a higher level of performance on retrospective memory.

There will be a significant difference in performance for both prospective and retrospective memory as a function of the level of difficulty relatedness between target and task. Relatedness refers to how visually similar the task item is to the target item. In other words, related target-task items are a direct pictorial representation of the main component of the prospective memory task. Unrelated target items bear no visual resemblance to the prospective task.

A number of studies (e.g. Einstein & McDaniel, 1996; Mantalya, 1996; McDaniel Robinson-Riegler & Einstein 1998) have suggested that a factor affecting prospective memory is the nature of the relationship between the cue (target) and the prospective task. In general, findings (e.g. Einstein & McDaniel, 1995; McDaniel & Einstein, 1993; McDaniel et al., 1998; Uttl & Graf, 2000) have shown that distinctive cues (i.e. cues that in some way draw attention e.g. large font, or a low frequency, or unfamiliar word) are more likely to be acted upon. Extending upon this, and in an attempt to move away from word-based laboratory stimuli to more visual real world images, the present study will examine how the nature of the cue will affect performance when the stimuli is presented pictorially (as opposed to written text). Accordingly, the stimuli cue (referred to as 'target') will be either directly physically (or conceptually) related to the prospective memory task; or the target will bear no physical resemblance (or obvious conceptual relation) to the task.

In light of previous research findings, it is predicted that the presentation of a related target and task will produce better recall and performance than an unrelated target and task.

Method

Ethics

This study adhered to the ethical code of conduct set out by the British psychological society (BPS). Ethical approval was granted by the University of Wales, Bangor school of psychology ethics committee.

Participants

Twenty participants, opportunity sampled from University of Wales, Bangor participated in this study. The participants were paid five pounds for participating. Eleven of these participants were female and nine were male. The mean age of this sample was 29 years (s.d. 7.38 years). The youngest participant was 21 years and the oldest 48 years, (range 27 years). All participants either held a University degree or were currently studying for one. The participants were blind to the precise nature of the experiment.

Apparatus/Stimuli/Materials

Apparatus An Apple Macintosh computer Performa 6200 was used to present the stimuli. The stimuli were presented centrally on screen; each image measured six inches by six inches. The rate of presentation was controlled by the participant.

A Kodak digital camera was used to take photographs of the majority of the stimuli, though some images were obtained from web sites.

Stimuli The stimuli consisted of a 32-item picture list. Each picture was composed of a real life image. Half of these stimuli were target items and half were designated as fillers. The 16 target items were equally divided into either related task items or unrelated task items. Related target items were a direct pictorial representation of the main component of the prospective memory task. Unrelated target items bore no resemblance to the prospective task. For example, if the task was to "sharpen a pencil," a picture of a pencil and sharpener was presented as the related target. In contrast, if the task was to, "take the disk out of the box," a picture of the University Gates was presented as the unrelated target.

The 16 filler items included eight "red herrings." These were images that could be construed as semantically, or visually related to the target items. (For example, a picture of drawing pins and container, which is semantically close to the target: paperclips and container).

The stimuli were randomly presented to the subject in each condition, with the exception of the instruction trial (see procedure).

Materials: A selection of objects was placed at random on a large desk, adjacent to the computer workstation. Sixteen of these desk items were integral to the study and required manipulation of some kind. Four items were fillers and did not require any manipulation. (See appendix one)

The target items were as follows: A shopping list with three items listed; a blue participant information form; a book and mark; a phone list and envelope; a disk and box; a red pen and note pad; a telephone message; some paperclips and a wooden container; a pencil and pencil sharpener; a calendar; a clock; four coloured felt pens and a case; a plant and a vase of water; a desk lamp; an eraser; and some blutack and its packet.

The filler desk items included: A pen attached to a chain; some drawing pins and container; a stapler and some staples; an empty glass bottle.
The responses of the participant in each condition were recorded on a score sheet. This included the correct score for each item as well as notes on type of error made and any mnemonic devices employed. Each participant completed a consent form and received written standardised instructions and a debriefing sheet.

Design

The study employed a within-subjects design. This design was employed to control for individual differences between subjects. Furthermore, since one of the aims was to establish learning over trials, the possible confound of practice effects was not an issue.
The independent variables in the study are; the relatedness of the target items to the task (either identical or unrelated), and the level of learning trial, represented by the three conditions. (Trial one no learning, trial two - errors

corrected from previous trial and trial three, final trial - errors corrected from previous trial)

The dependent variables were the retrospective memory recall for each condition; the prospective memory performance in each condition; the type of errors made; and mnemonic employed for linking the target and task.

The experiment consisted of three conditions, in each condition the same stimuli were randomly presented, this was to control for the confounding variable of novelty and learning by position of target stimuli. The retrospective and prospective memory performance recorded was recorded at the end of each trial. Any mnemonic strategies employed were recorded at the end of the experiment.

Procedure

The participants were recruited through advertisements in and around the University of Wales, Bangor. The participant was informed that the study was concerned with prospective memory and that the study would require them to complete a number of desktop tasks when certain images were presented. The participant was then presented with a consent form to date and sign. Once informed consent was obtained, the participant was given both written standardized instructions and verbal instructions.

In the first condition, the experimenter presented the target images and tasks. Each visual target was accompanied by the verbal task. The experimenter did not move on to the next one until the participant nodded or said, "Ok."

In this instruction part of trial one, the filler stimuli were excluded; only the target stimuli were presented, and the presentation also followed a set pattern of alternating related with unrelated. This pattern was the same for all subjects.

After this instruction trial, the participant was asked to recall (verbally) the target and corresponding task. During this and all other retrospective trials, the participant was not permitted to look at the desk where the tasks were set out, in order to control for the tasks providing visual cues.

Retrospective memory performance was free recall and no time limit was set, the final answer was recorded when the subject said they could not remember any more. The experimenter recorded the number of correct pairs (i.e. target and correct task), as well as errors.

On completion of this retrospective part of trial one, the participants were instructed to perform the prospective component. In this part of the trial, all 32 items were presented and the participant was instructed to work at his or her own pace, pressing the space bar to move on to the next stimulus. Participants were informed that some of the images would be fillers and were asked to ignore these, and move on until a target was presented. When they reached the target, they were asked to physically perform the corresponding task.

If the participant recognised the target but could not recall the task, they were instructed to verbally inform the experimenter.

Condition two began with retrospective free recall of the targets and associated tasks. Participants were asked to recall what they thought they were supposed to do, even if this was different from what they had actually done previously. After recall, participants were prompted on items, which had been omitted or were incorrect. If they were unable to recall with a prompt, they were provided with the correct answer by the experimenter.

After the retrospective component of condition two, the participants completed the prospective trial. This followed the same procedure as outlined in Condition one.

The third and final condition followed the same procedure as condition two; beginning with retrospective recall and ending in prospective performance.

In addition, after completing the prospective component of trial three, the participants were asked how they remembered to perform the task for each "unrelated" target. A record was made of any mnemonic links used.

Finally, participants were thanked for their time, and debriefed about the precise nature of the study. The entire procedure lasted on average 45 minutes.

Results

Table 1 Means, standard deviations and range for Retrospective and Prospective memory over each trial.

Condition & Trial	*Mean*	*Standard deviation*	*Min score*	*Max score*	*Range*	*N*
Retrospective One	6.95	2.52	3	14	11	20
Retrospective Two	8.5	2.04	5	14	9	20
Retrospective Three	11.25	2.05	8	15	7	20
Prospective one	10.55	2.04	8	15	7	20
Prospective Two	13.65	1.66	11	16	5	20
Prospective three	15.15	1.27	12	16	4	20

Table 1 shows, in general better performance for prospective memory for each trial.

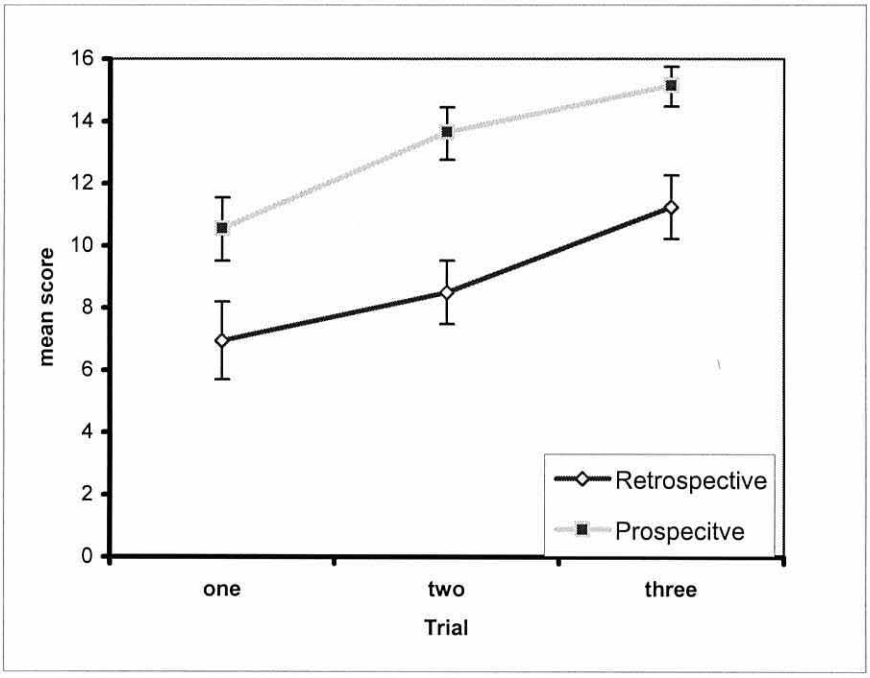

Figure 1: Graph showing mean and standard deviation scores for prospective and retrospective memory across trials

Figure 1 shows a positive gradient in performance, associated with learning trials. The graph shows little difference between prospective and retrospective memory in the relative improvement of performance over trials, with an increase of approximately 2 items over each trial for both prospective and retrospective memory.

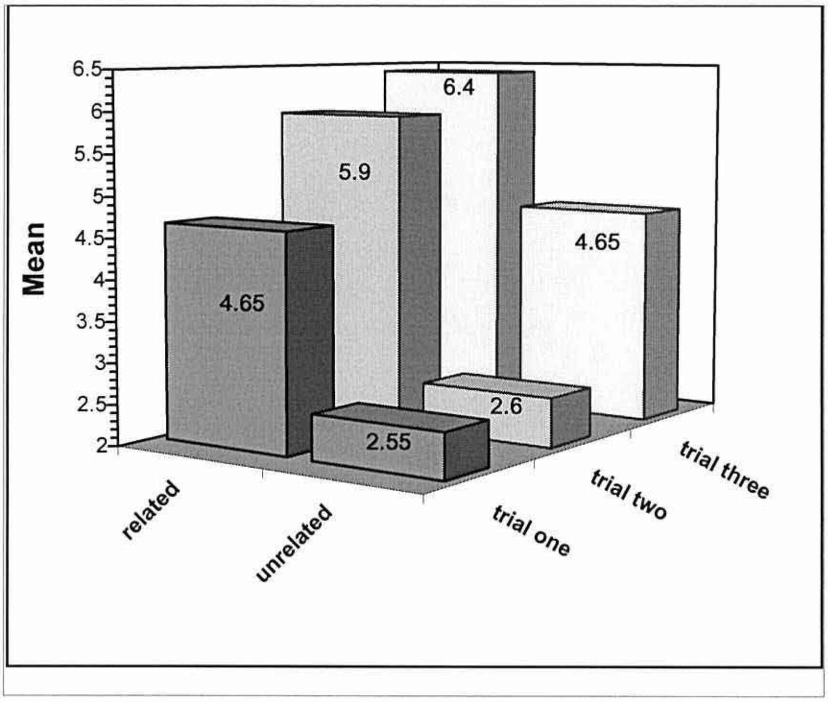

Figure 2: Retrospective memory performance for related and unrelated items over trials.

Figure 2 shows that for all three trials, the related conditions (targets which were identical to the task) resulted in better retrospective performance. In addition, retrospective performance for both related and unrelated items increased over the learning trials.

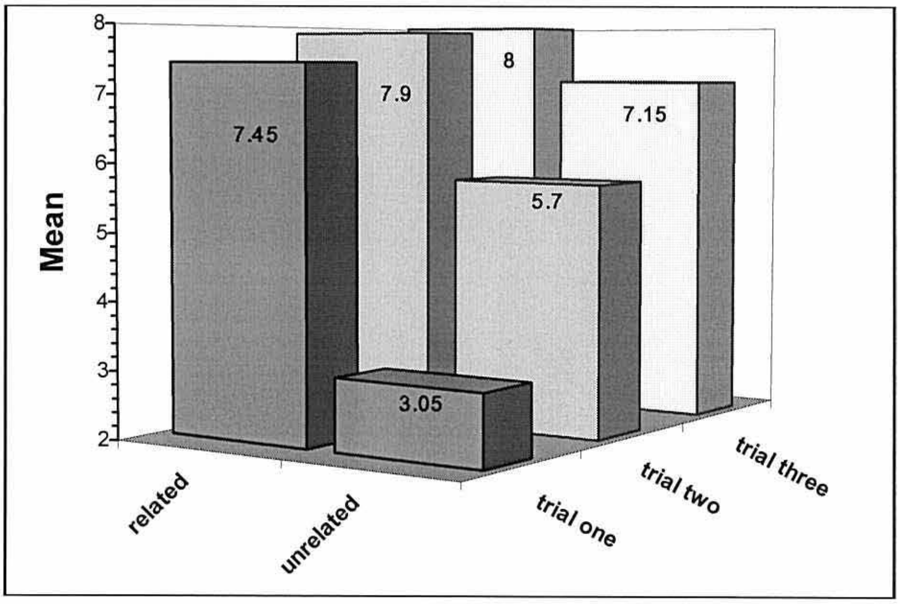

Figure 3: Prospective memory performance for related and unrelated items over trials.

In figure 3, prospective performance reveals a similar general pattern, with better performance for related items than unrelated items. However, in contrast to retrospective performance over trials, the table shows that the difference between unrelated and related attenuates over each learning trial. It is important to note that performance for related items is at ceiling on the final trial.
The effect of the target-task relatedness across all conditions and for retrospective and prospective memory is illustrated in figures 4 and 5 below.

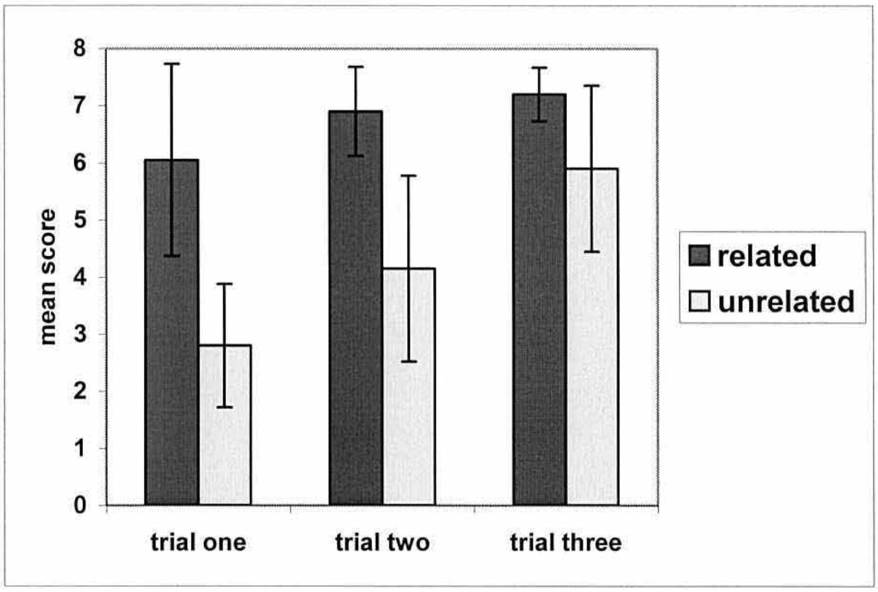

Figure 4:Mean and standard deviation scores for relatedness of target to task over trials; prospective and retrospective memory combined.

Figure 4 above, shows the superiority of performance across trials on related items for both retrospective and prospective memory combined. Trial one shows that performance for related items is almost double the performance for unrelated items on the same trial. However, the difference between unrelated and related reduces over learning, with scores for related items reaching ceiling.

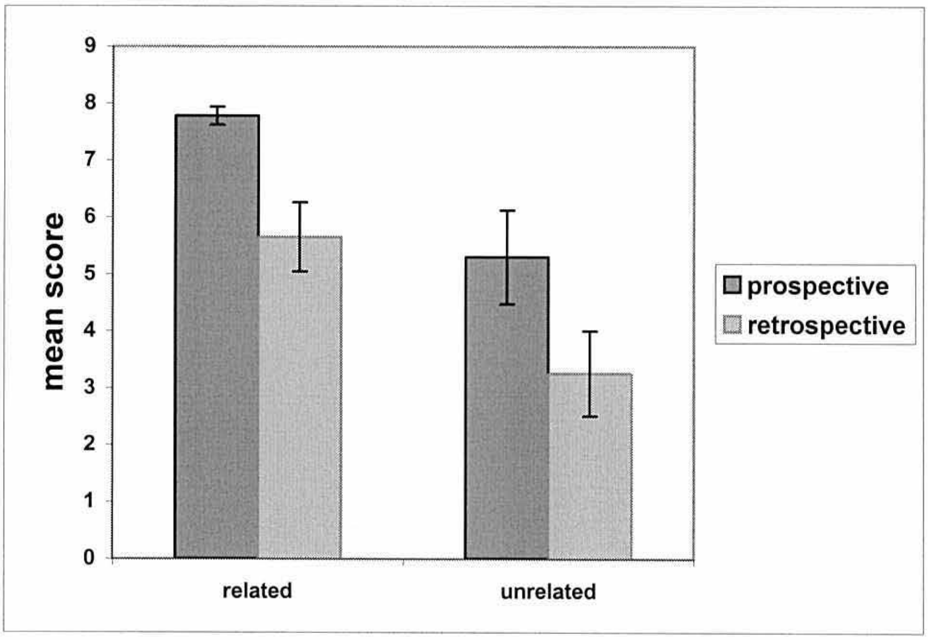

Figure 5:Mean and standard deviation scores for relatedness of target and task for prospective and retrospective memory; all trials combined.

Figure 5 above, shows prospective memory demonstrated superior performance in both unrelated and related tasks across the combined trials. Additionally, very little variance in performance for related items for the prospective memory condition is shown.

The descriptive statistics show some interesting differences in the data for memory type, learning trial, and level of relatedness. In order to ascertain whether significant interactions exist among these variables the data was subjected to a repeated measures ANOVA. Mauchly Sphericity[1] tests were conducted preceding each ANOVA.

[1] This tests the assumption of homogeneity of covariance (sphericity). Before carrying out ANOVA F-test, we must assume that the scores of the various levels of the within subjects factors are homogeneous. If violated the type I error (rejecting Ho when true), may be inflated. Thus, if value greater than $p= 0.05$ then no heterogeneity of covariance, i.e. homogeneity of covariance is assumed and ANOVA F-test can be used. Unless otherwise stated, all tests of sphericity were $p=>0.05$.

Main Effects:

The results showed a significant main effect for Memory, F (1,19) = 324.45, p<.001, suggesting that memory type (either prospective or retrospective) significantly affected performance. The mean scores (see Table 1 and fig. 5) indicate that prospective memory is generally superior to retrospective memory.

A significant main effect for learning trial was also found, F (2,38) =66.28, p<.001. This suggests that performance is significantly affected by learning. The pattern of means (see table 1, fig.1 and fig. 4) implies that performance is associated with a positive increase over each learning trial.

Finally, the main effect for relatedness was significant, F (1,19) =93.664, p<.001. This confirms that the degree of relatedness between the target item and task (unrelated or related) influences performance. On the whole, the findings from descriptive statistics (see table 1, fig. 2 and fig. 3) indicate that performance is better for related items.

Interactions:

The interaction of memory and learning trial was significant F (2, 38) =3.89, p<.05, indicating that the two types of memory are differentially affected by learning trial. Overall performance implies that prospective memory is superior for each trial.

A significant interaction for learning trial and relatedness of target was found, F (2, 38) = 19.43, p<.001, indicating that the pattern of performance for unrelated and related items is not the same across learning trials. Generally, related items are associated with better performance and less variability than unrelated items (see fig.4).

The interaction for memory type and relatedness was not significant, F (1, 19) =. 26, n.s. This suggests that memory type (either prospective or retrospective) is not differentially affected by the target-task relationship.

However, the three-way interaction of memory, relatedness, and learning trial was significant, F (2, 38) = 12.32, p<. 001. This suggests that when the variables are considered in combination, differences in performance are observed. (See figures 6 & 7).

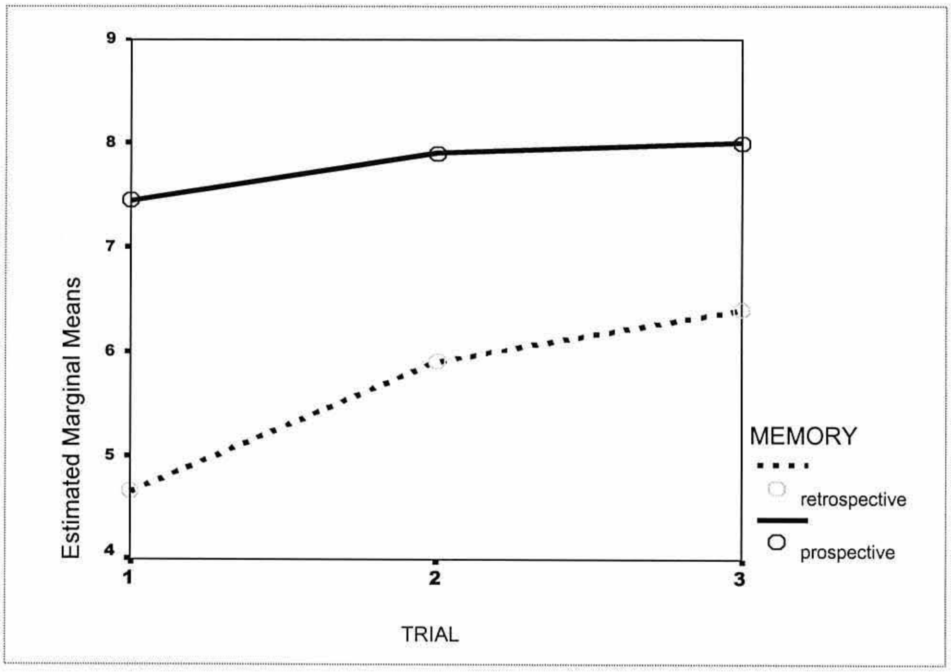

Figure 6: Graph of interaction for Related target-task items.

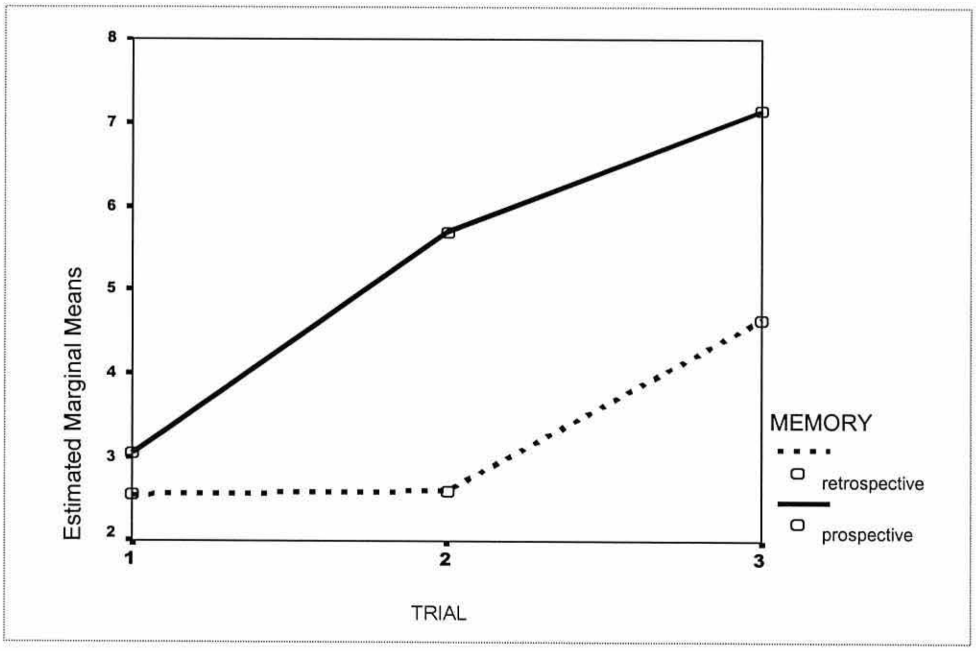

Figure 7: Graph of interaction for unrelated target-task items

Post Hoc Analysis

The ANOVA has revealed a number of significant interactions among the variables. Therefore, Post Hoc Analysis in the form of paired samples t-tests using Bonferroni Criterion[4] will be performed.

The findings of the paired samples t-tests are presented in Tables 2, 3, 4 and 5

Table 2: Paired samples t-tests performed for memory type over trials, with levels of relatedness combined.

Variable pair Tested	mean	df	t	p
Prospective trial one Retrospective trial one	10.55 6.95	19	7.21	<.0005**
Prospective trial two Retrospective trial one	13.65 6.95	19	11.27	<.0005**
Prospective trial three Retrospective trial one	15.51 6.95	19	11.27	<.0005**
Prospective trial one Retrospective trial two	10.55 8.50	19	5.6	<.0005 **
Prospective trial one Retrospective trial three	10.50 11.25	19	-1.39	<.18 **N.S.**
Prospective trial two Retrospective trial two	13.65 8.50	19	12.31	<.0005**
Prospective trial two Retrospective trial three	13.65 11.25	19	6.84	<.0005**
Prospective trial three Retrospective trial two	15.51 8.50	19	14.44	<.0005**
Prospective trial three Retrospective trial three	15.51 11.25	19	10.36	<.0005**

** significant at less than Bonferroni adjusted <.0018 level of chance

[4] To overcome the multiple comparison problem, or type II error, the Bonferroni procedure is simple and effective. The significance level is set at the level of each simple effect divided by the number of tests. For post-hoc paired sample t-tests this is p=<.0018.

Table 2 shows prospective memory performance is significantly better than retrospective memory, not only within, but also across learning trials, with the exception of the pair prospective one and retrospective three. This pair demonstrates no significant difference between the final learning trial for retrospective memory and first trial for prospective memory.

However, it should be noted that these results are based upon the combined performance for related and unrelated items. The effect of this relatedness variable is examined in Table 3.

Table 3: Paired samples t-tests performed for Memory type over trials, according to relatedness of target and task

Variable pair tested	mean	df	t	p
Trial One				
Prospective Related	7.45	19	9.92	<.0005**
Prospective Unrelated	3.05			
Retrospective Related	4.65	19	6.33	<.0005**
Retrospective Unrelated	2.55			
Trial two				
Prospective Related	7.9	19	5.39	<.0005**
Prospective Unrelated	5.7			
Retrospective Related	5.9	19	6.77	<.0005**
Retrospective Unrelated	2.6			
Trial three				
Prospective Related	8.0	19	3.00	<.007 **N.S.**
Prospective Unrelated	5.7			
Retrospective Related	6.4	19	4.27	<.0005**
Retrospective Unrelated	4.65			

** significant at less than Bonferroni adjusted **<.0018** level of chance

Table 3 shows a significant difference in performance between unrelated and related items for both prospective and retrospective memory over all trials, with the exception of prospective trial three. In this final trial, there is no significant difference in prospective memory performance between unrelated and related items. In general, table 3 shows that related items, or events that were identical to the target, resulted in significantly better performance than items, which were unrelated to the target.

Table 4: Paired samples t-tests performed for level of difficulty over trials by memory type.

Pairs of variables examined	mean	df	t	p
Trial One				
Prospective Related	7.45	19	8.3	<.0005**
Retrospective Related	4.65			
Prospective Unrelated	3.05	19	1.39	<.18 **n.s.**
Retrospective Unrelated	2.55			
Trial two				
Prospective Related	7.9	19	7.12	<.0005**
Retrospective Related	5.9			
Prospective Unrelated	5.7	19	7.23	<.0005**
Retrospective Unrelated	2.6			
Trial three				
Prospective Related	8.0	19	7.61	<.0005**
Retrospective Related	6.4			
Prospective Unrelated	7.15	19	7.61	<.0005**
Retrospective Unrelated	4.6			

** significant at less than Bonferroni adjusted **<.0018** level of chance

Table 4 shows a significant difference between memory type and level of difficulty over trials, with the exception of trial one, unrelated items. In this initial trial, there is no significant difference between prospective and retrospective memory performance for unrelated items. The means for this pair are also the lowest out of the trials and levels of difficulty.

In general, Table 4 shows that prospective memory for both related and unrelated items is significantly better than retrospective memory in the same condition (with the exception already noted)

The effect of learning trial on memory type is examined in Table 5.

Table 5: Paired samples t-tests performed for trial and memory type, with level of difficulty combined.

Pairs of variables examined	mean	df	t	p
Retrospective				
Trial one Trial two	6.9 8.5	19	2.95	<.008 **n.s.**
Trial two Trial three	8.5 11.25	19	-5.86	<.0005**
Trial one Trial three	6.9 11.25	19	-6.35	<.0005**
Prospective				
Trial one Trial two	10.55 13.65	19	-7.23	<.0005**
Trial two Trial three	13.65 15.15	19	-9.31	<.0005**
Trial one Trial three	10.55 15.15	19	-4.68	<.0005**

** significant at less than Bonferroni adjusted **<.0018** level of chance

Table 5 shows a significant difference in performance for both prospective and retrospective memory over learning trials, with the exception of retrospective one and two.

In general, the table shows that performance significantly increased with each trial. The means show that, for both prospective and retrospective memory, performance in the initial trial is poorest and performance in the final trial is best

However, it is important to consider that in Table 5 there was no significant difference within the final trial for unrelated and related items (unrelated was almost at ceiling and performance for related was at ceiling). Thus, three trials may be the optimum number of learning trials for prospective memory, in this population using this procedure.

Review of Findings of experiment one

The results of experiment one confirm the experimental hypothesis stating there will be a positive gradient associated with learning for both prospective and retrospective memory. The findings showed a significant increase for prospective memory with each trial. There is a similar pattern of results for retrospective memory, however although performance on the second trial was higher than the first, this was not significant.

The findings fail to provide support for the experimental hypothesis, predicting a significantly higher level of performance for retrospective memory in each trial. In contrast, with the exception of the third retrospective trial, and the initial prospective trial (The extremes of the learning trials) prospective memory was superior to retrospective memory between, and across all trials (including prospective trial one and retrospective trail two, and prospective trial two and retrospective trial three). This suggests that prospective memory is superior to retrospective learning from the outset and that even after three trials retrospective performance is only equivalent to baseline prospective memory.

Finally, the findings confirmed the hypothesis predicting a significant difference in outcome for both prospective and retrospective memory as a function of the level of difficulty in association. Overall, the findings demonstrated superiority in performance for events related to the target as opposed to unrelated to the target. However, when considering the interaction effects, it should be noted that performance is at the upper limit in prospective memory trial three for both unrelated and related items, and near maximum in trial two for related items. It is possible therefore, that this ceiling performance may mask the true effect and account for the non-significant difference between trials two and three.
Also, no significant difference was reported between prospective and retrospective memory for unrelated items in the initial trial. It is possible that this could be due to the level of processing required for the items. Accordingly, it would be expected that items that did not have strong associations (i.e. unrelated) would be more difficult to remember for both conditions. Additionally, since this was the first time participants performed the tasks, any benefits of an extra motoric form of encoding for prospective memory had not yet taken effect.

In general, experiment one has achieved the aim of exploring the benefit of learning on prospective memory. It would appear that learning improves prospective memory, perhaps more so than retrospective memory. This suggests that a learning technique may be beneficial as a way of minimising floor effects in Alzheimer's patients for a future study.

The study has also achieved its second aim of comparing retrospective and prospective memory in terms of encoding and production. The findings reveal that prospective memory is generally superior to retrospective memory and that the level of association formed at encoding does have an effect on performance for both retrospective and prospective memory.

Finally, it has achieved its aim of investigating multiple prospective outcome measures. The findings demonstrated that no subject performed at ceiling in the first trial, indeed maximum performance was seen only in the final learning trial for the eight related items. This is in contrast to the findings from the pilot study, where single repeated outcome measures have often led immediate ceiling effects. It could also be argued that performing a number of tasks in response to different events is more ecologically valid than the same response (a key press) to different events.

This type of outcome measure also contributed toward the elimination of response set. This was verified by the errors made; for example, some subjects performed the wrong task for the correct target or claimed they recognised the event but could not remember what to do. In most experimental studies of prospective memory, this type of error is not investigated, as the response is always the same.

Conclusions of experiment one

The results of experiment one revealed a positive gradient associated with learning; with performance in the final trial at ceiling for most subjects, providing justification for a learning paradigm, such as selective reminding. However, future experiments involving Alzheimer's patients would need to adopt a more simplified methodology.

The findings also demonstrated that prospective memory performance was typically better than retrospective recall. However, the experiment only examined performance under a passive background, and it may be beneficial to examine performance under differing levels of attention.

Additionally, the experiment is not immune to ceiling effects; however, this was not evident from the first trial. Instead ceiling effects occurred predominantly for the related target-task condition in trials two and three. This again suggests that prospective memory performance is affected by the nature of the cue in the target-task relationship. It also implies that learning by performing the action is particularly beneficial to prospective memory performance. Nevertheless, the existence of a ceiling effect does hamper the ability to provide a precise interpretation of the non-significant effect between trials two and three.

Finally, the findings indicate that when required to perform multiple actions prospective performance tends to be poorer and more errors are made. This suggests that this type of outcome measure may be a more valid measure of prospective memory than a repeated singular action.

Experiment two: Ageing and prospective memory

Survey one.

A survey was conducted on 30 opportunity-sampled participants aged over 60 years. The aim was to ascertain the kinds of everyday situations that older persons perceive as giving rise to prospective memory failure.

Self-report measures used in studies of everyday cognition, for example the Cognitive Failures Questionnaire (CFQ) (Broadbent, Cooper, Fitzgerald and Parkes, 1982) have found that in most cases, older participants tend to report more failures than younger participants (Martin, 1983; 1986). However, the CFQ attempts to assess the full domain of everyday cognition, (including perception, memory, and action) by using a 25-item Likert questionnaire. Consequently, only three questions can be construed as tapping into prospective memory.

The relationship between ageing and prospective memory has been investigated by Martin (1986), using the Everyday Memory Questionnaire (EMQ). The EMQ is a self-report measure of retrospective memory (e.g. face recognition, episodic, semantic and spatial memory) as well as prospective memory. The questionnaire measured self-ratings of how good the participant judged their memory to be for each item. Measures of prospective memory included self-ratings for keeping appointments, taking medicine, paying bills on time, etc. On the whole, findings suggested older participants rated their prospective memory as better than did the young group.

However, these questionnaires do not address the full range of everyday situations that are likely to give rise to prospective memory failure. Rather they illustrate judgements of performance (i.e. how good the individual thinks he or she is) for a relatively small number of prospective memory tasks.

Therefore, the present survey hopes to identify the areas of prospective memory that are perceived as being most likely to give rise to failure for a population of older people. The survey will use a broader range of everyday prospective memory tasks than previously investigated in other questionnaires. Additionally, where feasible, the prospective tasks identified as leading to the most failures will be utilised as experimental stimuli for use in a future study.

Methods

Ethics

This study adhered to the ethical code of conduct set out by the British psychological society (BPS). Ethical approval was sought and granted by the University of Wales, Bangor: School of Psychology ethics committee.

Participants

Thirty participants, opportunity sampled from Bangor and Colwyn Bay shopping centres, took part in this study. Fourteen of these subjects were male and 16 were female. The mean age for this sample was 69 years, (s.d. 6.5

years) with a median age of 68 years. The youngest participant was 60 years, the oldest 90 years (range 30 years). Females were on average older than males, with a mean age of 71 years, compared to the mean age of 67 years for males. However, this difference was not statistically significant. The participants were fully briefed about the nature of the questionnaire before participating.

Materials

A twenty-item questionnaire in the form of a Likert scale was used. The items were derived from a pilot questionnaire through the process of 'try-outs,' in which as many prospective memory situations as possible were identified and a convenience sample (consisting of older adults and colleagues) were asked if they considered these as an example of a situation in everyday life that would give rise to forgetfulness. Twenty items were included. However, it is acknowledged that the numbers of situations identified were not definitive, and accordingly, in the distributed questionnaire, there was space at the end individuals to identify any other situations that give rise to forgetfulness.

The items were worded as statements and each one included a different situation that may give rise to forgetfulness. The Likert rating included five degrees of frequency, ranging from always to never. These were scored from 0 (never) to 4 (always).

A high score indicated that the item was a frequent source of forgetfulness (see appendix two for copy of questionnaire).

Procedure

The participants were approached and asked to volunteer for a survey about memory. Before beginning the questionnaire, the participant was reminded of the nature of the survey and provided with an example of how to complete a Likert scale questionnaire. The participant was assured of confidentiality and when verbal consent was obtained, the participant was given the questionnaire to complete. The experimenter was present during the completion of the questionnaire. As a control for possible experimenter bias, the experimenter stood some distance away, so that the responses were not clearly visible. The assurance of confidentiality was intended to reduce a social desirability response set. The questionnaire took an average of five minutes to complete. Once the participant had completed the questionnaire, they were thanked for their time.

Results

Summary and descriptive data were obtained for the questionnaire items and responses.

Table 6: Mean and rank sum scores of variables

VARIABLE	*MEAN*	*MODE*	*SUM*	*N*
Message	1.97	3	59	30
TV programme	1.73	2	52	30
Grocery	1.73	2	52	30
Post box	1.7	2	51	30
Pills	1.6	2	48	30
Light	1.57	2	47	30
Bin	1.27	1	38	30
Contact	1.2	2	36	30
Item	1	1	30	30
Book	.96	1	26	27
Cooker	.93	0	26	28
Bill	.9	0	27	30
Washing	.81	0	17	21
Plants	.77	0	23	30
Change	.67	1	20	30
Appointment	.63	0	19	30
Key	.23	0	7	30
Dentist	.13	0	4	30
Lock	.13	0	4	30

Table 6 shows the participants' rating for each variable, arranged in descending order of likelihood of difficulty. The total number (N) of participants is 30; where a lower N value is reported this indicates that the variable was 'not applicable' to the participant, (for example *washing* – taking the laundry out of the washing machine, was not applicable to nine, mainly male, participants).

The greater the sum of a variable, the more it was reported as a source of prospective memory failure. Table 6 indicates that the variable most frequently forgotten is "pass on phone messages." In contrast, the variables rated as least likely to be forgotten are "a dentist appointment" and "lock the door."

Variables with a mean above 1.5 and mode response of 2 (sometimes) or greater are shown below, in table 7.

Table 7: Cumulative percentage of responses: "sometimes", "often" and "always", for each variable.

Variable	valid percent	Median rating
Post letter	70%	sometimes
phone message	67%	sometimes
TV programme	67%	sometimes
Buy Grocery	60%	sometimes
medication	57%	sometimes
lights off	53%	sometimes

Table 7 shows that "posting a letter" was the most commonly reported variable. Almost three quarters, (70%) of the sample responded that they at least 'sometimes' forget to accomplish this task. Other common areas of memory failure include "passing on a phone message" and "forgetting to watch a TV programme;" just over two thirds, (67%), of the sample responded that they 'sometimes' forgot to perform these tasks.

Review of findings for survey

The results indicate that the six most common areas of prospective memory failure reported by this sample of older adults are: "pass on a telephone message", "watch planned TV programme", "buy a particular item from a shop," "post a letter," "take medication on time" and "turn lights off after leaving room".

Though it is unwise to generalise findings from research when concurrent validity has not been established, it would appear that the results provide mixed support for Martin's (1986) study. Martin (1986) found that older people rated themselves as better at remembering appointments, taking medication and paying bills on time. Whilst it is acknowledged that the current survey did not compare age groups, the findings revealed that over half of the older sample reported that they at least "sometimes" forgot to take medication on time. In support of Martin's results, the survey found that both items, "forgetting to pay bills on time" and "forgetting appointments" had a mode response of "never." Indeed, 90% of respondents rated that they "rarely" or "never" forgot an appointment with friends. This figure rises to 97% for a Doctor's or dentist's appointment.

The results appear to contradict findings in Moscovitch's (1982) study. Moscovitch found that the older group performed significantly better than the young people at a telephone task. However, findings in the present study revealed that the variable "forget to pass on a phone message," was rated as at least ‘sometimes’ forgotten by over two thirds of the participants, (67%). Likewise, almost half the participants, (44%), responded that they at least “sometimes” “forget to contact someone”.

The study did not administer existing questionnaires (e.g. CFQ and EMQ) in conjunction with the newly developed questionnaire, since the newly developed questionnaire was concerned specifically with everyday prospective memory failures. Additionally, the items pertaining to prospective memory failure in both the CFQ and EMQ were included in the newly designed questionnaire.

Nevertheless, it is recognized that Moscovitch’s (1982) study examined the behavioural response, and the present study examined the subjective response to these variables. Thus, caution should be applied in comparing findings across studies of differing paradigms. Indeed, due the logistical difficulty involved in observing individuals during the course of their everyday lives, the present survey made no attempt to externally validate the findings of the self-report. Thus, whilst the findings may reflect the individual’s perception of their memory failures, they may not be an accurate reflection of the individual’s behaviour. As Martin suggests, it is possible that older people “forget that they forget.” (Martin, 1986, p.69).

The possibility of a response bias may also exist in the study. A number of precautions were taken to reduce social desirability response, for example, assurance of confidentiality; experimenter standing out of view of responses;

and instructions worded to reduce social desirability. However, it remains possible that some members of the sample did not want to admit to memory problems.

Furthermore, a possible limitation to the study could be the nature and size of the sample used.

In view of the fact that the aim of the study was exploratory rather than experimental, (i.e. the aim was to identify types of prospective memory failures, rather than compare groups) the sample size in terms of its influence on effect size or statistical power was not an issue. However, the possibility of sampling error cannot be ruled out. The individuals were drawn from a population of community dwelling older adults. The sample was not randomly selected, and no demographic characteristic other than age and gender were recorded. Accordingly, the types and frequency of the prospective failures cannot be deemed as truly representative of the kind of errors made by all older adults. Indeed, even within the study gender bias existed on certain types of task (for example for the task 'taking laundry out of washing machine', nine males identified this task as not applicable). However, with the exception of returning a library book, and cooking (not applicable to three, and two individuals respectively) all participants had experience of the prospective memory situations.

Another limitation in the design was the failure to establish external reliability, or stability. This could have been achieved by the test-re-test method.

However, a reliable study offers no guarantee of validity, and therefore it was felt that the costs, of contacting the same subjects and repeating the procedure, outweighed the benefits of establishing stability.

It should also be considered that findings in the present study are not to be taken at face value and the items will be utilised for a behavioural experiment that offers more control and validity than the present self-report questionnaire.

Nevertheless, the survey has achieved its aim of identifying areas of prospective memory reported as giving rise to failure in an older population (although it is accepted that the types of prospective memory failures identified are unlikely to be exclusive to older persons). Also, using some of these areas for the proposed behavioural experiment will add some degree of ecological validity to future behavioural experiments.

Experiment three

Age Differences in Prospective memory: A Multiple Response Paradigm.

The pilot experiment highlighted the need for developing a method of studying prospective memory that was not immediately susceptible to ceiling effects. This need was met in experiment one, which utilised a multiple response methodology, and subsequently demonstrated that ceiling effects could be controlled for, even during a passive background task.

Experiment two (the survey) drew attention to the fact that prospective memory failures are a common occurrence in the everyday lives of an older population. Although success is not uniform, some tasks (e.g. passing on a message) are reported as more prone to failure than others (e.g. keeping appointments). However, whilst these findings do draw attention to the fact that prospective memory failure is a ubiquitous feature in the everyday life of older persons, it does not provide evidence of prospective performance in a more controlled environment.

Experiment three: Aims

The aim of the present study is to investigate differences in actual prospective memory performance between the old and young during controlled conditions. There are a number of reasons to expect an age-related decline in prospective performance. Chapter one discusses a number of perspectives that go some way to explaining age-related decline in a number of memory procedures requiring a higher degree of processing.

Since many aspects of prospective memory share the properties of other memory types and cognitive processes (for example, retrospective memory, attention, planning and reality monitoring), predictions can be made regarding the age related deficits that may be expected in prospective memory. This in turn may be useful in understanding age related decline (or sparing) as well as allowing generalizations to be made regarding the daily functioning of an older population.

A number of theories and mechanisms have been proposed to account for an age related decline in cognitive performance. Such models tend to cite a reduction or inefficiency of cognitive processing resources as the reason for such a decline. *Processing resources* is a broad term and its operational definition is often dependent upon the theory in which it is incorporated more so than any single, observable behavioural measure. However, a number of researchers (e.g. Craik & Byrd, 1982; Park 2000) have viewed cognitive processing in terms of mental energy. Park (2000) suggests processing resources may be defined as "the quantity of mental processing power or mental energy that a given individual has available to use when performing a cognitive task." (Park, 2000, p.4.)

From this viewpoint, it can be imagined that such a reservoir of mental energy may be drawn upon to rapidly process and manipulate information whilst directing attentional control to the relevant task. Serving as an explanation for both indices of cognitive behaviour (for example, free and cued recall, speed and accuracy, inhibition, and dual task performance) as well as neurophysiological correlates (such as glucose or oxygen metabolism, cerebral blood flow) and more structural brain changes (e.g. atrophy). This view is echoed in the neuropsychological perspective (e.g. the HAROLD and CARA models).

Arguably, one of the most influential approaches to age related decline is Craik's functional account of age differences in memory, (Craik, 1986). This model views memory in terms of the amount of cognitive processing required for successful remembering (Craik & Byrd, 1982). It proposes that memory performance is the result of an interaction between internal and external factors. Internal factors include the amount of processing resources available and the associated *self-initiated activity* required to successfully organize and manage the information (such as encoding, transformation, attention allocation, retrieval, etc). External factors, by contrast, refer to the amount of *environmental support* available at the time of encoding or retrieval. Such environmental supports are intended to reduce the amount of self-initiated activity required. They may include external cues, which serve as prompts to retrieval, guidance on organizing the information for encoding and contexts or prior knowledge that may support successful encoding. Craik suggests that where environmental support is weak, or there are few external cues available, then the individual must rely on the more effortful self-initiated activity to recall the information successfully.

Additionally, Craik proposes that older adults would have particular difficulty in performing self-initiated retrieval because of a decline in processing capabilities or resources. In terms of prospective memory performance, Craik's framework would predict that age related decrements should be high. This is because prospective memory tasks are considered to require more effortful processing, involving a high degree of self-initiated activity. Indeed, it may be viewed as comparable to free recall, but without the prompt to begin recall. Thus, Craik's framework predicts that, because of its greater cognitive processing demands, prospective memory will be more vulnerable to age related impairment than retrospective memory.

However, Craik's assumption that prospective memory, particularly in older subjects, would depend even more heavily on self-initiated retrieval than free recall tasks, was based on evidence from retrospective memory tasks only. Thus, it would appear therefore that even though Craik's original theory of a processing decline with age may be substantiated, it is questionable whether all prospective memory tasks require a high degree of self-initiated activity. In particular, the decrement may not be as great in prospective tasks that are congruent with the prospective cue, because the congruence of the cue with the task may serve as a form of external support. However, for unrelated target-task items, the participant is required to engage in more self-initiated processing to form a link between the target and task, and accordingly age-related decrements can be expected in this condition.

The study aims to examine the role of processing by comparing performance on related target and task items with unrelated target and task items. It will attempt to compare performance on items that require a high degree of self-initiated activity with those which utilize more external support.

The study will also provide an opportunity to examine the role learning plays in prospective memory performance in an older cohort. The study will again measure retrospective recall of the prospective task and target a-priori, so that prospective performance and free recall may be directly compared. The types of errors made by the older and younger participants will be recorded, and analysed in order to examine both quantitative and qualitative mistakes in prospective performance.

Experiment three: Hypotheses:

In line with Craik's theory, the experimental hypothesis predicts there will be a significant difference in prospective memory performance between older and younger participants, with the younger group demonstrating superior performance to the older group.

Furthermore, whilst it is expected that performance for the related target-task items will be superior to the unrelated target-task items, it is predicted that the younger group will demonstrate superior performance on the unrelated items compared with the older group.

Finally, it is predicted that learning will have a beneficial effect on performance, which will increase over each trial.

Method

Ethics:

This study adhered to the ethical code of conduct set out by the British psychological society (BPS). Ethical approval was sought and granted by the University of Wales, Bangor School of Psychology ethics committee.

Participants

Forty participants, opportunity sampled from Bangor and its locale, participated in this study. Half of these participants were categorised as the younger group, of whom 11 were female and nine were male. The mean age of this sample was 29 years (s.d. 7.38 years). The youngest participant was 21 years and the oldest 48 years. The remaining 20 participants were categorised as the older group, of whom 12 were male and eight were female. The mean age of this sample was 71 years (s.d. 3.42 years), ranging from 66 years to 79 years.

All participants held a University degree with the exception of four participants from the younger group (who were studying for a degree at the time of the experiment) and five participants from the older group (three of whom held diplomas and one of whom was about to enrol on a part time degree course). Formal measures estimating intellectual level, for example the National Adult Reading Test (NART), Nelson, 1978) were not administered because of differences in first language. (Participants were either first language Welsh or English, and the NART is not available in Welsh language form). Other more formal tests (e.g. Wechsler Adult Intelligence scale (WAIS-III) Wechsler, 1997) would have increased testing time, and lead to fatigue. Furthermore, such formal measures of IQ require specialist training to administer. It was not financially viable in this study to pay for either a clinical psychologist to administer the tests, or further testing time for participants, therefore on balance, it was felt that years in education would be a sufficient match. Participants were paid five pounds per hour for participating. The participants were blind to the precise nature of the experiment.

Apparatus/Stimuli/Materials

See experiment one

Design

The study employed a mixed factorial design. The between subjects variable was the age group of the participants. This was either younger (under 50 years) or older (over 65 years). The within subjects variables in the study were: the relatedness of the target items to the task (either related or unrelated); and the level of learning, represented by the three conditions (trial one no learning, trial two - errors corrected from previous trial and trial three, final trial - errors corrected from previous trial)

The dependent variables were the retrospective memory recall and the prospective memory performance for each condition. The type of errors made and mnemonic employed for linking the target and task were also recorded. The experiment consisted of three conditions, in each condition the same stimuli were randomly presented, this was to control for the confounding variable of novelty and learning by position of target stimuli. Retrospective and prospective memory performance were recorded at the end of each trial.

Any mnemonic strategies employed were recorded at the end of the experiment.

Procedure

See experiment one

The entire procedure lasted on average 45 minutes for the young group and 60 minutes for the older group.

Results

Table 8:Means and standard deviations (in parentheses) for Prospective and Retrospective memory performance across trials: Comparison of older and younger groups.

Memory type & Trial	Mean (s.d.) Older group N = 20	Mean (s.d.) Younger group N = 20
Retrospective One	4.1 (2.81)	7.0 (3.23)
Retrospective Two	7.0 (3.23)	8.5 (2.4)
Retrospective Three	9.3 (2.81)	11.25 (2.05)
Prospective One	10.5 (2.76)	10.55 (2.04)
Prospective Two	12.2 (2.24)	13.65 (1.66)
Prospective Three	13.15 (2.03)	15.15 (1.27)

Table 8 shows superior performance for the younger group compared with the older group across all three trials and for both prospective and retrospective memory. However, for prospective trial one this average difference is very small (0.05). The older group tends to demonstrate a wider variability of scores across all trials, with the exception of retrospective trial one. In this condition, the standard deviation for the young group suggests greater variability.

A 2x3x2 mixed factorial ANOVA with between subjects factors of Age and within subjects factors of learning trial and memory type was performed. This demonstrated significant main effects for all variables: Age group (either old or young): F, (1,38), 7.74, p = <.008; Memory type (prospective or retrospective): F, (1,38), 469.2, p = <.0001; Learning Trial (one, two and three): F, (2,76), 127.87, p=<.0001. The two way interaction of memory by trial was significant, F, (2,76), 4.81, p = <.011; as was memory by age, F, (1,38), 4.66, p=<.037; but not trial by age, F (2,76), .64, p = N.S. Finally, the three-way interaction of memory by trials by age was found to be significant: F, (2,76), 6.32, p=<.004.

Post Hoc independent t-tests analyses using the Bonferroni method, with alpha level set at .004, found significant differences between old and young for trial three prospective memory and trial one retrospective memory. No significant difference between old and young performance was found for the remaining conditions.

Prospective Trial one: t, (38), .07, p= N.S. Prospective Trial two, t, (38), 2.33, p = N.S. Prospective Trial three, t, (31.8), 3.73, p =<0.001. Retrospective trial one, t (38), 3.38, p=<0.002. Retrospective Trial two, t (32.1), 1.76, p=N.S. Retrospective Trial three, t (38), 2.51, p=N.S. The significant differences reflected superior performance by the younger group.

The nature of the target-task relationship was also investigated under the Association variable. This examines prospective performance according to whether the target was related or unrelated to the task. In each condition the maximum score is 8. The memory performance of the older and younger group according to relatedness of target to task is illustrated in figures 9 & 10.

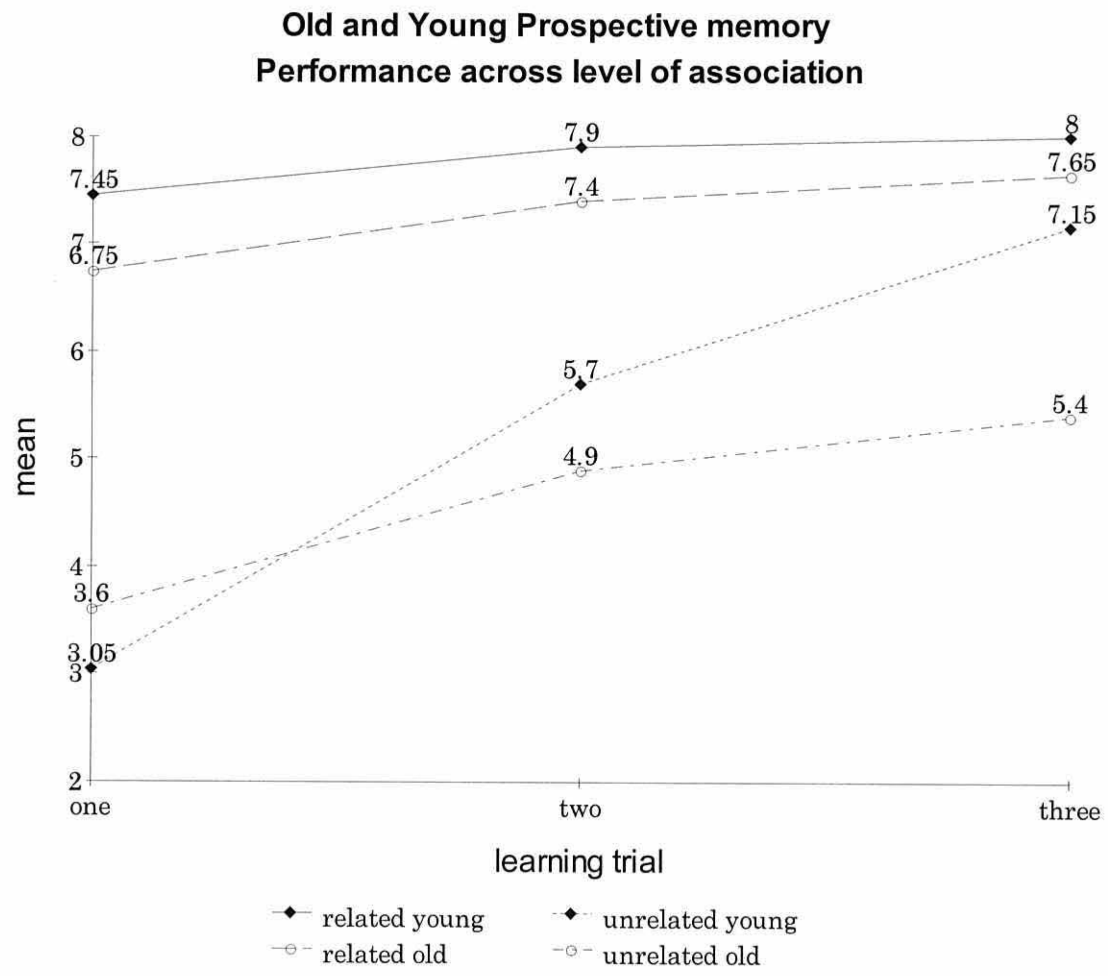

Figure 8 :Comparison of old and young Prospective memory Performance across learning trials: according to level of Association.

Figure 8 demonstrates higher performance of both older and younger groups for the related target-task condition compared with the unrelated target -task condition. The graph shows better performance by the younger group across all trials for the related condition. The rate of learning reveals a similar pattern for both groups, with the older groups making relatively better gains over trials, but still demonstrating poorer performance at each stage. In contrast, for the younger group, performance is close to ceiling from the second trial (7.9) at ceiling by the final trial (8).

The unrelated target-task condition demonstrates a different pattern of findings from the related target-task condition. In trial one, the older group exhibits superior performance to the younger group. However, as the graph illustrates, the young group quickly recoup this deficit and by trial two and by trial three demonstrate better performance. The pattern of learning in the unrelated target-task condition demonstrates a much steeper rate of gains for the younger group compared with the older where the learning curve is less steep.

A mixed factorial ANOVA was performed, with between subjects factors of Age and within subjects variables of Association (related or unrelated target & task), and Learning Trial (one, two and three). The results reveal significant main effects for all variables.

Association: F, (1,38), 125.97, p=<.0001; Learning Trial: F, (2,76) 79.4, p=<.0001; Age: F, (1,38), 4.52, p=<0.04, (marginally significant).

The findings imply that prospective memory performance is generally better when the target and task are semantically related. In addition, the results suggest that prospective memory improves over learning trials, however although the younger group demonstrate superior performance to the older group overall, this difference is only marginally significant.

The 2-way interactions revealed significant effects for Learning Trial by Age; F, (2,76), 5.22, p=<.01 and Association by Trial, F, (2,76) 33.02, p=<.0001; but no significant interaction for Association by Age, F (1,38), .11, p = N.S. The

3-way interaction of age by trial by association was significant, F (2,76), 11.25, p=<. 0001.

Post hoc independent t-tests using the Bonferroni method (∂ = .004) found no significant difference between older and young for the Unrelated target-task conditions in the first two trials: Trial one: t, (1,38), -.88, p = N.S. In this condition the older group's performance, (M = 3.6; S.d.= 2.04), was marginally, (but not significantly), better than the younger group's performance, (M = 3.05; s.d. = 1.91). No significant difference in prospective performance was found for Unrelated Trial two, t, (1,48). 1.33, p = N.S. In this condition the young group's performance, (M = 5.7; s.d. = 1.72) was not significantly better than the old group's, (N = 4.9; s.d = 2.08).

The Unrelated target and task condition in trial three did reveal significant differences between the older and younger groups: t, (34.55), 3.61, p =<.001. In this condition, performance by the younger group, (M = 7.15; s.d. =1.27), was superior to performance by the older group, (M = 5.4; s.d. 1.76).

No Significant differences between the older and younger group were found for the Related target and task conditions across all three prospective trials: Related Trial one: t, (33.29), 2.55, p = < .016. N.S. In this condition the young group's performance, (M = 7.45; s.d. = .69), was superior to, (but not significantly better), than the old group's performance, (M = 6.75; s.d. = 1.02).

Related trial two: t (26.46), 2.99, p = < .006 . N.S. demonstrated a similar pattern with the younger group, (M = 7.9; s.d. =.31), exhibiting better (but not significantly better), performance than the older group, (M = 7.4; s.d. =.681). This pattern of results was reproduced in Related trial three: t, (19), 2.67, p = <.015. N.S. with superior, (but not significantly better), performance by younger group, (M = 8; s.d = 0), compared with the old the older group (M = 7.65; s.d. = .59).

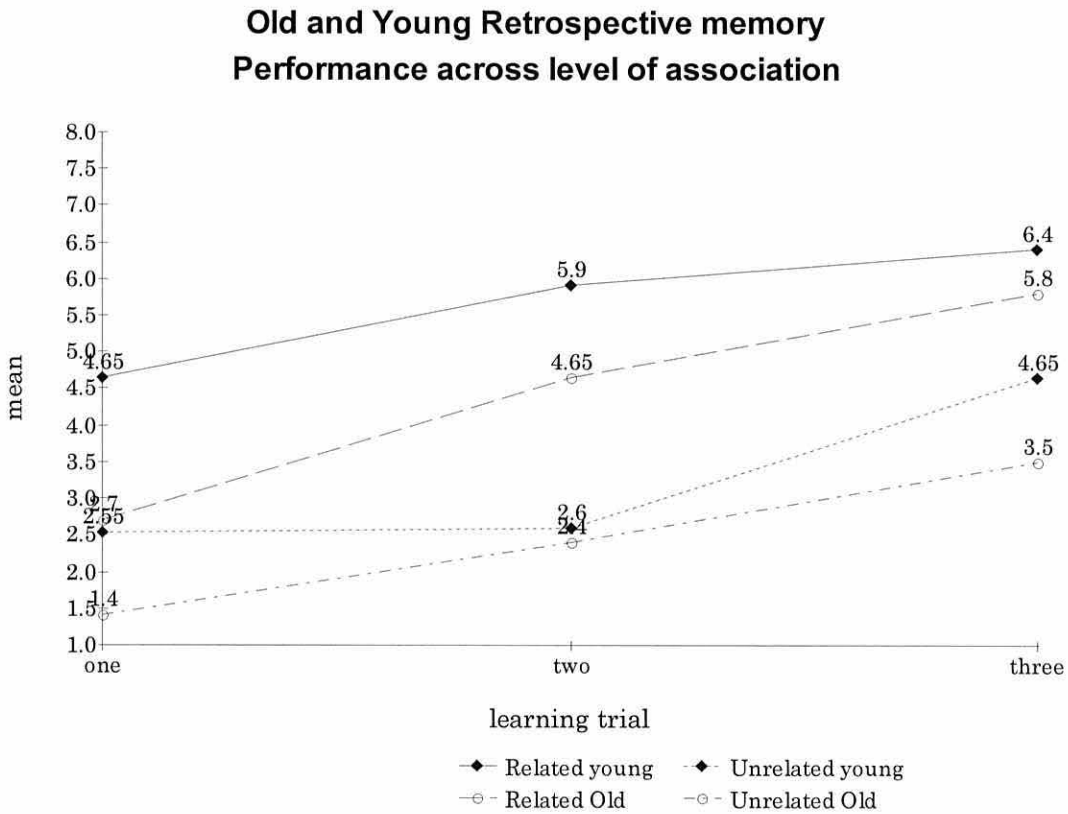

Figure 9: Comparison of older and younger Retrospective memory Performance across learning trials: According to level of Association.

Figure 9 depicts higher levels of performance for both groups in the related target-task condition compared with the unrelated target-task condition.

Performance for the younger group is better than the older group across all trials for the related target-tasks.

The pattern of learning suggests that the older group make relatively better gains from the first to second trial; however, performance is much poorer than the young group. The results suggest the older group are performing approximately one learning trial below the young group. The findings show that retrospective performance, even in the related condition, is much poorer than prospective performance (figure 8).

Findings for the unrelated target-task condition show superior performance for the younger group compared with the older group. The graph illustrates superior learning (in terms of relative gains) for the older group in the unrelated condition from trials one to two. However, this pattern is reversed for trials two to three, where the younger group demonstrates a faster rate of learning.

A mixed factorial ANOVA was performed, with between subjects factors of age and within variables of Association (related or unrelated target & task), and Learning trial (one, two and three). The results reveal significant main effects for all variables.

Association: $F, (1,38), 104.07, p=<. 0001$; Trial: $F, (2,76) 68.38, p=<. 0001$; Age: $F, (1,38), 9.81, p=<. 003$. The findings imply that retrospective memory performance is generally better when the target and task are semantically related. In addition the results suggest that retrospective memory improves over learning trials. The findings also indicate that retrospective memory performance is influenced by age. The 2-way interactions revealed a significant effect only for Association by Trial, F, (2,76) 3.88, p=<. 025. No significant interactions were found for Association by Age, F (1,38), 1.04, p = N.S. and Learning Trial by Age: F, (2,76), 2.58, p=N.S. The 3-way interaction of age by trial by association was significant, F, (2,76), 3.88, p=<. 025.

Post hoc independent t tests, (∂ =.004) found a significant difference in Retrospective performance between old and young only in the first, related trial. Trial One related: t, (38), 3.52, p = <.001. In this condition performance by the younger group, (M = 4.65; s.d. = 1.41), was superior to performance by the older group, (M = 2.7; s.d. = 2.01).

No significant difference was found for Retrospective Trial one Unrelated: t, (38), 2.54, p = <.015. N.S. In this condition performance by the younger group, (M = 2.55; s.d. = 1.43), was superior (but not significantly better) to performance by the older group, (M = 1.4; s.d. = 1.42).

No significant differences between older and younger were found in the second trial: Related trial two: t, (32.6), 2.43, p = <.021. N.S. & Unrelated trial two: t (38), 1.56, p = N.S.

Finally, and consistent with the above findings, no significant difference in performance between the older and younger was found in the third trial. Unrelated trial three: t (38) 1.97, p = N.S. Related trial three: t (38) 1.56, p = N.S.

Error Analysis

In addition to the correct responses to the target and task stimuli, the types of error made were recorded for each incorrect response.

Seven types of error were identified, the classification is as follows:

Confused/Response substitution (C/RS): This type of error is characterised by performing an inappropriate, but valid, task for a valid target. (For instance putting pens in case in response to picture of shop front).

Content Omission (CO): This type of error is identified as a retrospective deficiency. It is characterised as recognising the target and the general task, but mistaking specific detail. (For example correctly recalling red pen and paper as target and correctly recalling that something should be written on paper in red ink, but incorrectly recalling *what* should be written.)

Response Omission (RO): This type of error is characterised by a retrospective deficiency. It includes correctly recognising the stimuli as a target but not being able to recall the corresponding task.

Omission(O): This type of error is characterised by the participant not responding to the target. For instance failing to recognise an image as a valid target, and accordingly failing to perform the appropriate task.

Commission/ Response Perseveration(C/RI): this type of error is characterised by performing the same (valid) task more than once for different targets. For example putting the blutack in packet when see bandstand and again when see gate.

Confabulation/ Response Invention(C/RI): This type of error is characterised by the performance of an invalid task for an invalid target. (For example picking up pen when see black pen top.)

False Target (FT): This error type is characterised by performing a valid task for an invalid target (a red herring). For example, completing the blue participant form when the non-valid white form is encountered.

The nature and quantity of the errors for old and young are presented in table 9. In general, not only did the older group make more errors, they also made qualitatively different errors (see table 9). This is also illustrated in figure 10, showing the percentage of participants from each group who committed each error type.

The most frequent error committed by the young group was a response omission (RO). 100% of the young sample committed this error on at least one occasion throughout the experiment. Additionally, RO accounted for about 50% of the younger group's errors. The second most frequently committed error was a confused/ response substitution (C/RI), again each participant committed this error at least once, and it accounted for approximately 30% of the errors. (Other categories accounted for less than 10% each). None of the young sample committed a confabulation/response invention error (see figure 10)

In contrast to the young group, the old group committed errors from every category. The distribution of errors across categories tended to be more even than the young group (see figure 10). The greatest proportion were the confused/response substitution errors, accounting for just fewer than 30% of the errors committed. False targets accounted for 19% of the errors, and were committed by 100% of the group on at least one occasion. The category that contained the least number of errors was the Commission/response perseveration errors accounting for just over 5% of the errors. However, although C/RP accounted for the lowest number of errors overall, this error was made by 75% of the older group, compared to just 10% of the younger group.

These findings would suggest qualitative as well as quantitative differences in the variety of errors committed by the two age groups.

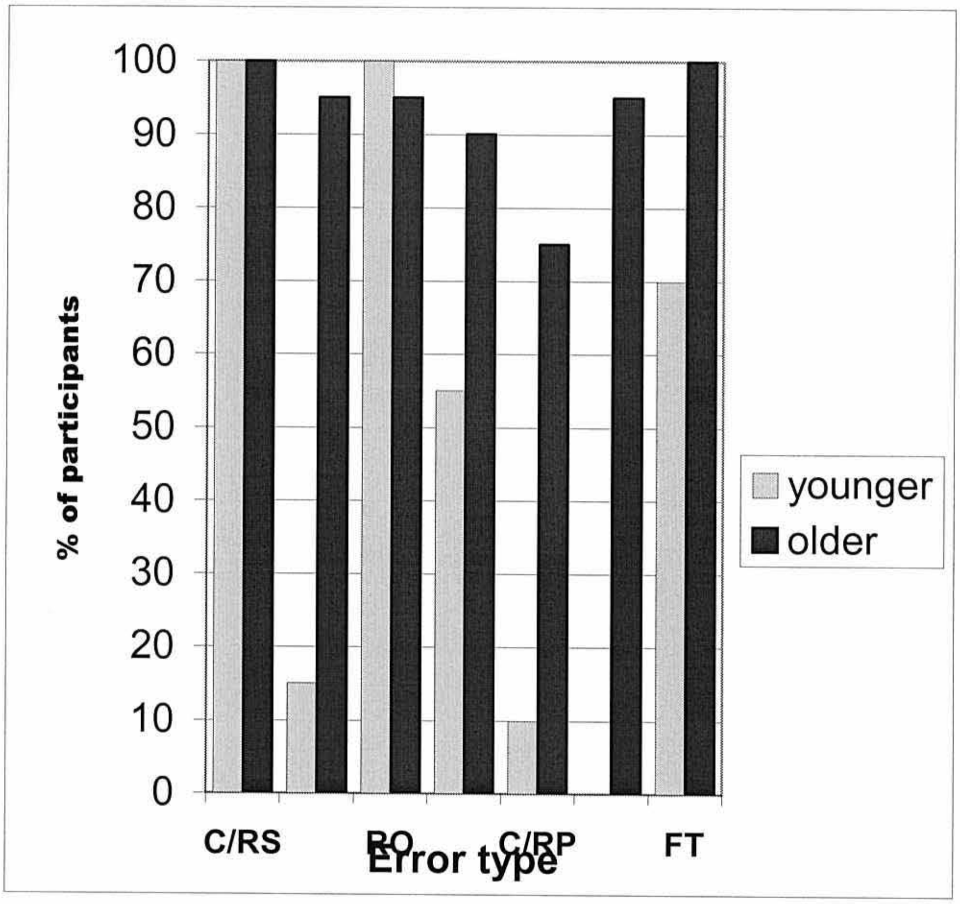

Figure 10: Percentage of participants committing each error type.

The responses were also analysed according to the age of the participant and for each trial. These are illustrated in Table 9.

Table 9: Mean, s.d. and Total number of Errors committed according to Group

Group	*Error Type*	*Sum*	*Mean*	*Percentage*
Younger	Content Omission	5	.25	2.7%
	Confabulation/ Response invention	0	0	0%
	Commission/ Response perseveration	3	.15	1.6%
	Confused/ Response Substitution	60	3	32.1%
	False Target	18	.9	9.63%
	Omission	10	.5	5.35%
	Response Omission	91	4.55	48.7%
Older	Content Omission	21	1.05	5.6%
	Confabulation/ Response invention	50	2.5	13.37%
	Commission/ Response perseveration	20	1	5.35%
	Confused/ Response Substitution	110	5.5	29.4%
	False Target	71	3.5	19%
	Omission	42	2.1	11.22%
	Response Omission	60	3	16.04%

To test whether there were significant differences in the number of errors made between the older and younger groups, Mann-Whitney tests were performed on the total numbers of each error type. The findings revealed that the older group committed significantly more errors in all categories, with the exception of response omission, where no significant differences were found. See table 10, below.

Table 10: Summary of Mann-Whitney tests for error types: All trials combined

Error type	N	Mean Rank Old	Mean Rank young	U	Sig ∂ = <.05
Content Omission	40	25.25	15.75	105	P =<.003
Confabulation/ Response invention	40	27.00	14.00	70	P =<.00001
Commission/ Response perseveration	40	23.65	17.33	136.5	P =<.024
Confused/ Response Substitution	40	25.42	15.57	101.5	P=<.007
False Target	40	26.58	14.43	78.5	P =<.0007
Omission	40	23.67	16.20	136.5	P = <.024
Response Omission	40	17.17	23.83	133.5	P= .07 N.S.

To test whether there were significant differences in the number of errors made between the older and younger groups in the first trial, Mann-Whitney tests were performed on the total numbers of each error type for trial one. The findings revealed that the older group committed significantly more errors in most categories than the younger group. However, no significant difference was found for Commission/ Response perseveration and False target type errors. In addition, the difference for confused/response substitution and omission errors was marginal. Finally, the younger group committed significantly more response omissions in the first trial than the older group. See table 11.

Table 11: Summary of Mann-Whitney tests for error types: Trial 1

Error type	N	Mean Rank Old	Mean Rank young	U	Sign $\partial = <.05$
Content Omission	40	24.7	16.3	116.0	P =<.006
Confabulation/ Response invention	40	25.00	16.00	110.0	P =<.00009
Commission/ Response perseveration	40	21.00	20.00	190.0	N.S.
Confused/ Response Substitution	40	24.15	16.85	127.0	P=<.043
False Target	40	23.27	17.73	144.5	N.S.
Omission	40	23.63	17.38	137.5	P = <.049
Response Omission	40	13.75	27.25	133.5	P= .0002

Review of findings: Experiment three

The findings fail to provide conclusive evidence to support the hypothesis that there will be a significant difference in prospective memory performance between old and young. The findings revealed no significant difference between the two groups for the first two prospective trials (trials one and two). However, the findings did demonstrate a significant difference between old and young for the final trial (trial three). This was in line with the prediction that the young group would demonstrate superior performance to the older group. The results from the ANOVA reveal significant main effects for learning trial, age, and association. The three-way interaction of age by learning trial by association was also significant

The findings suggest using the current paradigm, there does not appear to be an age related decline in prospective memory performance. The interaction of learning rates and nature of the target-task stimuli may account for significant differences. It is possible the superior performance by the younger group in the final trial may be a result of a faster learning rate than the older group.

The results provide support for the prediction that performance for the related target and task items will be superior to performance for the unrelated target and task items. The significant differences shown in paired t-tests between related and unrelated items across all trials (one, two, and three) for both old and young demonstrate this. In each case, performance in the related trial was superior to performance in the unrelated trials. This suggests that items requiring less cognitive processing are more likely to be successfully performed than items that are not directly related and are much more cognitively demanding. This appears to be the case for both older and younger groups.

The findings do not fully substantiate the hypothesis that the younger group will demonstrate superior performance on the unrelated items compared with the older group. Although independent t-tests revealed no significant difference between the groups for the related items (as expected), a significant difference was found for the unrelated items only in the final (third) trial. No significant difference between older and younger groups was found for the first two unrelated trials (trials one and two). This is corroborated by a lack of significance in the two-way interaction of association by age.

These findings imply that there is no difference between older and younger groups when the prospective task requires minimal processing. Furthermore, there is no evidence for an age related processing decline in the initial unrelated trials of prospective memory. It is likely that a faster rate of learning (or an increased benefit of practice) may account for the superior performance demonstrated by the younger group in the final trial. Again, this is substantiated by the significant interactions of learning trial by age, as well as learning trial by association by age.

The results do provide support for the prediction that learning will have a beneficial effect on performance, which will improve over trials. Both old and young groups demonstrated a significant difference between each trial (one and two; two and three). As predicted, the subsequent trial was superior. This suggests that prospective memory improves with practice.

The final prediction that performance on prospective and retrospective memory would be comparable, was not supported. Performance on prospective tasks was better than retrospective free recall. This was also the case when learning opportunity was equivalent (by comparing retrospective trial three and prospective trial two). This suggests that event based prospective memory may be less cognitively demanding than free recall.

This study has shown that in a low-demand background task, with a high number of prospective actions to perform, older individuals generally do not perform significantly worse than younger adults. Significant differences however do become apparent in the final learning trial, possibly because younger adults demonstrate a faster learning rate then older adults.

It is also possible that differences were due to the older group committing more errors than the younger group, and errors of a different nature (confabulation). The broader implications of this study and its contribution to theories of age-related change, as well as false remembering will be considered in the discussion section (Chapter five).

Experiment four: Older and younger dual task

Experiments one and three have explored prospective performance in the context of a passive secondary task. However, experimental research has recognized the fact that the nature of the secondary task may also affect prospective memory performance (Busch, 2001; Cherry & le Compte, 1999; Kidder et al., 1997; Marsh & Hicks, 1997; 1999). In line with processing theories (e.g. Craik, 1983, 1986), a secondary task that places high demands on cognitive resources (e.g. verbal working memory tasks, Kidder et al., 1997; Park 1999; or executive and visuospatial working memory, Busch, 2001; Marsh & Hicks, 1998) generally, though not consistently, results in poorer prospective memory performance.

Nonetheless, it should be noted the nature of both the secondary task and the prospective task, varies widely from experiment to experiment. Consequently, there appears a need for further investigation into the effect such variables have on performance, with particular emphasis on age-related performance.

With this in mind, the aim of Experiments 4 (a) and 5(a) is to manipulate the cognitive demands of the secondary task, and investigate the effect on prospective performance in different subject populations. To control for floor effects, the multiple-task approach adopted in experiments one and three will be replaced by the more standard approach of using a reduced number (two) of prospective memory tasks.

In addition to investigating prospective memory using experimental measures, the experiment hoped to ascertain if there was a relationship between subjective reports of everyday prospective performance and actual performance.

Considerable evidence exists to support the idea that age-related losses occur in many aspects of episodic memory (e.g. Schaie, 1996; Hultsch, Hertzog, Dixon & Small, 1998; Nilsson et al., 1997; Park et al., 1996), at the same time older adults tend to report greater frequency of forgetting than younger adults (Dixon & Hultsch, 1983; Gilewski, Zelinski & Schaie, 1990; Hultsch, Hertzog & Dixon, 1987). Together, this would lead to the expectation of a high correlation between behavioural measures of memory and self-reported memory. However, the findings concerning this relationship are inconclusive (Comijis, Deeg, Dik, Twisk & Jonker, 2002; Commissaris, Ponds & Jolles, 1998; Hertzog, Dixon & Hultsch, 1990; Martin, 1983; 1986). If anything, ratings of memory show a low correlation with actual performance (Kapur & Pearson, 1983; Hertzog et al., 1990).

In terms of prospective memory, the picture is even less clear. Objective measures of prospective memory function do not consistently show either age group as out- performing the other (Cherry & LeCompte, 1999; Einstein & McDaniel, 1990; Einstein et al., 1992, 1995; Einstein, Smith, McDaniel & Shaw, 1997), although recent research tends to support the idea of an age-related decline (Cockburn & Milne, 2000; Einstein et al., 1992; Maylor, 1996; Park et al., 1997; Uttl & Graf, 2000). In contrast, subjective reports of prospective memory (Martin, 1986) have found that older adults on average rate their prospective memory as better than younger adults.

Studies examining the relationship between subjective memory and objective prospective memory performance have also produced mixed findings (Dobbs & Rule, 1987; Kidder, Park, Hertzog, & Morrell, 1997; Maylor, 1990; Sunderland, Watts, Baddeley, & Harris, 1986; Zelinski, Gilewski, & Anthony-Bergstone, 1990). Some studies report no relationship between the participants' self-reported memory problems and their performance on prospective memory tasks (Dobbs & Rule, 1987) whereas others have found very weak, non-significant correlations between self-reported memory functioning and prospective memory tasks (Sunderland et al., 1986; Zelinski et al., 1990). On the other hand, Kidder et al. (1997) found a significant correlation between prospective memory performance and self-rated performance. However, the rating or “postdiction” (Kidder et al. p.95) was made on the prospective memory tasks after their completion.

Accordingly, the findings in the area are inconclusive, and it would appear that the relationship between self-reported prospective memory and prospective memory requires further investigation.

In addition to investigating objective measures of prospective memory performance, experiment 4(b) and 5(b) aims to examine the relationship between actual behavioural performance of prospective memory and subjective accounts of everyday memory performance.

Hypotheses:

It is predicted there will be a significant decline in prospective performance as the demands of the ongoing task increase.

No significant difference between the old and young is expected in the low secondary task condition.

It is predicted prospective memory, in medium and high on-going conditions, will be poorer for the older group than the younger group.

It is predicted that younger adults will rate their everyday memory as better than older adults.

It is predicted that there will be a positive relationship between self-rating and objective performance.

Methods Section: Experiment 4(a) Experimental study

Ethics

This study adhered to the ethical code of conduct set out by the British psychological society (BPS). Ethical approval was granted by the University of Wales, Bangor school of psychology ethics committee.

Participants

Thirty-one participants took part in this study. Approximately half (N=15) were aged less than 34 years, of whom eight were female and seven were male. The mean age of this sample was 22 years (sd 3.7 yrs; range 19 to 33 years). The remaining 16 participants were aged over 70 years, of whom nine were female and seven were male. The mean age of this sample was 78.5 years (s.d 6.15; range 71 to 93 years).

The younger group averaged 14.5 years in education; the older group averaged 12 years in education.

The younger group were Psychology Undergraduates and participated as part of a University course requirement, and received course credit for taking part. Participants from the older group were sampled from the University Community Participation panel and were paid five pounds per hour for participating.

Apparatus/stimuli/materials

Apparatus: An Apple Macintosh Performa 6200 computer was used to present the stimuli. The stimuli were presented centrally on the screen, each image measured ten inches by ten inches. Digits were presented in the top right hand corner, in size 46 Times New Roman font. The rate of presentation was approximately 3.5 seconds per item. The experimenter suspended presentation whilst the participant performed the prospective task.
A Kodak digital camera was used to take photographs of the majority of the stimuli, other images were obtained from websites and Microsoft word software.

Stimuli: The stimuli consisted of a 64-item picture list. Each picture was composed of a real life image. Two of the images were designated as targets. One was categorised as related to its respective task. This target was a photograph of a telephone memo; the corresponding prospective task was to pass a telephone memo along the desk to the experimenter. The actual memo was identical to the memo in the photograph. The other target image was categorised as <u>unrelated</u> to the task. This target was a photograph of the inside of a café; the corresponding prospective task was to add the word tea to a shopping list. Although, arguably, a semantic link could be formed between the task writing "tea" and a photograph of a café, it was deemed unrelated because the content of the target did not portray either a shopping list or reference to tea, rather the main features of the image were tables, chairs, a plate and a tray. In addition, participants were not explicitly instructed to form such a semantic link.

Each target appeared at random amongst the stimuli list eight times.

A digit ranging from and including 1 to 10 was displayed in the top right hand corner of the screen. This number appeared randomly for every image, as part of the cover task.

Four (b) Questionnaire

An adapted version of the Subjective Memory Questionnaire (Bennett-Levy and Powell, 1980) was administered (see Appendix three). The scale on the questionnaire was modified to include a 'not applicable' category. This was in response to the findings on the previous survey (see experiment two), which highlighted the fact that some aspects of prospective memory are not relevant to an individual's daily life. Additional modifications included removing a repeated item, and replacing the adjective 'bad' with the adjective 'poor'.

The adapted questionnaire included 42 items designed to assess real life memory abilities, including eight statements relating to prospective memory (for example returning a borrowed item; passing on a message). All items were rated according to a 5-point Likert scale. The questionnaire was divided into two sections. Section 1 contained 35 statements and responses were recorded according to how good or poor the participant rated his or her memory. The corresponding scale points were: 5 representing very good, 3 representing average, and 1 representing very poor. A score of 0 was given for questions that were not applicable.

Section 2 contained 7 statements with responses rating how frequently an instance occurred. The corresponding scale points were polarised with: 1 representing very often, 3 average, and 5 very rarely.

Materials

A selection of familiar desktop objects was placed at random on the desk in front of the participant. Two of the objects corresponded to the prospective tasks, and required manipulation as part of the experiment. These objects were a telephone memo and a shopping list (with pen). The shopping list was placed adjacent to the participant's dominant hand, (i.e. on the right of a right-hander). A calendar displaying all 12 months of the year was also placed on the desk. This was required as part of one of the background tasks. Remaining items (pencil and sharpener, envelope, and stapler) were included as filler items and did not require manipulation as part of the experiment.

Each participant completed a consent form and received written standardised instructions and post-experiment debriefing.

Design

The study employed a mixed factorial design. The between subjects' variable was the age group of the participant. This was either younger (under 50 years) or older (over 65 years).

The within subjects' variables in the study were: the relatedness of the target item to the task (either related or unrelated) and the cognitive load of the cover task, minimum, medium or high. The minimum cover task required the passive viewing of images. The participant was required only to identify the prospective targets and respond accordingly. The medium load cover task required the participant to view the digit (which appeared for every image) and point to the corresponding month of the year on a calendar placed on the desk adjacent to them.

The high load cover task required the participant to perform a subtraction exercise. The participant was given a figure (100) to begin with and was required to subtract the number displayed on screen from this figure; the participant was instructed to continue subtracting each new digit from the subsequent total.

The experiment consisted of three conditions, minimum load or baseline; medium load, and high load (outlined above). The presentation of the conditions was counterbalanced to control for order and learning effects. In each condition, the stimuli were randomly presented, also to control for learning effects.

Procedure

Participants were informed that the study was concerned with a type of everyday memory known as prospective memory. Examples were provided to illustrate this type of memory (e.g. remembering to turn a cooker off after cooking; or return a library book). Participants were then informed that the study consisted of two parts. These were: completing a questionnaire about their own memory, and taking part in an experiment. Participants were made aware the experiment would require them to carry out two simple tasks (passing a telephone memo to the experimenter, and adding the word 'tea' to a shopping list) whenever the corresponding target for each task appeared on a computer screen. Additionally, participants were advised that they would be asked to carry out another (secondary) task in the interim. Participants were told that the experiment comprised three trials, and in each trial, the nature of the secondary task altered. (For a more detailed account of each secondary task see section *experimental procedure*).

Finally, participants were informed they would be given a short training/learning trial before the main experiment in order to ensure that they could successfully perform the prospective task at the appropriate time. (See section *prospective training*).

Each participant was presented with a consent form to sign and date. Once informed consent was obtained, the participant was given both written standardised instructions and verbal instructions.

The procedure is described according to each component: Prospective memory training, Questionnaire Completion, and Experimental Procedure.

Prospective Training.

Participants were given training on the prospective tasks and their corresponding targets. This was to control for the confounding variable of retrospective memory failure; that is failing the prospective task because the content of the intention cannot be recalled (or forgetting what you are supposed to do). It was also to ensure that the participant could physically perform the prospective task successfully.

The training was based upon a spaced retrieval paradigm (Landauer & Bjork, 1978). Essentially this technique involves presenting the item to be learned (in this case the prospective target and task) and gradually expanding upon the length of time the participant can correctly recall (and perform) the task, using cues or prompts as necessary. In general, since the number of items to be learned was low (two) and the population were not cognitively impaired, the typical learning schedule was immediately after presentation, followed by a three-minute gap, then finally, an eight-minute gap. The decision to use 8 minutes as the longest gap was based upon the observation by Camp et al. (1996) that a critical recall period of 6-8 minutes existed for cognitively impaired individuals. That is, if an individual is able to retain and successfully recall the information for this period, then the information is consolidated into long-term memory, and can be retained across the length of the training session and up to one week later. Intervening periods were filled with completion of general participation forms, demographic questions, and general conversation. Once the participants had successfully demonstrated that they could perform the prospective task after an eight-minute gap, they were requested to complete the Subjective Memory questionnaire. This served the dual purpose of collecting subjective data on ecologically valid everyday memory failures including prospective memory failure, and providing a distraction before the experimental task.

Questionnaire Completion

The instructions for completing the questionnaire were as follows:

"This is a short questionnaire looking at the things which people commonly remember and forget. Please read through each question and tick the box that you think most accurately describes your memory. Please note for Section 1 rate how good you think your memory is for each item, and for Section 2 please rate how often each item occurs."

Completion of the questionnaire on average took five and a half minutes for the younger group and eight minutes for the older group.

Experimental Procedure

After completion of the questionnaire, participants were informed that the experimental part of the study would now begin. Participants were advised that there would be three short trials to complete.

The trials corresponded to the three conditions of minimum, medium, and high attentional load of the secondary task. Presentation was in random order.

The prospective task and targets remained the same throughout the trials. The target image(s) appeared at random amongst the on-screen stimuli.

The secondary tasks were incorporated into the prospective procedure via the stimuli. For each stimulus item presented (both filler and target items) a digit appeared in the corner of the screen. The secondary task required the participants to respond in some way depending upon the level of cognitive load of the secondary task. This ensured the participants were occupied in some way during the periods when a prospective response was not required.

The minimum load condition required the passive viewing of images and responding to the target image with the appropriate task. Essentially this was a simple decision making exercise of identifying the correct target image from amongst filler images and responding accordingly. It should be noted this condition differed from retrospective cued–recall in that the experimenter gave the participant no prompt to aid identification of the corresponding task. Instead, the participant would need to rely on his or her own self-initiated activity to identify the target as a cue to perform the task. Additionally, although observing images is a passive task, requiring few cognitive resources, it differs from cued recall in that the participant was not required to make a prospective response for every task, and thus did have to disengage from one task (viewing) to perform the prospective task.

In the medium load condition, the participant was informed that a number would appear in the top right hand corner of the screen for every picture. The participant was asked to indicate the corresponding month of the year on the calendar. For example if the number was 5 the participant was asked to point out May. The response time for this was not recorded. The calendar remained accessible to the participant throughout the condition.

In the High load condition, the participant was informed that a number would appear in the top right hand corner of the screen for every picture. The participant was asked to perform a subtraction exercise. The participant was told he or she would be given a figure (100), and the requirement was to subtract the number on screen from this figure to find a new total; then subtract the next number from this total, and to continue subtracting each number from the subsequent total, until the total was smaller than the number, in which case the participant was required to begin from 100. The participant was given a demonstration of this exercise (for example, if the first number was 4, the total would be 96, if the next number was 7 the subsequent total would be 89, etc.). The participant was informed if they "lost track" during the trial the experimenter would provide a new total. The participant was asked to state each total out loud. This task was deemed to place a heavy load on working memory and associated cognitive resources, since it required the participant to keep track of the total as well as perform the calculation.

A break of approximately two minutes occurred after each condition, this time was used to reset the computer for each new condition.

The entire experimental procedure lasted on average 40 minutes for the young group and 50 minutes for the old group.

Results

Effect of Attentional load of secondary task on prospective memory performance:

A comparison of older and younger groups' performance according to the level of attentional demands is shown in figure11. The results indicate a slight negative gradient in prospective performance associated with higher demands in the secondary task, though this pattern of decline in performance appears greater for the older group than the younger group. The results show that for the minimum–load condition, performance is at ceiling for the younger group and almost ceiling for the older group. The medium load condition also demonstrates high performance for both groups. The greatest difference between the groups is for the high-load condition, where the older group demonstrate a greater decline in performance than the younger group.

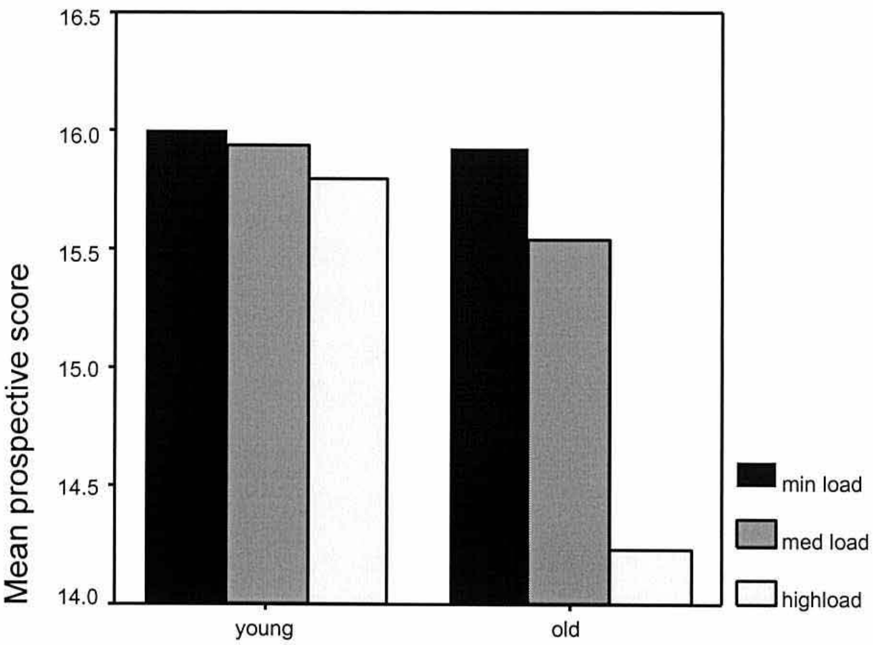

Figure 11: prospective performance according to condition for old and young: Related and Unrelated combined.

A-priori independent t-tests show a significant difference in prospective performance only for the high demand condition: t (16) 2.8, p=<.02. This, and the non-significant difference in the minimum and medium conditions, suggests that overall prospective memory performance is only compromised when demands placed on attentional resources are high (although note that the younger group were performing close to ceiling levels).

Effect of Target-task relatedness

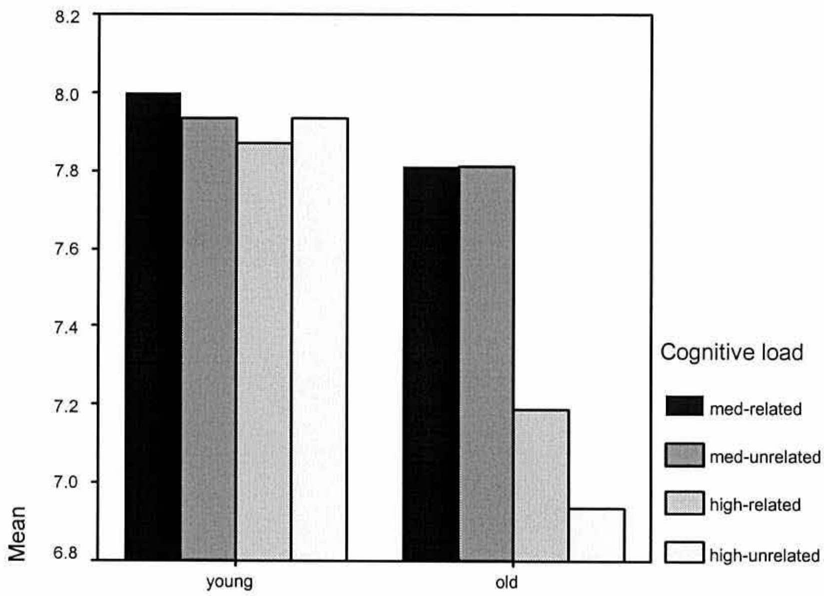

Figure 12:Effect of target-task Relatedness on prospective performance for the Medium and High cognitive load conditions.

Fig 11 displays the prospective scores for older and younger groups. The results show that performance for the medium load conditions is almost ceiling for both groups. However, performance for the high load condition is poorest, particularly for the older group.

A-priori Independent t-tests reveal significant differences in performance only for the high load unrelated condition. T, (16) 2.8, p=<.012.

This implies that high demands placed on performance by the secondary task may, together with an unrelated target (itself theoretically more cognitively demanding) lead to poorer performance for the older group.

However, it is important to consider that the High Related condition was marginally significant: t, (17.4), 1.98, p=<.056, and that no difference between related and unrelated was demonstrated for the other conditions. This suggests that the nature of the background task in terms of attentional demands is more important in terms of successful prospective performance than the relatedness of the target-task relationship.

Main Analyses

A 2x3x2 mixed ANOVA with the between subjects factor of Age, and within-subject factors of cognitive load and relatedness of target –task was conducted. Prior to analysis, Mauchly's sphericity tests were conducted for both attentional load (W, 92) =.176, $p<.001$) and load and relatedness (W, (2) =.29, <.001). Since sphericity could not be assumed, the findings were adjusted using Greenhouse-Geisser figures. Results revealed significant main effects for Attentional load, $F (1.1) = 11.58$, $p=<.001$ and Age, $F (1,29) = 6.33$, $p<.05$, but no significant Main effect for target-task relatedness $F (1)=.862$, N.S The two-way interaction for Attentional load and Age was significant, $F (1.1)=7.65$, $p<.01$. However no other interaction was significant. Relatedness and Attentional load, $F (1.18) =.091$, N.S. or Relatedness and Age, $F (1)=.862$, N.S. The three-way interaction of attentional load, relatedness and age was found to be non-significant.

Post Hoc pair-wise analyses adjusted using the Bonferroni procedure found significant differences between the High load condition and the medium load condition, as well the High load condition and the low load condition. There was also a significant difference in overall (i.e. related & unrelated combined) performance for Age (in favour of the young group). No other significant differences were found.

The findings suggest that in terms of prospective performance, the demand level placed by the secondary task is an important factor in influencing successful performance. In this study, the older group demonstrates significantly poorer prospective performance as the demands of the secondary task are increased to the highest level.

The above findings consider prospective performance only. However, in order to function effectively in everyday life, one must be able to perform the required prospective task whilst at the same time managing other tasks. In this study, this is analogous to accurate performance on *both* prospective memory and the secondary task. In general this 'dual' aspect of prospective memory performance is not evaluated in mainstream studies of prospective memory, where the focus is on prospective outcome alone. The assumption of such research is that prospective memory is compromised as the secondary task places greater demands on cognitive resources. Although the current study replicates this approach, and the findings do suggest that prospective performance for the older group decreases in a high-load secondary task, it does not allow for an understanding of how performance on the secondary task may be affected by prospective memory.

Accordingly, in order to take into account overall performance, and gain an insight as to how one task may be comprised by the other, an attempt was made in this study to estimate, in broad-brush terms, the balance between performance on the prospective and secondary tasks. In order to do this, performance across the two tasks was categorised as follows:

A score of '3' was awarded for successful performance of both prospective task and secondary task.

A score of '2' was awarded for successful performance of prospective task only.

A score of '1' was awarded for successful performance of background task only.

The findings are illustrated in figure 12 and 13.

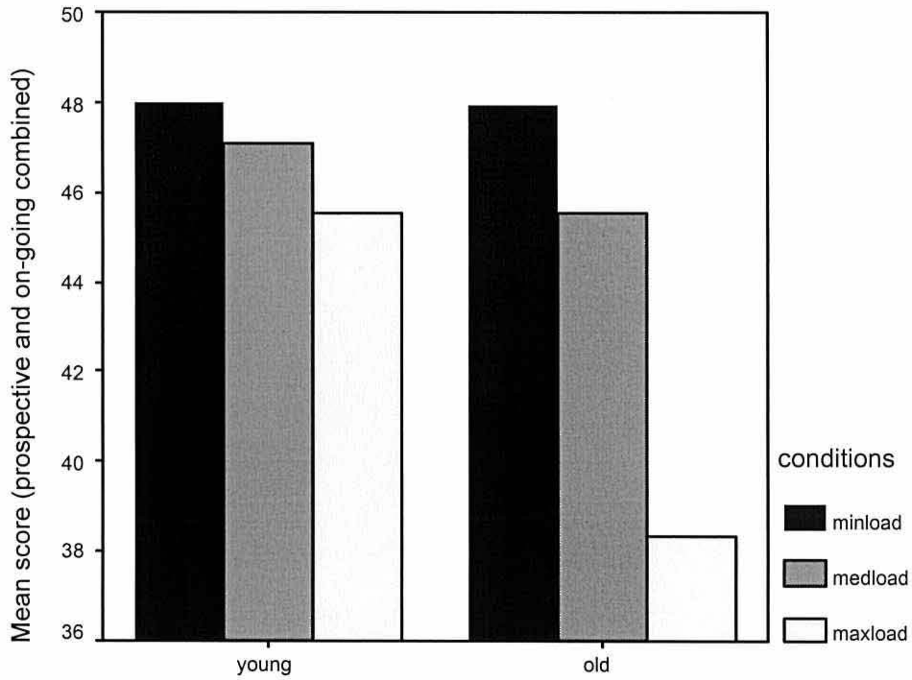

Figure 13: Mean performance (scores transformed) for old and young according to cognitive load: Related and unrelated combined.

Figures 11 & 12 show that both groups demonstrate a decrease in overall performance as the secondary task demands are increased. However, this deficit appears greater for the older group. The difference in overall performance, compared with prospective performance (particularly for the high-load condition) indicates that as demands increase, the older group differentially allocate priority to the prospective task, at the expense of the secondary task.

A mixed 2x3x2 ANOVA was performed on the transformed scores to investigate the effect of load and Age on overall performance. Results from the Mauchly Sphericity test were significant (W (2)=. 3, <.001), indicating that sphericity could not be assumed; therefore the adjusted figures from the Greenhouse-Geisser were used to determine significance in the tests.
The results revealed significant main effects for both Attentional load, F(91.8) =34.42, p<.001, and for Age F(1,29), 12.53, p<.001, as well as the two-way interaction of load by age, F (1.8),=12.2,p<.001.

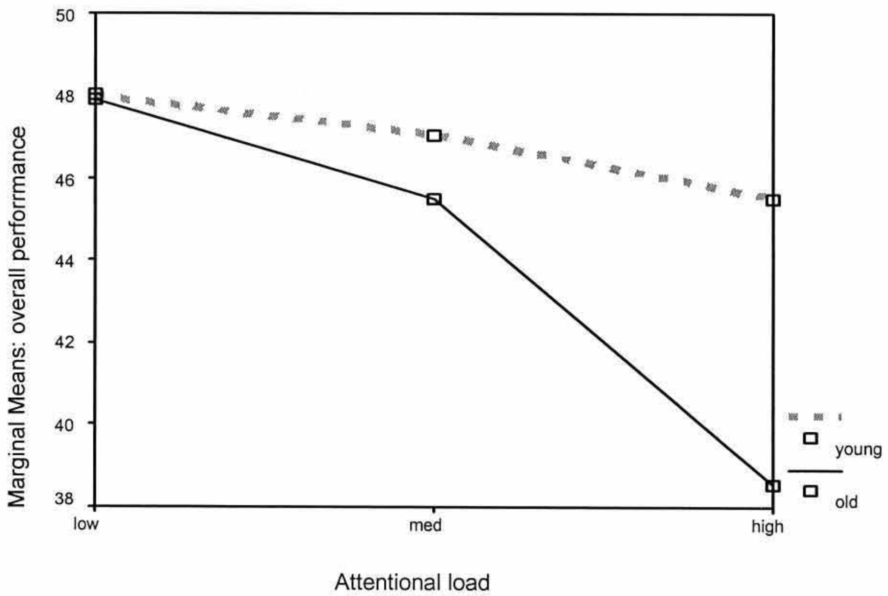

Figure 14:Mean performance (scores transformed) for old and young according to cognitive load: Related and unrelated combined.

t-tests reveal that these differences are significant for both the medium (t (21) 2.3, p=<.03) and high-load conditions, (t (19.6), 3.74, p=<.001) but not the low load condition.

The findings from fig12 & fig13 suggest that, in line with the age related deficit hypothesis, the older group do indeed demonstrate a poorer performance when attentional demands are high. It can be speculated, when attentional resources are stretched the older group selectively allocate resources to the task perceived as more important (in this case the prospective task).

Findings from questionnaire

The questionnaire revealed a similar pattern of responses for both groups for the Everyday memory items. Younger group (M= 3.6, range 1.2); Older group (M= 3.5, range 1.9). There was no significant difference between the groups' ratings of their everyday memory performance: U(30) =109.5, N.S.

However there was a significant difference between the groups' ratings of their prospective memory performance, U (30) =60.5, =<.05. This difference reflected higher self-rated performance for the older group (M= 3.9, range 1.3) compared with the younger group (M= 3.5, range 1.5).

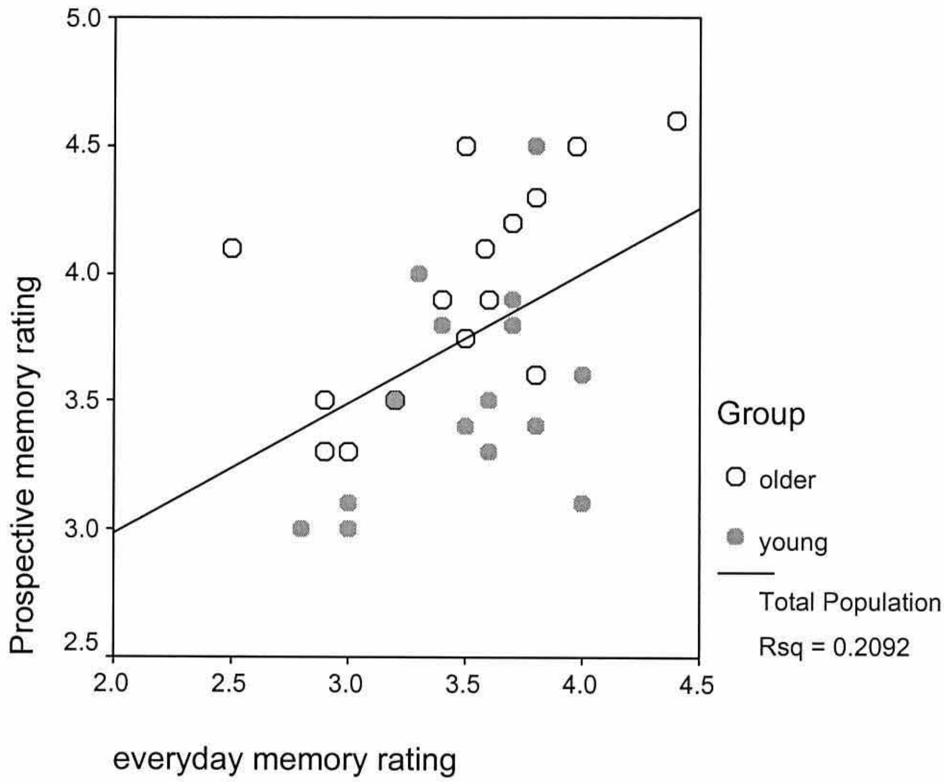

Figure 15: Scatterplot of old and young responses for the factors of prospective memory and everyday memory.

Figure 14 shows a positive relationship between participants' ratings of their everyday memory and their prospective memory. However, older participants prospective memory appears more highly rated than both their own everyday memory, and young participants' ratings of memory (both prospective and everyday). Pearson correlations comparing ratings for everyday memory and prospective memory revealed a significant relationship only for the older group r (16)=.621, p=<.01. No significant relationship between everyday memory and prospective memory was reported by the younger group r(15), .42, n.s.

Correlation between behavioural response and self-report.

A Pearson correlation was performed to establish the relationship between participants' self-reported prospective performance, and their actual prospective performance. The results revealed no significant correlations between performance and rating for either the older or the younger group (see table 13).

Table 12:Summary of Pearson correlations for self-rated prospective memory and actual prospective performance.

	Young	*old*
Min load	not performed (ceiling)	R (16) =.11,n.s.
Med load	R (15)=.22, n.s.	R (16)=.14, n.s.
High load	R (15)= .10, n.s.	R (16) .03, n.s.

Review of findings Experiment 4a & 4b

The prediction that no significant difference between the old and young would be found in the low secondary task condition was retained.

However, a significant age-related decline in prospective memory was found only for high on-going conditions, and not for the medium load condition. Although when overall performance was examined (ongoing & prospective combined) significant differences emerged for both medium and high conditions.

The prediction that younger adults will rate their everyday memory as better than older adults was not supported. The results revealed no significant difference in everyday memory between the age groups. However, it was found that the older group rated their prospective memory performance higher than the younger group.

Finally, although a positive relationship between self-rating and objective performance was shown, this was found to be non-significant.

The results therefore suggest that the processing demands of the secondary task have the greatest influence on prospective performance. The results indicate that prospective performance in older participants is reduced when the cognitive demands in the secondary task are high. Moreover, the overall performance of the older group is particular disadvantaged when the cognitive demands are high, and when the scores consider overall performance (both background and prospective components). This disadvantage is apparent from the minimum condition, suggesting that the older group differentially allocate resources to performing the more important prospective task, than the secondary task.

The findings also show that the nature of the target-task relationship does not seem to have a significant effect on performance. Differences only emerged in the high load condition. This is counter-intuitive to theory as well as findings from experiment 3. However, this could be due to the low number prospective items, alternatively, the training received for the prospective task may have resulted in participants being more motivated to complete the prospective task.

Finally, the findings from subjective questionnaire seem to be inconsistent with actual performance. In particular, incongruity occurs between the older group's rating of their prospective memory, which was significantly higher than the young group's, and their actual performance, which was not significantly different from the young group (except for the final trial in which case it was poorer).

Experiment five a & five b Dual task: Controls and persons with dementia

The aim of this study is to investigate prospective performance in Alzheimer's disease or probable Alzheimer's disease.

The first part of the study is to successfully implement a training programme to control for retrospective failure.

The second part of the study will compare performance between persons with dementia and the healthy elderly controls.

Performance will be explored under the conditions of target-task relatedness and cognitive load of the ongoing task.

Finally, the study will investigate the relationship between subjective report of prospective memory and behavioural performance.

hypotheses

On the basis that the S-R technique has been successfully implemented, it is predicted that a significant difference in prospective performance will exist between controls and persons with dementia (PWD) in all conditions. It is predicted that this difference will be greatest for the equated condition. (This corresponds to the medium load condition for the dementia group, compared with and the high-load condition for the control group).

It is predicted that there will be a significant difference between the control group and the dementia group for all levels of cognitive load.

It is predicted that performance for both groups will be poorer for the unrelated conditions.

It is predicted that there will be a positive relationship between carers' subjective report of PWD memory and actual performance.

Methods

Ethics

Ethical approval was obtained from the University of Wales, Bangor School of psychology committee, as well as the North Wales health Authority Research Ethics Committee (west). (See appendix four)

Participants

Thirty participants took part in this study. Approximately half (N=16) of the participants (the healthy controls) were classified as the elderly control group. Participants in this group were drawn from the University Community panel; they were successfully living independently and none of these participants had sought, or were seeking medical advice for memory complaints. The mean age of this group was 78.5 years (s.d. 6yrs; range 71 to 93 years). Nine members of this group were female, and seven were male.

The remaining 15 participants were classified as the persons with dementia (PWD) group. This figure represents the total number of the participants for whom full experimental data exists. An additional four participants were excluded or withdrew participation from the study. Participants in this group were recruited from Heulwen Memory clinic, Bangor, North Wales. Inclusion criteria for this group was based on a diagnosis of probable dementia of the Alzheimer type. Diagnosis was made by a specialist NHS dementia service. A clinical psychologist assessed all Participants. All participants in the dementia group had a MMSE score of <26/30. Mean score 17.33 s.d. 4.6 (minimum score 9, maximum score 26). The mean CAMCOG score for the group was 62.86, s.d. 10.73 (minimum score 45, maximum score 77). Exclusion from this group was based on the clinical psychologist's judgment that the individual did not present with dementia of the Alzheimer's type (including individuals scoring higher than 26/30 on the MMSE or impairment being the directly attributable to a stroke). The mean age of the dementia group was 80 years (s.d. 7 years; range 62-93 yrs). Nine members of this group were female, and six were male.

The control group averaged 12 years in education; the dementia group averaged 11 years in education. This difference was not significant, t (28) = 1.3, p>.05.

Apparatus/stimuli/materials

Apparatus and Materials:

See experiment 4: young and old dual task.

Stimuli:

See experiment 4.

Questionnaire:

See experiment 4.

Design

The study employed a mixed factorial design. The between subjects' variable was the group membership of the participant: either healthy control, or PWD. The within subjects' variables in the study were: the relatedness of the target item to the task (either related or unrelated) and the cognitive load of the ongoing task. The minimum ongoing task required the passive viewing of images. The participant was required only to identify the prospective targets and respond accordingly. The medium load ongoing task required the participant to view the digit (which appeared for every image) and point to the corresponding month of the year on a calendar placed on the desk adjacent to them. The high load ongoing task required the participant to perform a subtraction exercise. The participant was given a figure (100) to begin with and was required to subtract the number displayed on screen from this figure. The participant was instructed to continue subtracting each new digit from the subsequent total.

The experiment consisted of three conditions, minimum load (baseline); medium load, and high load (outlined above). Presentation of the conditions was counterbalanced to control for order and learning effects. In each condition, the stimuli were randomly presented to control for learning effects.

The PWD group received only the minimum and medium load conditions, as pilot work suggested the high load presented too great a cognitive difficulty. The control group received all three levels.

Procedure

For Healthy Controls see experiments 4a & 4b

Procedure for persons with dementia group

Participants were identified as likely candidates for the experiment by the clinical psychologist at the Heulwen Clinic, Ysbyty Gwynedd. The participant was approached by the experimenter and invited to participate in a study about memory. The participant was informed that the study was concerned with prospective memory (this was defined as an everyday type of memory – and a number of examples were given). The participant was seated at the desk (in the consulting room) and informed they would be asked to carry out two simple everyday tasks when certain images were presented on screen. Each participant was presented with a consent form to sign and date. As a formality, participants were given written standardised instructions as well as verbal instructions.

The procedure will be described according to each component: Prospective memory training, Questionnaire Completion, and Experimental Procedure.

Prospective Training

Participants were given training on the prospective tasks and their corresponding targets. This was to control for the confounding variable of retrospective memory failure; that is failing the prospective task because the content of the intention cannot be recalled. It was also to ensure that the participant could physically perform the prospective task successfully.
The training was based upon a spaced retrieval (S-R) paradigm (Landauer & Bjork, 1978.) Essentially this technique involves presenting the item to be learned (in this case the prospective target and task) and gradually expanding upon the length of time the participant can correctly recall (and perform) the task, using cues or prompts as necessary.
For each participant, the training took place over one or two sessions.
At the commencement of each session, the experimenter chatted with the participant to establish rapport. The participant was then seated at a desk, and asked if they were comfortable. They were then shown the target image on screen and asked if they could describe it to the experimenter. This was to ensure that the cue item was visually recognisable to the participant. Any participant who could not identify the image because of problems with visual

acuity were thanked for their time and excluded from the study. The experimenter then reiterated what the participant accurately described, and labelled the image according to its cue label in the standardised instructions. (e.g. the image of the table and chairs was labelled as a café; the telephone memo image was labelled as a telephone message). The participant was asked if they agreed that the label given by the experimenter was an accurate description of the image. This was to ensure continuity and consistency in procedure and training.

The participant was then asked to perform the corresponding task; this was to ensure there were no problems with the execution of the action. For instance, when the training session was concerned with the café, participants were asked to write tea on the shopping list; for the telephone memo, the participant was asked to pass it to the experimenter.

Two items were selected as the optimum number to be trained. This was based upon the findings of two pilot studies, which revealed that two items was the maximum number of items that could be successfully performed in one session.

The typical learning schedule was immediately after presentation, followed by a 10-second gap, a 30-second gap, a one-minute gap, three-minute gap, a five-minute gap, then finally, an eight-minute gap[9]. When the participant had successfully demonstrated a retention interval of 8 minutes, this was expanded by 5 minutes up to a maximum retention of 30 minutes. This was to ensure that the material would be remembered for at least as long as the experimental

[9] See experiment 4 for decision to use 8 minute gap.

procedure. Intervening periods were filled with completion of general participation forms, demographic questions, and general conversation.

This approach to S-R does not follow the typical method of doubling the time interval practised in many S-R studies, although there are variations to the schedule (Simmons-D'Gerolamo & Cherry, 1999)[10] However, the procedure does follow the principles of spaced retrieval as outlined by Camp (1989) & Camp & Stevens, (1990) in that it involved repeated recall attempts of a new piece of information over increasingly longer retention intervals. Additionally, in line with Camp et al. (1996) it utilized a motor response as the 'to be learned' material.

Questionnaire Completion

In deciding whether or not to use patients' self-rating of memory, two main issues were considered. These were cognitive impairment and lack of awareness; both are characteristic of dementia. Cognitive impairment is part of the diagnostic criteria for dementia (DSM-IV, 1994) and increases in severity with the progression of dementia until the ability to communicate is seriously impaired. This poses obvious threats to reliability and validity of self-report. Accordingly, a number of studies have assessed proxy reports rather than patient self-report (Jorm, 1992; 1996; 1996; 2004; Jorm, Christensen, Henderson, Korten, Mackinnon, & Scott, 1994). Alternatively, evidence from other studies (Clare, 2003; Freidenberg, Huber & Dreskin, 1990) indicates

[10]Simmons-D'Gerolamo & Cherry, 1999 implemented the following expansion schedule: 5, 10, 20, 40, and 60 s. When a 60 s retention was demonstrated, the interval expanded by 30 s after each successful recall. After a 3 min retention, the interval was expanded by 1 min. After a 6 min retention, the interval was expanded by 2 min, up to a maximum retention of 10 min

patients in the early stages of dementia are able provide both valid ratings of memory.

Another issue that may threaten the validity and reliability of self-report data from persons diagnosed with dementia is loss of insight or awareness. Loss of insight and awareness is also common in dementia (Harwood, Sultzer, & Wheatley, 2000; Lopez, Becker, Somsak, Dew & DeKosky ,1994; Ott, Lafleche, Whelihan, Buongiorno & Fogel, 1996; Sevush & Leve, 1993), although Brod, Stewart, Sands &Walton (1999) assert that loss of awareness is not a unitary phenomena. Additionally Clare (2003) reported findings from a study in which all 12 patients interviewed not only displayed some level of awareness of their memory difficulties, but also formed subjective responses to the tension created by this acknowledgement. This would suggest that individuals with minimal severity do have awareness of their memory changes. Other studies have reported a correlation between severity and awareness, in that the greater the severity, the lower the impairment (Harwood et al., 2000; Derouesne et al., 1999; Freidenberg et al., 1990; Sevush & Leve, 1993).

In general, however, studies focusing on awareness in Alzheimer's disease have yielded conflicting findings (for reviews see Clare, 2002; 2004; Markova, Clare, Wang, Romero & Kenny, 2005). Divergent results may be due to differences in the definition of the term 'awareness' (Markova and Berrios, 2001; Clare 2002), this varies from study to study, and arguably often depends on the 'object' of awareness. (Markova et al., 2005; Markova, 1997, as cited in Clare, 2004). In addition the inconsistency in findings may be due to the differing methodological approaches used in the studies, including carer-patient discrepancy studies (Kalbe et al., 2005; Snow, Norris, Doody, Molinari, Orengo, & Kunik, 2004), prediction-performance discrepancies, and clinician ratings (for review see Clare 2004; Clare, Marková, Verhey, & Kenny, 2005).

It would appear therefore that awareness of memory complaints is at best heterogeneous, and with this in mind, the decision was taken - in view of the range of severity and likely range of awareness- to only use proxy ratings for the patient sample for the current study.

The questionnaire was sent to the next of kin for completion on behalf of the participant. In cases where the next of kin did not respond, or could not be contacted; staff from the memory clinic / day hospital were asked to complete the questionnaire on behalf of the participant.

Experimental Procedure

After completion of both S-R sessions (one for each target-task item), participants were given a short break while the experimenter set up the equipment. In some instances the experimental session was carried out one week later. This was due to time constraints imposed by the location and participant. Participants were obtained from a day care memory clinic, where they were often engaged in a variety of activities, as a result the window of opportunity for testing was reduced. Further, if participants received the s-r training near the end of the day, it was felt it was preferable to leave the full experimental procedure until a time when the participant was unlikely to be interrupted to go home. As participants typically attended on a once weekly basis, this meant the study could not be continued until one week later. Whilst it is acknowledged this time lapse between training and experimentation could be a possible confound (e.g. the participant could 'forget' the material or no longer want to participate), there is evidence from the literature that material learning during s-r training can retained for periods of this duration, and longer (Camp, Foss, Steven & O'Hanlon, 1996; Cherry, Simmons, & Camp, 1999: McKitrick, Camp & Black, 1992). However, as an additional measure the experimenter addressed ascertained that the participant could still correctly perform the prospective components, and where necessary, a refresher training session was performed.

The participant was then informed that the experimental part of the study would now begin. Participants were told there would be two short trials to complete. The trials corresponded to the two conditions of minimum and medium attentional load. These were presented in random order.

The minimum load condition required the passive viewing of images and responding to the target image with the appropriate task. Essentially this was a simple decision making exercise of identifying the correct target image from amongst filler images and responding accordingly. It is worth noting this condition differed from retrospective cued–recall in that no prompt was given to the participant to aid identification the corresponding task. Rather, the participant had to rely on his or her own self-initiated activity to identify the target as a cue to perform the task. Additionally, although observing images is a passive task, requiring few cognitive resources, it differs from cued recall in that the participant was not required to make a prospective response for every task, and thus did have to disengage from one task (viewing) to perform the prospective task. Accordingly, it satisfied criteria of a prospective memory task.

In the medium load condition, the participant was informed that a number would appear in the top right hand corner of the screen for every picture. The participant was asked to indicate the corresponding month of the year on the calendar. For example if the number was 5 the participant was asked to point out May. The response time for this was not recorded. The calendar remained accessible to the participant throughout the condition.

A break of approximately four minutes was taken after each condition; this time was used to reset the computer for each new condition. The entire experimental procedure (excluding training) lasted on average 30 minutes for the dementia group and 50 minutes for the healthy control group.

Results

Table 13: Mean prospective performance according to load and target-task congruence.

Descriptive Statistics

Group		Mean	Std. Deviation
control	min load unrelated	7.94	.25
	min load related	8.00	.00
	med load related	7.81	.40
	med load unrelated	7.81	.40
	equated (related)	7.19	1.26
	equated (unrelated)	6.94	1.37
	med load	15.62	.71
	med load transformed scores	45.50	2.41
	equated load	14.13	2.30
	equated transformed	38.56	6.82
dementia	min load unrelated	5.60	2.88
	min load related	4.13	3.09
	med load related	1.53	2.45
	med load unrelated	2.33	2.60
	equated (related)	1.53	2.45
	equated (unrelated)	2.33	2.60
	med load	3.87	4.61
	med load transformed scores	21.47	6.86
	equated load	3.87	4.61
	equated transformed	21.47	6.86

Table 13 shows prospective performance for each condition, with related and unrelated tasks combined. Equated scores represent the control group's high attentional load compared with PWD group's medium load. Transformed scores refer to the score obtained according to successful performance on all components of the prospective task (prospective and secondary task).

Table 13 shows superior performance for the control group for all conditions. The older group generally shows a slight advantage for the related target and task conditions. In contrast, the PWD group shows the reverse pattern, a slight advantage is shown for the unrelated target-task stimuli.

A-priori t-tests adjusted to using the Bonferrroni correction (alpha level .013) were performed comparing groups' performance for minimum, medium, and equated conditions. Levene's tests were significant; therefore, t-test for unequal variance was used. The t-tests revealed a significant difference between control group and PWD group (in favour of the control group) for each condition: Minimum load: $t(14.08.)=5.34, p<.001$; Medium load: $t(14.6)=9.55$, $p<.001$, and equated (control high loads) vs (PWD medium load), $t(20.54) = 9.12$, $p<.001$.
This would imply despite training to control for retrospective failure, the persons with dementia perform significantly worse on a prospective memory task than healthy controls.

Planned comparisons examining the effect of 'relatedness' revealed no significant differences between the unrelated and related items for either the control group or the PWD group, for any level of load. This suggests the relatedness of the association is not a significant variable in determining performance.

Planned pair-wise comparisons examining the effect of cognitive load (corrected alpha level of .013) revealed that both PWD and control groups demonstrate better performance in the less demanding conditions. The PWD group demonstrated a significant difference in performance between the minimum and medium condition: t (14) = 5.68, p=<.001. The control group demonstrated a significant difference in prospective memory performance between the medium and high (equated) conditions (t (15) 13.35, p<.004). No significant difference was found between the minimum and medium condition for the control group.

This suggests that as the demands of the secondary task increases, prospective memory performance is compromised for both the PWD and control group, although this deficit occurs earlier for the persons with dementia.

A 2x2x3 mixed ANOVA was performed to investigate the effect of relatedness, group and load on prospective performance. Prior to analysis, Mauchly's test of sphericity was performed. This was significant for the all conditions (relatedness, load, and Relatedness x Load) hence sphericity could not be assumed for these conditions. The Levene's test performed on the between subjects variable of group was also significant, denoting unequal variance. Accordingly, findings are adjusted using the Greenhouse-Geisser correction.

The ANOVA revealed significant main effects of: Load: F (1.25, 36.21) =38.92 p <.001 and Group: F (1,29)=73.97, p<.001. The main effect of Target-task relatedness was not significant: F (1,29)=3.13, N.S. The Two-way interaction of group x load was significant: F (1.25, 36.21) =19.4 p=<.001, as was the 2-way interaction of relatedness x group: F (1,29) = 4.9, p=<.05, and the two-way interaction of load x group: F(1.25, 36.2) = 19.4, p=<.001. The two-way interaction of relatedness x load was non-significant: F (1.16, 33.48)

=.48, N.S. Finally, the three-way interaction of relatedness x load x group was non significant: F (1.15, 33.47) = .29, n.s. The findings of the ANOVA confirm the findings in the a-priori tests, in that the level of cognitive load has a significant effect on performance, as does group.

Secondary task and prospective memory performance for dementia group.

The relationship between performance on the secondary task and prospective performance was examined for the PWD group. Figure 16 shows a negative relationship between prospective memory performance and correctly performed secondary tasks, in that, the higher the secondary score (calendar task) the lower the prospective task. This correlation is significant, r (15)=.62, p<.01.

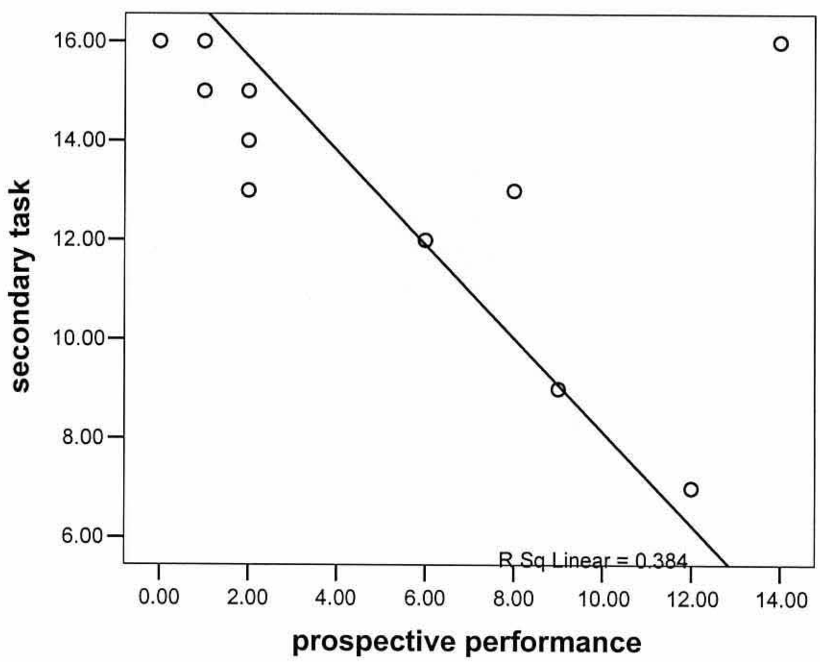

Figure 16 Relationship between successful secondary task and prospective memory performance for persons with dementia.

This suggests that, for persons with dementia, successful performance on one task compromises performance on the other. In particular, fig 16 shows that for the majority of cases, scores on the prospective task are negatively correlated with low scores for the secondary tasks.

Analysis of Subjective Memory Questionnaire

The relationship between self (or carer) reported prospective memory and everyday memory was examined (see figures 17 and 18). Both graphs show a positive linear relationship between everyday memory and prospective memory. This relationship is stronger (Rsq =.86) for the PWD group (as rated by carer). Pearson correlations found the relationship significant for both groups. (Control: r (16)= .621, p=<. 01; PWD Group: r (15)=. 93, p<. 0001.)

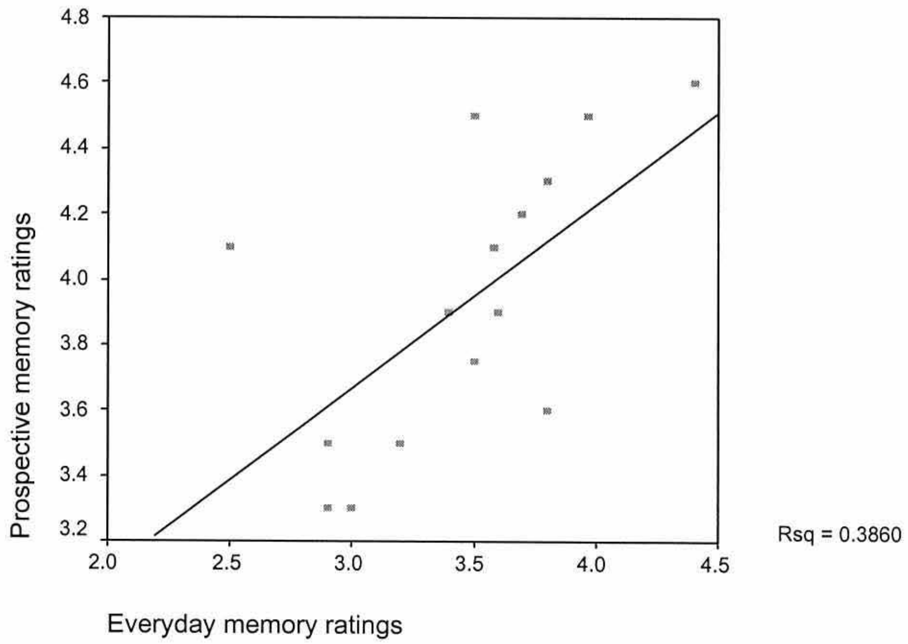

Figure 17: Relationship between self-rated prospective memory and everyday memory in healthy Control Group.

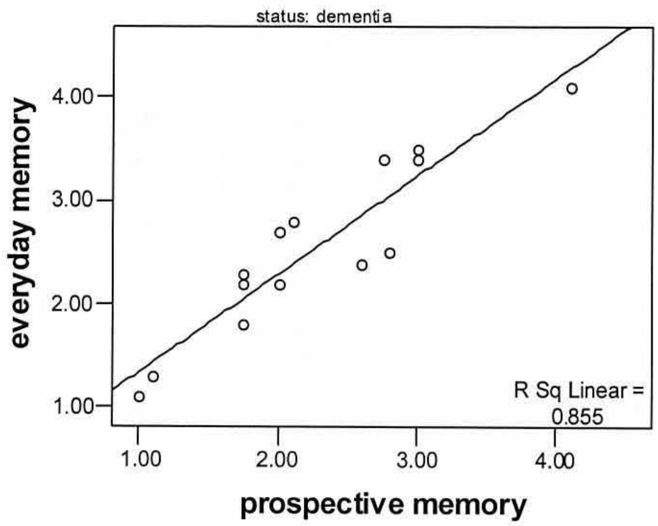

Figure 18: Relationship between carer-rated prospective memory and everyday memory ratings in Dementia group.

The findings suggest that for both healthy control, and persons with dementia, prospective memory performance is positively correlated with other aspects of our everyday memory; including retrospective and spatial memory.

The relationship between self –reported Prospective Memory and behavioural measures of Prospective Memory

The behavioural prospective data was compared with self (or carer) reported data to investigate the relationship between objective performance and subjective reports of prospective memory.

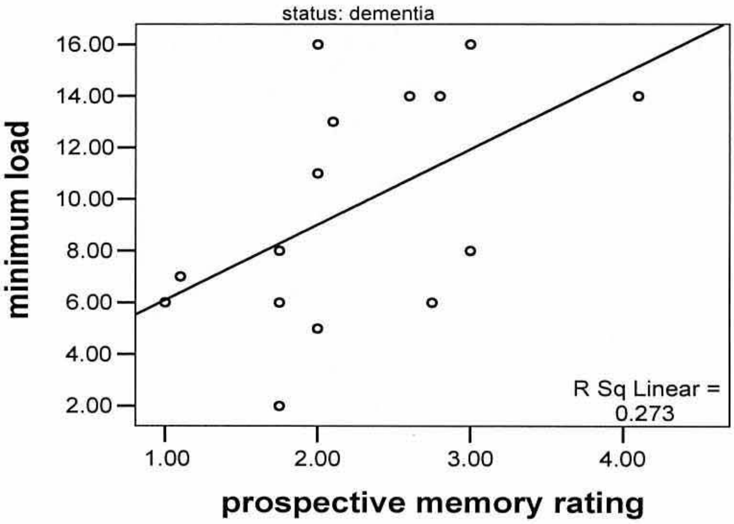

Figure 19:Relationship between objective prospective performance (minimum load condition) and subjective carer-ratings for dementia group.

Findings generally showed no significant relationship between self-report and actual performance for any conditions (see Table 14), with the exception of the minimum condition (carer-rated report and the objective prospective performance) for the PWD group; this was marginally significant. R (14)= .52, p=.045. The direction of this relationship appeared to be positive (see fig 19), suggesting that a higher subjective rating of performance was correlated with better objective performance, although the strength of this relationship was weak (rsq=.28). However, it is important to consider that the objective performance for the elderly controls in these conditions was ceiling or near ceiling, which could account for the non- existence of a relationship

Table 14:Correlations between objective prospective performance and subjective report, according to background load.

Group	Minimum load	Medium Load
Control	R(16)= .113, N.S.	R(16) =.138, N.S.
PWD	R(15)= .523, p<.045	R (15)=..132, N.S,

Summary

In summary, the findings suggest that for both groups, the nature of target and task (i.e. the relatedness) is not a significant factor in the successful performance of the prospective task. However, the level of cognitive demands placed on the individual via the secondary task does produce a significant negative effect. In view of the finding that the PWD group demonstrated a significant difference between the minimum and medium condition, whereas the control group did not, it can be concluded that the dementia group may be more vulnerable to the demands placed by the secondary task.

Evaluation of data for clinical cases

In the previous study, performance in the PWD group was examined as a whole. The results revealed a significant difference between the healthy control and dementia group on all aspects of prospective memory. This was predicted, nevertheless in view of the fact that retrospective memory was controlled for, by use of Spaced retrieval, it implies that prospective memory is not simply another form of delayed recall.

The following section aims to examine prospective performance in relation to specific dementia subtypes, or 'clusters' of deficit. The section additionally includes patients previously excluded from the main study, in view of not meeting the diagnostic criteria for probable Alzheimer's disease.

The patients were sub-divided into groups on the basis of scores obtained from the CAMCOG subsections and observations from the clinical psychologist who carried out the assessment.

The patients following groups were identified:

Group 1: This group demonstrated most severe impairments in memory and particularly new learning, and is consistent with the clinical 'type' of Early dementia of Alzheimer type.

Group 2: This group demonstrated global impairment across a number of cognitive domains, and is consistent with the clinical 'type' of Moderate Dementia of the Alzheimer type:

Group 3: This group demonstrated deficits predominantly in executive function, and is consistent with the clinical 'type' of Frontal type dementia including Picks disease.

Group 4: Attentional deficits: This group was indicative of parietal dysfunction, whereby attention was impaired, disproportionately to executive function.

For individual MMSE scores and group profiles see tables 15 & 16 and figure 20.

Table 15: Neuropsychological profile and prospective memory scores for each case, according to profile cluster group.

	MMSE	CAMCOG TOTAL	CAMCOG RECENT MEMORY	CAMCOG REMOTE MEMORY	CAMCOG NEW LEARNING	CAMCOG ATTENTION	CAMCOG EXECUTIVE FUNCTION	Prospective Memory BASELINE	Prospective memory DUAL
Patient Group 1 Early AD									
Mb-F1	16	68******	0********	2*****	8*****	7*	15*	7	6
Jc-M1	19	67******	1********	3****	7******	6**	11***	5	2
Hl-M1	16	63******	2********	3****	3******	6**	14**	6	1
Gj-F1	22	75****	2********	4**	4*******	7*	13**	16	12
Gw-F1	21	61*******	4	4**	7******	7*	14**	13	0
Eh-F1	26	77****	4	4**	7******	9	15*	14	0
Patient Group 2 **Moderate AD**									
Ap –F2	14	50*******	2********	4**	3*******	5****	4*****	2	1
Jm –M2	14	45*******	1********	2*****	4*******	2******	9****	6	0
Iw –F2	10	50*******	2********	3****	2*******	2******	10***	8	2
Ew –F2	19	60*******	1********	1*******	6*****	3******	8*****	14	8
Mj – F2	15	47*******	2********	4**	8*****	1*******	6*****	6	2
Patient group 3 **Frontal dementia**									
Ww – M3	23	78***	4	6	9****	9	6*****	16	14
Vm-F3	17	68******	2********	4**	13*	3*****	9****	14	9
Patient Group3 Attentional deficits									
Ts –M4	19	70*****	2********	5*	6*****	3*****	14**	11	0
Wp- M4	9	64******	1********	5*	9****	1*******	12**	16	1

Key:

* < 1 s.d. from healthy control mean
** < 1.5 s.d. from healthy control mean
*** <2 s.d. from healthy control mean
**** <2.5 s.d. from healthy control mean
*****<3 s.d.
******<4 s.d
*******5 s.d.
Healthy control mean N=92 taken from Woods et al. (2002)
All patients obtained from Heulwen memory Clinic.

Table 16: Mean scores, according to Cluster group, for neuropsychological tests and Prospective memory tests.

Cluster Group	MMSE	CAMCOG TOTAL	CAMCOG RECENT MEMORY	CAMCOG REMOTE MEMORY	CAMCOG NEW LEARNING	CAMCOG ATTENTION	CAMCOG EXECUTIVE FUNCTION	Prospective BASELINE	Prospective DUAL
1 N=6	20	68.5	2.17	3.3	6	7	13.67	10.17	3.5
2 N=5	14.4	50.4	1.6	2.8	4.6	2.6	7.4	7.2	2.6
3 N=2	20	73	3	5	11	6	6	15	11.5
4 N=2	14	67	1.5	5	7.5	2	13	13.5	0.5

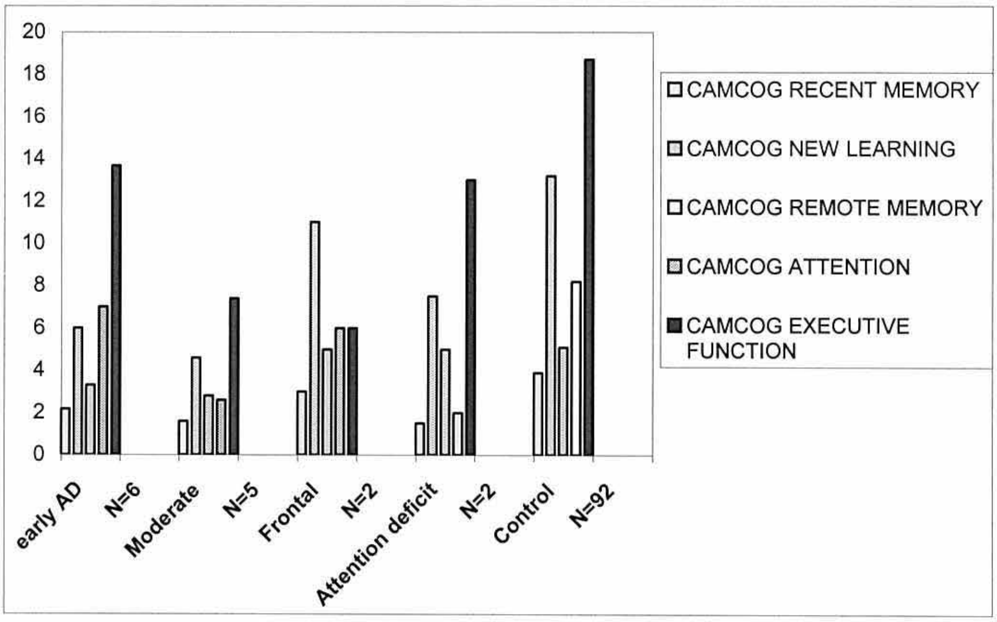

Figure 20: Group profiles according to mean score on Camcog subtests of memory, executive function and attention.

Tables 16 &17 show that all groups demonstrate a decline in prospective performance for the medium task; however, this decline is most dramatic for group 4. Figure 20 shows that this group shows poorest performance on attention measures of the Camcog. Error analysis for this group revealed a high incidence of perseveration (performing one prospective task for each target). It may be probable that the inability to set-shift can account for this pattern of results. However, it is not possible to draw firm conclusions, with such a small number in this group.

Group 2 also show a substantial decline for medium condition, this group demonstrate quite new poor learning scores on the camcog (fig20). It is possible that the poor performance in the medium condition, relative to the minimum condition is due to the higher demands compromising cognitive resources.

Group 1 generally demonstrate poorest performance across all of the Cam cog sub-sections, as well as prospective performance. It is possible that prospective memory performance in both conditions is poor due to a global cognitive impairment associated with dementia at this stage.

Interestingly, Group 3 frontal dementia (though impaired relative to healthy controls on dual task) does not demonstrate a marked decline in dual task; performance in both conditions is better than other clinical groups. This is counter- intuitive to literature in prospective memory. It is possible that learning strategy (S-R) is most beneficial to this group. This suggestion is corroborated by new learning score, which is generally higher than the other groups. However, once again it is difficult to draw firm conclusions when inferential statistics cannot be performed due to small sample size.

Summary of findings

In conclusion, the findings from the case groups have demonstrated that prospective memory appears to operate on a number of dimensions, other than retrospective memory (which was controlled through training) and executive tasks.

In line with findings from healthy control group, it appears that one of the most influential factors in the successful execution of prospective memory is the nature of the ongoing task. A task that places demands on available cognitive resources will invariably have a negative affect on prospective memory performance. Furthermore, the effect of secondary task demands exacerbates poor prospective memory for those groups compromised on other aspects of cognitive function, in particular attention and memory.

Five

Discussion

Review of Experiments

The findings from each experiment will be summarised and evaluated in terms of theory and broader implications.

Experiment one

The use of a multiple response methodology appeared successful in achieving its aim of overcoming the problem of response set, as evidenced by the variability in performance. Further, the use of a variety of everyday tasks is an improvement on the ecological validity of experimental research in prospective memory, in that the tasks performed (e.g. setting a clock, and sharpening a pencil) are arguably more closely related to everyday tasks than pressing a computer key. However, like other experimental studies of prospective memory, it is acknowledged that this study was performed under controlled conditions, in a relatively short period. Accordingly, it is unwise to generalise performance under these conditions to performance in the real world, where different conditions (e.g. reminders, motivation, distractions) interact with prospective memory functioning.

In general, prospective memory was superior to retrospective memory between, and across trials, even when opportunity for learning was controlled. This suggests that prospective memory performance is higher than retrospective learning from the outset, and retains this improved performance over trials.

Coherence with theoretical perspectives

Before considering the findings in terms of their relationship to other research, it is important to acknowledge the paradigm adopted in this study is qualitatively different from other approaches. Accordingly, caution is applied when making direct comparisons with other prospective memory research.

At first sight, the findings would appear to contradict Craik's (1986) hypothesis, which suggested prospective memory relies on more self-initiated retrieval, and consequently would be poorer than retrospective memory. A possible explanation for the results is that event-based prospective memory is not as reliant on self-initiated activity as Craik originally thought. It is possible that the target served as a cue to instigate the action, thus accomplishing the role of external prompt. This assertion is supported by the superior performance for the related target-task items, in comparison to the unrelated items, as, in keeping with Craik (1986), it would be expected that items that did not have strong associations would be more difficult to remember.

Additionally, in the present study, comparisons between retrospective and prospective memory were based upon retrospective recall and prospective performance. Therefore, it could be argued performance was more analogous to free recall (for the retrospective condition) and cued recall, (for the prospective condition). From this view point, the superiority of prospective memory is unsurprising, although it stills fails to support Craik's idea that prospective memory should be more demanding than free-recall.

Additionally, this view does not fully explain the increased benefit of learning trials for prospective performance in comparison to retrospective performance. It is possible that prospective memory differs in the way items are encoded. Indeed research (e.g. Englekamp & Zimmer, 199; Koriat, Benzur & Nussbaum, 1990); Zimmer & Englekamp, 1999) suggests that performance of the action as a method of encoding is superior to verbal or written instructions. Consequently, actual prospective performance may have been superior to retrospective recall because of this 'richer' form of encoding.

The idea that the opportunity for learning via motor encoding is beneficial to prospective memory is also of importance to the wider theoretical investigation of prospective memory. Few studies in the field of have explored the role of learning in prospective memory; most studies (e.g. Brandimonte et al., 2001, Cherry et al., 1999, Einstein et al., 1990, 1993, 1995; Guynn et al., 1998, McDaniel & Einstein, 1993, McDaniel et al., 1998; Stone et al., 2001) have assessed performance at the end of trials. Thus, in most experiments (and trial one of this study) participants are verbally instructed to perform the action, as opposed to keeping the mode of encoding and performance congruent. As a result, the prospective performance may not be given the opportunity to fulfil its full potential.

The findings also provide mixed support for Einstein & McDaniel's Simple Activation model and McDaniel &Einstein, (2000) Automatic process view of prospective memory. The results of the present study consistently demonstrated an advantage for related target-task items (e.g. sharpen pencil for target image "pencil sharpener") in preference to unrelated target-task items (e.g. ask for eraser for target image "bandstand").

According to Einstein & McDaniel's Simple Activation model, distinctive targets should benefit prospective memory performance more so than familiar targets, since distinctive and unfamiliar targets will have a smaller spread of association, and consequently a stronger level of activation. This level of activation is necessary for raising the intention into awareness, where it should elicit the associated prospective performance.

Contrary to this prediction, unrelated targets did not elicit better performance; in fact, they were significantly poorer until the final trial, where no significant difference was found. However, a possible interpretation of this discrepancy is the higher numbers of target-task combinations to be performed in the present study, compared with McDaniel & Einstein's 1990 & 1993 study. The simple activation model was developed in response to findings showing that distinctive targets (e.g.

monad or yolif, Einstein and McDaniel, 1990, 1993) produced better prospective performance than familiar targets (e.g. belt or movie). However, in these experiments only two such cues were used (and the response for each target was identical), this differs substantially from the present study in which eight distinctive (i.e. not associated with the tasks) targets were employed, (each requiring a separate response). Accordingly, it is possible that having such a large number of unrelated tasks attenuated the distinctiveness element. This may have resulted in a failure for the targets to reach the level of activation necessary to keep the intention in a state of heightened awareness, and subsequently perform the action.

However, paradoxically, the Simple activation model is useful for interpreting the findings in relation to the related target-tasks. If one assumes that items closely associated produces a high level of activation, then it is likely that the related target corresponded both with the task item as well its motor affordance (e.g. picture of pencil sharpener associated with pencil and action of sharpening pencil). These together perhaps strengthened the association, and accordingly the target-task pair was activated enough to be called into conscious awareness, where it was performed.

Finally, the findings are perhaps best interpreted in light of McDaniel & Einstein's (2000) Multi-process approach. It is likely that when the memory trace is strong enough (i.e. in the case of highly associated target-task pairings) then the prospective process is relatively automatic, however, in cases when the retrieval of the intention is not spontaneous (e.g. un-related targets and tasks, that have not been deeply processed), then a more strategic search must be undertaken. This would be consistent with a flexible and adaptable cognitive system.

Broader Implications

The idea that prospective memory performance appears to benefit from the opportunity to learn (by doing) has broader implications for general memory improvement, as well as potential for rehabilitation of cognitively impaired groups. For instance, in populations known to have problems with verbal encoding (e.g. Alzheimer's disease, Karlsson et al., 1989; or traumatic brain injury, Cockburn, 1996) the use of motor action as a form of encoding may facilitate subsequent performance in this modality.

Experiment two: Survey

Since the primary motivation for this thesis is to explore ageing (and abnormal ageing) in prospective memory. The first step was to establish prospective memory as an area of everyday cognition that gives rise to memory failure.

This was accomplished by conducting a survey on community dwelling persons over 60 years old.

In contrast to other self-report measures of memory (e.g. Everyday Memory questionnaire, Martin, 1986), where participants judge how 'good' they deem their memory to be, the present investigation asked the elderly participants to rate the frequency of occurrence of a range of prospective memory scenarios.

The advantage of this approach is that it obtains a broader view of the variety of prospective memory task perceived as most common in the everyday lives of the older persons. In other words, rather than rating the individual's memory for failures, the category of prospective memory is graded for frequency of failure.

The results of the survey revealed that a number of prospective memory tasks give rise to failure for the elderly. These ranged in frequency of occurrence, from passing on a phone message (which was the most frequently reported failure of prospective memory) to locking the door (which was rated as least likely to be forgotten).

Limitations

In any study using self-report measures, validity is always an issue. The accuracy of recall should be interpreted with caution, since the opportunity for error is potentially great in subjective reports of memory. One such error is the metamemory paradox, this is where individuals who commit the most errors are least likely to report them, because as Martin (1989) suggests, they "forget they forget".

In theory, the issue of validity could have been addressed by observing performance on this measure. However, in practical terms it is not feasible to observe individuals in the course of their daily lives.

Another problem arises from the individual variation in the opportunity to commit errors. For example, an individual who rarely corresponds by mail may possibly report fewer instances of forgetting to post a letter than an individual who undertake regular correspondence. Although the present investigation attempted to control for artificially low ratings by excluding ratings for tasks that were not applicable to the individual (e.g. taking the washing out of the washer was not applicable to nine participants). It was not possible to equate opportunity for every prospective task. Accordingly, it is possible that some individuals may have reported types of prospective memory as more frequently giving rise to failure, simply because they are performed more frequently.

Further, it is acknowledged, the sample may not be representative of an ageing population, and accordingly this makes the generalising of findings difficult. Indeed many of the prospective problems identified may not be exclusive to an ageing population.

Broader Implications

Despite the limitations discussed, the present investigation has drawn attention to the variation in prospective memory failure in the everyday lives of older persons. It appears that some areas of prospective memory are problematic for the elderly, (e.g. pass on a message, or watch a TV programme) whilst at the same time, some areas are rarely forgotten (e.g.

lock the door). The reason for this variation is not clear, however, it could be speculated that motivational aspects (for example the fear of crime may motivate the task to lock the door) and personality characteristics may be as much a contributing factor to prospective memory as cognitive factors.

Furthermore, the present investigation has highlighted the importance of effective prospective memory performance as necessary for successful independent living. For example, albeit an encouraging finding that the sample of older persons did not report forgetting 'to turn off the cooker' as an area of prospective memory failure; over half reported that they at least 'sometimes' forgot to take medication.

Thus, it would appear that further investigation is necessary to ascertain what factors contribute toward successful prospective memory.

Experiment three.

In terms of learning and target-target task relatedness, experiment three displayed a pattern of results comparable to experiment one. In general, both prospective and retrospective memory performance improved over learning trials, and related items were better recalled than unrelated items. Further, for both older and younger adults, prospective memory was superior to retrospective recall.

In terms of significant age differences in prospective memory, these were evident only in the final trial (unrelated condition). By contrast, for retrospective memory, a significant difference in performance was apparent for the initial trial, (related condition). In both cases, superior performance was in favour of the younger group. However, it should noted that for the majority of trials and conditions, no significant age effects were found; suggesting that age-related decline is not a reliable feature of prospective memory.

Finally, the findings revealed a qualitatively different pattern of errors between the age groups.

Consistency of findings with other research.

The findings are consistent with Einstein and McDaniel (1990) who also found no significant difference in performance between old and young groups for an event based task.

The findings are not consistent with the findings by Maylor, (1993; 1996) or Park et al. (1997). However, this could be explained in terms of the differing methodologies adopted. In both Maylor's (1996) and Park's et al. (1997) studies the ongoing task could be considered more cognitively demanding than the one utilised in the present study. For example in Maylor's study the ongoing task required the participant to generate names and name faces, whilst the prospective task was to circle a number when a particular target feature appeared, (beard or glasses.) Similarly, the ongoing task in Park et al.

(1997) study was a verbal working memory task. Thus, to disengage from such demanding tasks in order to respond to the target may have required more attentional resources than the current study, which was designed to be passive.

This assertion is supported by a feature in McDaniel & Einstein's (1990) methodology. In this study, level of difficulty in the ongoing task was equated for old and young groups. This implies that a lack of difference between the groups might be attributed to the amount of cognitive resources available to attend to the prospective task. Thus, in both the present study, and McDaniel & Einstein's, the older and younger group probably had sufficient processing resources available to perform the prospective task.

The idea that processing demands made by the secondary task can significantly reduce prospective memory performance has been demonstrated by Marsh & Hicks (1998). In this study, of the healthy young, executive-based tasks were employed as ongoing tasks. The findings demonstrated a decrement in prospective performance under conditions when attentional resources are divided.

Thus, it follows that a key feature in accounting for age-related differences in experimental studies could be the nature of the background task. More specifically, the amount of cognitive load required to perform this ongoing task, as well as switching attention to execute the prospective task. (This issue is addressed in experiment four.)

The findings appear to provide little support for Craik's (1986) proposal that prospective memory will show more age discrepancies than free recall, because of its greater cognitive processing demands. Although both groups performed more poorly in the conditions requiring more cognitive processing (the unrelated items), this was not a greater problem for the older group as suggested by Craik's model of age-related decline in processing. Furthermore, in contrast to Craik's theory, prospective memory performance was actually superior to retrospective free recall. A possible explanation for this is that it is possible to design prospective memory tasks that do *not* require a high degree of self-initiated activity.

Further, both older and younger people may develop strategies, which allow the targets to serve as cues, particularly for the related items that serve as a direct prompt for the required task. Accordingly, insofar as the participant can correctly identify targets, the prospective task approaches a cued recall task.

The analysis of error types committed suggests that the older group had more difficulty in correctly identifying targets (for example being more likely to respond to invalid targets) than the younger group. Additionally, the older group made a number of 'confabulatory' errors, none of which were shown by the younger group.

A possible explanation for the age-related differences in error type could be differential susceptibility to false recall between the older and younger groups. The findings are consistent with research (Hess, 1984, Isingrini, Fontaine, Taconnat & Duportal 1995; Jacoby, Bishara, Hessels & Toth, 2005; Karpel, Hoyer, & Toglia, 2001) who also found older adults were much more likely to falsely remember information than younger adults, even when original learning was controlled for (Jacoby, Bishara, Hessels & Toth, 2005). This is also the case for pictorial material (Koutstaal & Schacter 1997; Schachter, Koutstaal, Johnson, Gross & Angell 1997).

Another account for the high degree of false remembering could be that the 'red-herring' filler items grasp older adults' attention drawing on cognitive resources. According to this view, the age-related increase in false error rates would be consistent with the inhibition-deficit effect (Hasher and Zacks 1988; Zacks, Hasher & Li, 2000) in that older adults demonstrate an inability to dis-inhibit the response produced by presentation of a lure/prime.

This view is reiterated in the Capture model (Jacoby et al., 2005) in which false remembering can be accounted for by differences in "bringing an item to mind" (Jacoby et al., p.144). The capture model argues young adults are more able to control what comes to mind, whereas older adults' retrieval is insufficiently constrained. As a consequence of this lack of constraint, older adults' attention is more susceptible to being captured by a prime (lure) resulting in false remembering.

Alternatively, the findings can be explained in terms of a difference in strategy between the age groups. Research (Kelley & Sahakyan, 2003; Koriat & Goldsmith,1994; 1996) suggests younger adults are more likely to not make a response (or pass) on a stimulus than older adults, thus avoiding false recall errors. In contrast, older adults tend to be more reluctant to 'pass' and instead are more liable to make errors of false recall. This view is supported by the 'response omission errors' made by the younger group, and the 'false target errors' committed by the older group.

This implies that the older and younger groups differed in the way they distributed their resources, with the older group tending to spread them quite thinly across demands in an attempt to cover all possible cues. The younger group appear to be more strategic in applying their resources, avoiding making mistakes and learning more efficiently from practice. In contrast, the older group's learning may have been hampered by the errors committed, in that they may have produced interference from strong procedural memory traces.

Nonetheless, a considerable amount of variation existed among the types of errors committed by the older group. Not all older persons committed errors of confabulation, and false target was not committed often, suggesting that age related cognitive performance is widely variable.

Consistent with experiment one, the findings also provided evidence for McDaniel & Einstein's Multiprocess model. The findings demonstrated that highly associated items were better recalled (for both groups), leading to automatic retrieval of the intended action. However, in conditions requiring a more strategic search i.e. unrelated (or *not* highly associated) target-task pairings performance was poorer.

The findings suggest that age differences in prospective memory are mediated by a number of factors including nature of the task, learning, and strategies for distributing cognitive resources.

Broader Implications

The findings have broader implications for older adults in their everyday environment. The results imply that older persons are just as capable as younger persons in carrying out a wide variety of prospective tasks (including less obvious ones), when they have little else to compete for attention. This may also account for the superior performance of the older in naturalistic studies such as Martin (1986). It is possible that the older were able devote more resources to the naturalistic task than the younger group, (who may have been in employment or having to cope with the attentional demands of a family.)

The findings also suggest that prospective memory may be improved by learning and practice. This is particularly important in the instruction of new tasks such as taking new medication or operating different objects. The superior performance in prospective compared with retrospective memory implies that to improve prospective performance older adults should be encouraged to actually perform the action rather than relying on verbal instruction.

In conclusion, the findings imply that though the older adults may not be as efficient as the younger adults when it comes to allocating processing resources and completing tasks, they are not significantly worse.

Experiment four

The findings suggest that in terms of prospective performance, the demand level placed by the secondary task is an important factor in influencing successful performance, particularly in relation to ageing.

In this study, both groups demonstrated a decline in performance, though this deficit is greater for the older group. In relation to age differences, the older group demonstrated significantly poorer prospective performance as the demands of the secondary task were increased to the highest level. In this high load condition, significant age effects emerged.

In terms of overall performance (i.e. performance of both prospective and ongoing task elements), the older group is particular disadvantaged as the cognitive demands of the ongoing task increases. This age deficit is apparent for the medium as well as the high condition. This suggests that the older group may differentially allocate resources to performing the more important prospective task, rather than the secondary (ongoing) task. This is supported by phenomenological reports by elderly participants at the end of the study that 'something had to give' so they 'concentrated on carrying out the prospective task'.

This implies that the older group have some insight to their processing limitations, and accordingly may compensate for low attentional resources by adopting a strategic approach in their allocation. However, this does not explain why the prospective task would be favoured at the expense of the ongoing task. A possible explanation is that the training received for the prospective tasks may have led to the impression that prospective memory was a more important feature of the study than the ongoing task. As a result, participants were more motivated to complete this aspect.

The findings are consistent with a cognitive deficit hypothesis as well as the levels of processing theory. It suggests that as demands increase, the older group become more compromised and performance diminishes. However, the relatively high percentage of correct prospective responses precludes the assumption that the old group are grossly impaired on such tasks (in that prospective performance is close to ceiling for condition1 and 2).

In terms of the nature of the target-task relationship, the findings do not reliably demonstrate a significant effect of target-task relatedness. Evidence for a significant effect was found for un-related items between the old and young, and only for the high load condition. In view of the fact that related items in this condition were marginally non-significant, it is most likely that this effect was a function of the processing demands made during the high-load ongoing task, rather than the nature of the task.

This lack of effect is counter-intuitive to Craik's processing theory, as well as the findings from experiment 3. However, a possible explanation for this could be the low number of prospective items, and the training received for the prospective task, both of which might have attenuated the need for extra processing of the target during the prospective task.

Finally, the findings from subjective questionnaire seem to be inconsistent with actual performance. In particular, contradiction occurs between the older group's rating of their prospective memory (which was significantly higher than the young group's) and their actual performance (which was not significantly different from the young group – expect for the final trial in which case it was poorer).

However, this may be accounted for by ceiling effects, or that the experimental tasks were not sufficiently representative of real world or everyday memory tasks.

Coherence with Theory.

The findings are consistent with the ageing and prospective memory studies (e.g. Dobbs and Rule 1987; Einstein et al., 1992; Maylor,1993,1996; Park et al., 1997; Uttl & Graf, 2000) that reported an age-related deficit in prospective memory. It could be argued that a possible reason for age-related differences in prospective memory is the demanding nature of the ongoing task. In order to control for the possibility of rehearsal of the prospective task, these studies adopted challenging secondary tasks. However, by doing so prospective memory was compromised, and it was difficult to tease apart whether the reason for this was a failure of retrospective memory, or the difficulty in identifying the target, or the dual-like difficulty of the ongoing task. By systematically manipulating the level of cognitive load in the ongoing task, and training individuals to ensure that the content of the prospective task is learned, the present study has demonstrated that successful prospective memory performance is dependent upon the demands placed on the individual during the ongoing task.

Overall, the findings provide support for processing theories of age, for example Craik (1986) and Salthouse (1991, 1996). The findings demonstrate an age related deficit in prospective memory occurs as demands on cognitive processes increase (i.e. during the ongoing tasks). This is inline with Craik's processing resource hypothesis, which predicts processing resources diminishes with age, resulting in a deficit in cognition, which is greatest in tasks requiring manipulation.

The findings can also be interpreted by drawing upon Salthouse's (1991,1996) speed of processing theory (limited time mechanism). This theory suggests that ageing is accompanied by a cognitive slowing, in which older adults run out of time needed to complete complex tasks. In support of this view, performance by older adults was poorest in the high load ongoing task, which required greatest cognitive manipulation.

The findings also provide indirect support for the HAROLD model (Cabeza, 2002). This model of hemispheric activation in the prefrontal cortex has shown that for a number of cognitive processes including episodic memory retrieval (Bäckman et al., 1997; Cabeza et al., 1997), semantic memory retrieval, (Logan & Buckner, 2001), and working memory, (Reuter-Lorenz et al., 2000) older adults engage both hemispheres. This is in contrast to younger adults, who adopt an asymmetrical pattern of activation for encoding and retrieval. Reuter-Lorenz theorizes that this activation of both hemispheres serves a compensatory function for older adults; in that to function efficiently, older adults need to activate both hemispheres to achieve what younger adults can remember using just one. Although this strategy is successful for basic memory tasks (Bäckman & Dixon, 1992 Reuter-lorenz, 1999) it leaves regions (i.e. left PFC) unavailable for complex tasks. Accordingly, older adults demonstrate a greater deficit in strategic or complex processing tasks, such as those involving divided attention (Anderson et al., 1998). In relation to the present findings, it is possible to speculate that the older group 'tied-up' both hemispheres during the less demanding secondary tasks, whereas the younger adults were able to perform these through unilateral activity. Accordingly as the complexity of the secondary task increased, (the high load condition), the younger adults were able to recruit both hemispheres, whereas these were no longer available for the older adults, resulting in their impaired performance in this condition.

However, it is important to consider that this assertion would need to be verified in a future study, using neuroimaging evidence to substantiate the claim.

In terms of the relationship between self-report and objective prospective memory performance, the findings do little more than add to the already inconclusive findings in this area (Dobbs & Rule, 1987; Kidder, Park, Hertzog, & Morrell, 1997; Maylor, 1990; Sunderland, Watts, Baddeley, & Harris, 1986; Zelinski, Gilewski & Anthony-Bergstone, 1990). Although findings are most consistent with those by Sunderland et al. (1986) and Zelinski et al. (1990) who also reported a very weak, non-significant correlations between self-reported memory functioning and prospective memory tasks.

Broader Implications

The experiment has highlighted the role of the ongoing task in prospective memory performance. This is of significance since it may go some way toward accounting for the equivocal findings in prospective memory literature. The findings would imply that prospective performance does not just depend on the target task relationship; rather, performance is mediated by the ease of disengaging from the ongoing task. From this perspective, it would appear that prospective memory shares elements of a dual task. This has implications for older persons in a variety of prospective memory circumstances where ongoing tasks are considered demanding, from driving a car, to managing a home.

However, the study also highlighted the fact that the older group appear to allocate resources to the task deemed more important. Thus, older persons may reorganise their environments to reduce conflicting demands, (e.g. disengage from conversation when driving; or systematically performing one household task at a time).

This aspect of selective allocation of resources requires further investigation. Additionally, future, naturalistic, research could investigate what factors explain the successful prospective performance by older persons outside the lab.

Finally, the study has highlighted the value of a prospective training programme for both young and old groups.

Experiment five

Initial findings from the training demonstrated success for the spaced rehearsal method. The persons with dementia group successfully recalled both target and task pairings under delayed conditions. Accurate recall of the target-task pairings was confirmed after the experiment, suggesting that S-R was robust, and participants did not forget the training during the experiment. This suggests that, with intensive training, persons with dementia can improve encoding, storage and retrieval aspects of memory for very simple items. Success of this training in terms of prospective memory performance is crucial in that it allows control of the possibility of retrospective failure (i.e. forgetting the content of the task). Thus, since every individual knew what they were supposed to do before and after the experiment, any prospective failure may be attributable to aspects other than retrospective encoding failure.

The findings consistently demonstrated significantly poorer performance for the PWD group in comparison with the healthy controls. This deficit in performance existed across every condition, and all combinations of ongoing task load.

Predictably, both groups performed significantly better in conditions in which the secondary task was less demanding. This indicates as on-going processing demands increase, prospective performance appears to be compromised for both groups. However, this deficit is originates earlier for the PWD group in comparison to the older group.

The findings suggest that a key variable in prospective performance is the nature of the on-going task, particularly in terms of the demands made on processing resources.

A possible reason for this could be the dual-task nature of the on-going and prospective task. In support of this assertion, the findings demonstrated a significant negative correlation between successful ongoing task performance and prospective performance; suggesting, for persons with dementia, successful performance on one task compromises performance on the other. In particular, high scores for the medium load ongoing task are strongly correlated with low scores for the prospective tasks. Such a pattern of results implies a deficit with set shifting, attentional control, or perseveration.

Although the data showed slightly higher performance for the PWD group for the unrelated compared with the related items, no significant difference was found between related and unrelated target-tasks for any of the conditions. This lack of effect was comparable for the controls, except that findings showed a trend for successful performance for related target-task items. This suggests that the nature of the target-task relationship is not a significant factor in prospective memory for either persons with dementia or older adults. However, this could be accounted for by the intensive training; both related and un-related target-task items were equally well learned, and just as likely to trigger a response.

Unsurprisingly, the subjective reports of memory performance were significantly poorer for the PWD group (as rated by carers) than the control group. However, whilst the relationship between self-report and prospective memory was in the predicted, positive direction, it was not found to be significant. This suggests that observer ratings of performance do not always concur with objective performance. A possible reason could be the unique nature of prospective memory, particularly in terms of its impending and internal characteristics. For example, retrospective failure (e.g. failure to recall a name, or misplaced object) may be evident to the observer, however, it is more difficult for an observer to know that an individual intended to do something, but failed to carry this out, as there is no record of an internal intention.

Findings from the dementia subtypes, or clusters of deficit, revealed a widely variable ability in prospective memory. Predictably, the moderate dementia group had poorest overall performance. All groups demonstrated a decline in performance for the medium condition compared with the minimum condition. This was greatest for the attentional deficit group, where the drop in performance from the minimum condition to the medium condition was quite dramatic. Unpredictably, the frontal group demonstrated the least decline in performance between minimum and medium load condition. This is counter-intuitive to theory (e.g. frontal deficit theory), and it is possible that S-R training compensated for the usual problems in switching attention. Interestingly, this group had the highest score on the CAMCOG sub scale of new learning. Accordingly, a possible explanation for the findings is that new learning ability is an important factor during prospective memory performance, particularly under more demanding conditions. However, the very limited size of this group and variable individual characteristics makes it impossible to draw firm conclusions.

In general, the findings from the sub-groups have demonstrated that prospective memory appears to operate on a number of dimensions, other than retrospective memory and executive tasks. However, the limited numbers in the sub-groups make it difficult to clarify precisely to what extent these variables contribute to prospective memory performance.

Coherence with other research

It should be acknowledged, in terms of prospective memory in dementia research, there exist few experimental studies with which the present findings can findings can be compared. The seminal study by Huppert and Beardsall, (1993) suggested: "prospective memory may be particularly sensitive to impairment" in dementia. However, methodological problems in Huppert & Beardsall's study needed to be addressed before the validity of the conclusion could be established.

The present study tackled a number of these issues (including controlling for retrospective failure, spatial memory, and age differences), and consistent with Huppert and Beardsall did find a significant prospective memory impairment for persons with Alzheimer's disease compared with healthy controls. Further, this impairment was not attributable to retrospective failure.

It would seem therefore that Huppert & Beardsall's assertion was correct. However, further research needs to undertaken before this can be accepted conclusively. Additionally, it is not clear whether prospective is any more a 'sensitive indicator' of dementia than other aspects of memory, for example delayed recall.

In terms of coherence with research on retrospective memory performance in dementia (e.g. Baddeley et al., 1991 & Logie, 2001), a number of parallels can be drawn, particularly with regard to findings from working memory. For example, the present study demonstrated a significant decline in performance as the demands of the ongoing task increased. This was coupled with a significant negative relationship between ongoing task performance and prospective memory. These findings would imply that the dementia group were particularly compromised by the dual elements of the prospective task. These findings are consistent with Baddeley et al. (1991) and Logie (2001) who suggest that dual-task performance in Alzheimer's is grossly impaired.

Limitations of Study

The study was not without limitations, and it is important to highlight some of these issues. For instance, the outcome measure; prospective performance was measured as successful if the participant completed the task. It could be argued, differences may have been more obvious if reaction times had been recorded. This is particularly the case for older adults in the medium and high load conditions. In response to this, there were a number of reasons why reaction times were not chosen as outcome measures. For instance, it was felt that reaction times, as measured by a key press would not afford any ecological validity to the study. It was also felt the time taken to record how long the outcome measures took to complete, would be subject to such wide variability as to make them insensitive.

Another limitation is the use of carer report on behalf of the dementia group as a subjective measure for everyday memory, the decision to adopt this approach, and the issues associated with proxy reports is discussed in greater detail in the method section. However, the main problem with proxy reports of prospective memory is one of reliability, since the carer cannot foresee what the person is intending to do.

The study also highlights the problem of heterogeneity in performance by persons with dementia. This could be due to some variables outside the experimenter's control for instance, motivation, or effects of the disease on the individual. Accordingly, the findings are interpreted with caution. Notwithstanding, it is also recognised that Alzheimer's disease is not a homogenous condition, and differences in performance are inevitable.

Broader implications

The study provided encouraging evidence regarding memory training for persons with dementia. The findings show that persons with dementia can be successfully trained to encode, retain, and perform prospective memory tasks over a period of time. At first glance, this is encouraging in terms of retaining independence for persons with dementia. However, the experiment also highlighted a caveat in this training; in that training can be undermined if the conditions during retrieval place extra demands on persons with dementia. This would suggest that in environments where the person with dementia has several engaging on-going to tasks to accomplish, prospective performance may be sacrificed.

It is also accepted that the training method differed to standard approaches, although the method could be judged successful since all participants could recall the targets and tasks at the end of the study.

The findings also highlighted the disparity in performance by the dementia sub-types, or clusters. This has implications for prospective theory development, in terms of identifying the cognitive elements (e.g. new learning) necessary for successful performance. As well as for the individuals who comprise these categories, for instance prospective training can be given to those from groups most likely to benefit and retain these benefits.

Conclusion

In conclusion, the thesis has highlighted a number of conditions and factors that affect prospective memory. The findings have informed upon theoretical models of prospective memory (in particular those of Craik, 1986 & McDaniel and Einstein, 2000), as well as drawing attention to methodological issues in prospective memory research, including response set, and the nature of the ongoing task.

The thesis has also informed upon the nature of prospective performance in an older population; providing support for ageing theory, specifically a processing deficit.

The subjective data gained has drawn attention to the fact prospective memory is widely variable; some aspects are more prone to failure. In addition, the findings have shown that self-perception of memory is not necessarily correlated with memory performance in experimental conditions.

The research has also demonstrated that prospective memory training is successful for both healthy and cognitively impaired groups.
Finally, the thesis has made an important first step in systematically investigating prospective and dementia under experimental conditions.

However, many facets of prospective memory, in both the laboratory and the real world, remain to be investigated.

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Appendix one: Material list Experiment one

List of Materials

Experimental Target Items and corresponding task:

- Shopping list: Participant required to add the word " tea" to this list.
- Pencil Sharpener and pencil: Participant required to sharpen pencil
- White writing pad and red pen: Participant required to write word red with red pen.
- Book with bookmark placed inside: Participant required to remove bookmark from the book.
- Calendar: Participant required to turn calendar to month of July.
- Clock: Participant required to set the clock to 12.00 o'clock.
- Blue participation form: Participant required to complete this short form.
- Paperclips and wooden container: Participant required to put paperclips in the container.
- Phone list and envelope: Participant required to put the phone list into the envelope.
- Coloured pens and case: Participant required to place the pens in their case.
- Plant and container of water: participant required to water the plant.
- Desk Lamp: Participant required to turn on the desk lamp.
- Computer disk (floppy) and box: Participant required to remove the disk from the box.

- Telephone memo with message: Participant required to deliver the message to the experimenter.
- Blutack and packet: Participant required to put the blutack back in its packet.

Experimental Filler items:

- Drawing pins and container – within container
- Staples and container - within container
- Vase
- Diary
- Black Pentel marker pen
- organizer
- Pen attached to chain
- Stapler

Task not requiring desk top item:

- Request for eraser from experimenter.

Appendix two: Survey questionnaire

As part of a project at the University of Wales, Bangor, I am looking at everyday memory problems in older people. I am especially interested in the way people forget to do things and the situations most likely to give rise to forgetfulness.

I would like your help in identifying common circumstances in which you are most likely to forget. (For example if you frequently forget to post Birthday cards.)

The following questions are about everyday situations which may give rise to forgetfulness. I would like you to rate how often you have forgotten to do this item in the last year by ticking the box you most agree with. For example if you always forget to post a birthday card tick the box underneath **Always**.

Example:

Do you Forget to post Birthday cards?

Always	**Often**	**Sometimes**	**Rarely**	**Never**
❑	❑	❑	❑	❑

There is also room at the end of the questionnaire to add any situations not mentioned in the questionnaire that you feel give rise to forgetfulness.

If you do not understand any part of these instructions, please ask for clarification

Your help is greatly appreciated.

Please write down your age in years ________ years

Please tick appropriate box.

Are you: male ❑ or female ❑

Q1. Do you forget to switch lights off in a room?

Always	**Often**	**Sometimes**	**Rarely**	**Never**
❑	❑	❑	❑	❑

Q2. Do you forget to turn cooker off after using it?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑

❑

Q3. Do you forget to post letters?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑

❑

Q4. Do you forget to watch a T.V. programme you had planned to watch?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑

❑

Q5. Do you Forget to buy items from the shop?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑

❑

Q6. Do you forget to take washing out of washer when it has finished?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑

❑

Q7. Do you forget to turn the hob or cooker on?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑

❑

Q8. Do you Forget to return library books on time?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑

❑

Q9. Do you Forget to pay bills on time? (not ignore bills)

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑ ❑

Q10. Do you Forget to pass on phone messages?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑ ❑

Q11. Do you forget appointments with friends?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑ ❑

Q12. Do you Forget Doctor's/ Dentists appointments?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑ ❑

Q13. Do you forget to take medication at correct time?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑ ❑

Q14. Do you Forget to put bin out for collection?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑ ❑

Q15. Do you forget to lock door when going out?

Always Often Sometimes Rarely Never

❑ ❑ ❑ ❑ ❑

Q16. Do you forget to take keys out of door when door is open?

Always ❑ **Often** ❑ **Sometimes** ❑ **Rarely** ❑ **Never** ❑

Q17. Do you forget to claim change at the shop?

Always ❑ **Often** ❑ **Sometimes** ❑ **Rarely** ❑ **Never** ❑

Q18. Do you forget to pick up an item which has been paid for at the shop?

Always ❑ **Often** ❑ **Sometimes** ❑ **Rarely** ❑ **Never** ❑

Q19. Do you Forget to contact someone when you're supposed to?

Always ❑ **Often** ❑ **Sometimes** ❑ **Rarely** ❑ **Never** ❑

Q20. Do you forget to water the plants when you should?

Always ❑ **Often** ❑ **Sometimes** ❑ **Rarely** ❑ **Never** ❑

Any other situations that give rise to forgetfulness:

____

____

____

Thank-you for your time.

Appendix three: Subjective memory Questionnaire

Healthy young group control

Memory Questionnaire

This is a short questionnaire looking at the things which people commonly remember and forget. Please read through each question and tick the box that you think most accurately describes the memory of ....

Section 1. For each item, please rate how good you think the memory is of ....

Question 1.1. *Names of people (minutes after being introduced)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.2. *Names of people (a few days or weeks later)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.3. *Birthdays*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.4. *Telephone numbers*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.5. *Shopping lists*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.6. *Where things were put*

ot applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.7. *Appointments*

t applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.8. *Faces*

applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.9. *Theme or tune of song*

›plicable	Very Good	Good	Average	poor	Very poor
](0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.10. *Lyrics of song*

›licable	Very Good	Good	Average	poor	Very

☐(0) ☐(5) ☐(4) ☐(3) ☐(2) ☐(1)

Question 1.11. *Names of Streets/houses*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.12. *Number of house / flat*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.13. *Details of a book read, (characters' names, etc)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.14. *Train or bus times*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.15. *Jokes*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.16. *Mathematical formulae or conversion (eg how to convert miles to kilometres; Or pounds to kilograms)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.17. *Facts about people, (e.g. where they do; where they met)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.18. *Place in a book*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.19. *Colour codes (e.g. changing plugs: blue= neutral)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.20. *Returning a borrowed item*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.21. *Names of public figures attached to particular jobs*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐(1)

Question 1.22. *Details of shoe sizes, clothes sizes, etc. (of close relatives, e.g. spouse)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.23. *Signs (road/ traffic)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.24. *When last carried out jobs (e.g. watered plants)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.25. *Giving messages to people (e.g. passing on phone messages)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.26. *Right/left orientation (e.g.. which side of the door the door bell is; or turning key left or right)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.27. *Names of actors in films*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.28. *Names of titles of films*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.29. *Everyday times, (e.g. time of the ITV or BBC News)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.30. *Learning of new skills (e.g. gears of new car, buttons of new VCR, etc.)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.31. *Learning movements (e.g. dance steps)*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.32. *Directions to get somewhere*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.33. *Matching colours (e.g. thread to colour of shirt – when not together)*

Not applicable	Very Good	Good	Average	poor	Very poor

☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.34. *Recalling dreams*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Question 1.35. *Spelling words*

Not applicable	Very Good	Good	Average	poor	Very poor
☐(0)	☐(5)	☐(4)	☐(3)	☐(2)	☐ (1)

Section 2. For the following items please rate how often each occurs for ....

Question 2.1. *Set off to do something, then can't remember what.*

Not applicable	Very Often	Quite Often	Sometimes	Rarely	Very Rarely
☐(0)	☐(1)	☐(2)	☐(3)	☐(4)	☐ (5)

Question 2.2. *Forget what he or she was saying, mid sentence*

Not applicable	Very Often	Quite Often	Sometimes	Rarely	Very Rarely
☐(0)	☐(1)	☐(2)	☐(3)	☐(4)	☐ (5)

Question 2.3. *Forget a particular word during conversation*

Not applicable	Very Often	Quite Often	Sometimes	Rarely	Very Rarely
☐(0)	☐(1)	☐(2)	☐(3)	☐(4)	☐ (5)

Question 2.4. *Forget whether or not he or she has locked the house or closed the windows etc.*

Not applicable	Very Often	Quite Often	Sometimes	Rarely	Very Rarely
☐(0)	☐(1)	☐(2)	☐(3)	☐(4)	☐ (5)

Question 2.5. *Unable to place voices of people whom they have heard before*

Not applicable	Very Often	Quite Often	Sometimes	Rarely	Very Rarely
☐(0)	☐(1)	☐(2)	☐(3)	☐(4)	☐ (5)

Question 2.6. *Unable to place faces of people whom they have seen before*

Not applicable	Very Often	Quite Often	Sometimes	Rarely	Very Rarely
☐(0)	☐(1)	☐(2)	☐(3)	☐(4)	☐ (5)

Question 2.7. *Needing to recheck a map to find a route which they have just looked up*

Not applicable	Very Often	Quite Often	Sometimes	Rarely	Very Rarely
☐(0)	☐(1)	☐(2)	☐(3)	☐(4)	☐ (5)

Thank you for your time!

Appendix four: North Wales health Authority: Certificate of Confirmation of Ethics approval

NORTH WALES HEALTH AUTHORITY
RESEARCH ETHICS COMMITTEE (WEST)

PWYLLGOR MOESEG YMCHWIL (GORLLEWINOL)
AWDURDOD IECHYD GOGLEDD CYMRU

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Room 1/178
Ysbyty Gwynedd
Bangor
Gwynedd LL57 2PW

<u>Certificate of Confirmation of Ethics Approval</u>

Name of Lead Researcher : Ms J Wilson

Title of Study : The effects of different retrieval contexts on prospective memory in Alzheimer disease

I confirm that all requirements have now been received for the study mentioned above. The research therefore has this Committee's full ethics approval. (Approval from host institutions must be sought separately).

If, during the course of the study, there are protocol changes, serious adverse events, or major subject recruitment problems, you are required to notify the Committee as soon as possible .

It is also requested that you provide an annual interim report on the conduct and progress of the study, plus a final report within three months of completion .

The Committee wishes you every success with your research.

Signed : ....

Mr B Napier, Chairman .

Date : 7.9.00

Appendix five: University of Wales, Bangor:

Confirmation of Ethics approval

Prifysgol Cymru · University of Wales
BANGOR

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c.c. Professor Bob Woods

March 30, 1999

Jenny Wilson
Graduate Assistant
School of Psychology
University of Wales
Bangor
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LL57 2DG

Dear Colleague

The effects of different retrieval contexts on prospective memory

Your research proposal (referred to above and on the attached sheet) has been reviewed by the School of Psychology Research Ethics Committee and they are satisfied that the research proposed accords with the relevant ethical guidelines. Please note however the words missing from the Consent Form.

If you wish to make any substantial modifications to the research project, please inform the committee in writing before proceeding. Please also inform the committee as soon as possible if participants experience any unanticipated harm as a result of taking part in your research.

Good luck with your research.

Kath Chitty

Kath Chitty
Coordinator -School of Psychology Research Ethics Committee