Retrospective and prospective memory in healthy and cognitively impaired older adults: Using subjective and objective assessment

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TABLE OF CONTENTS

LIST OF FIGURES iv

LIST OF TABLES v

ACKNOWLEDGEMENTS vii

ABSTRACT viii

CHAPTER 1 - INTRODUCTION 1

1.1 What is memory? 1
1.1.1 Definition of memory 1
1.1.2 Taxonomy of memory 1
1.1.3 Retrospective memory 3
1.1.4 Prospective memory 10

1.2 Memory and normal ageing 16
1.2.1 Normal ageing 16
1.2.2 Retrospective memory and normal ageing 19
1.2.3 Prospective memory and normal ageing 24

1.3 Non-age associated memory decline 31
1.3.1 Causes of non-age associated memory decline 31
1.3.2 Retrospective memory and dementia of the Alzheimer type 40
1.3.3 Prospective memory and dementia of the Alzheimer type 42

1.4 Assessment of memory 46
1.4.1 Subjective assessment of memory 46
1.4.2 Objective assessment of memory 48

1.5 Current study 50
1.5.1 Aim 50
1.5.2 Hypotheses 50

CHAPTER 2 – METHODOLOGY 53

2.1 Design 53
2.1.1 Literature review search strategy 53
2.1.2 Current study design 54
2.1.3 Ethical considerations 55

2.2 Materials 56
2.2.1 Demographic information 57
2.2.2 Standardised assessment 57

2.3 Participants 64

2.3.1 Healthy older adult participants 64
2.3.2 Cognitively impaired older adult participants 65
2.3.3 Determining sample size and power 65

2.4 Procedure 66
2.4.1 Contacting research participants and obtaining their consent 66
2.4.2 Administration of the measures 67

CHAPTER 3 – RESULTS 68

3.1 Analytical strategy 68

3.2 Descriptive statistical analysis 70
3.2.1 Total sample 70
3.2.2 Healthy older adult participants 70
3.2.3 Cognitively impaired older adult participants 70
3.2.4 Group comparison 73

3.3 Inferential statistical analysis 73
3.3.1 Hypothesis 1. 73
3.3.2 Hypothesis 2. 75
3.3.3 Hypothesis 3. 78
3.3.4 Hypothesis 4. 81
3.3.5 Overall Summary 95

CHAPTER 4 – DISCUSSION 96

4.1 Discussion of main findings 96
4.1.1 Does retrospective and prospective memory functioning deteriorate with the onset of dementia? 96
4.1.2 Are retrospective and prospective memory functioning equal in healthy old age? 96
4.1.3 Are retrospective and prospective memory functioning equal in dementia? 100
4.1.4 Is insight into mnemonic functioning associated with severity of cognitive impairment? 102

4.2 Strengths and limitations of the study 107
4.2.1 Statistical power analysis 107
4.2.2 Design 108
4.2.3 Recruitment 109
4.2.4 Measures 110

4.3 Future research 111

4.4 Clinical implications 111

4.5 Summary 113

REFERENCES 115

APPENDICES 137

Appendix 1 – Ethics approval 138
Appendix 1.1 – Ethics Committee approval letter 138
Appendix 1.2 – Ethics Committee letter approving amendment to recruitment strategy 138
Appendix 1.3 – Management approval letter 138

Appendix 2 – Measures 139
Appendix 2.1 – Addenbrooke's Cognitive Examination Revised 139
Appendix 2.2 – Prospective and Retrospective Memory Questionnaire 139

Appendix 3 – Participant information sheet 140
Appendix 3.1 – Healthy participant information sheet 140
Appendix 3.2 – Patient participant information sheet 140

Appendix 4 – Consent form 141

Appendix 5 – GP Letter 142

Word count: 29, 730

LIST OF FIGURES

Figure 1.1: Squire's (1993) Taxonomy of Memory 3
Figure 1.2: Feldman and Woodward's (2005) Portrayal of DAT Symptom Progression, as Quantified by the MMSE. 36
Figure 1.3: Katzman (1993) Model of DAT. 38

LIST OF TABLES

Table 1.1: Maylor's Summary of Craik's Functional Account of Age Differences in Memory Tasks..... 25

Table1.2: Stages of DAT, as Classified by the Clinical Dementia Rating Scale, the Global Deterioration Scale and the Functional Assessment Staging Test. 37

Table 3.1: Demographic Characteristics of the Healthy and Cognitively Impaired Older Adults. 72

Table 3.2: Means and Standard Deviations of the *T* Scores of the Healthy and Cognitively Impaired Older Adults' Performances on the RBMT and CAMPROMPT..... 74

Table 3.3: Unadjusted and Adjusted Mean RBMT and CAMPROMPT *T* Scores in Healthy and Cognitively Impaired Older Adults. 74

Table 3.4: Multiple Regression Model of RBMT Belonging, Appointment and Message Subtests on CAMPROMPT *T* Scores in Healthy Older Adults..... 77

Table 3.5: Multiple Regression Model of RBMT Belonging and Message Subtests on CAMPROMPT *T* Scores in Cognitively Impaired Older Adults..... 80

Table 3.6: Means and Standard Deviations of the Healthy Older Adults and Cognitively Impaired Older Adults Self-Rated Total, Prospective and Retrospective Memory Ability, as Measured by the PRMQ. 82

Table 3.7: Unadjusted and Adjusted Mean Self-Ratings on the PRMQ Total, Prospective and Retrospective Scales of the Healthy and Cognitively Impaired Older Adults. 83

Table 3.8: Correlation Matrix of the Relationship between Healthy Older Adults' Performances on the RBMT, the CAMPROMPT and the PRMQ Total, Prospective and Retrospective Scales. 84

Table 3.9: Correlation Matrix of the Relationship between Cognitively Impaired Older Adults' Performances on the RBMT, the CAMPROMPT and the PRMQ Total, Prospective and Retrospective Scales..... 86

Table 3.10: Means and Standard Deviations for Each of the 17 Cognitively Impaired Participants' Self- and Proxy-Ratings of Total, Prospective and Retrospective Memory Ability, as Measured by the PRMQ. 88

Table 3.11: Correlation Matrix of the Relationship between Cognitively Impaired Older Adults' Self- and Proxy-Ratings on the PRMQ Total, Prospective (PM) and Retrospective (RM) scales..... 89
Table 3.12: Unadjusted and Adjusted Mean ACE-R Scores of the Healthy and Cognitively Impaired Older Adults..... 91
Table 3.13: Correlation Matrix of the Relationship between ACE-R Scores and Self-Ratings on the PRMQ Total, Prospective and Retrospective Memory Scales. . 92
Table 3.14: Multiple Regression Model of PRMQ Proxy-Ratings, CAMPROMPT *T* Scores, RBMT *T* Scores and PRMQ Self-Ratings in Cognitively Impaired Older Adults. 94

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ABSTRACT

BACKGROUND: Retrospective and prospective memory deteriorate with age and deteriorate further with the onset of dementia. As previous research has tended to use idiosyncratic and heterogeneous methodologies, it is not known if the deterioration in retrospective or prospective memory is equal or how such deterioration is related to insight into mnemonic performance.

DESIGN: The present study used a mixed, cross-sectional design. It examined retrospective and prospective memory in healthy and cognitively impaired older adults using objective and subjective assessment.

METHODOLOGY: Twenty healthy and twenty cognitively impaired older adults were assessed. The objective measures were standardised and had high ecological validity, to maximise the assessments' generalisability to everyday mnemonic functioning. The subjective measure was a standardised assessment of subjective appraisal of retrospective and prospective memory. This subjective assessment was used to gain self-ratings from the healthy and cognitively impaired older adults and, in addition, to gain proxy-ratings from the cognitively impaired older adults' partners/carers. Participants were also assessed using a measure of general cognitive functioning.

RESULTS: Healthy older adults performed significantly better than cognitively impaired older adults on both the retrospective and prospective memory test, although performance in both groups was higher on the prospective memory test than on the retrospective memory test. Neither proxy-ratings, nor overall severity of impairment, were associated with subjective assessment of prospective or retrospective memory. In the healthy older adults, self-rating of memory was not associated with objective memory performance. In the cognitively impaired older adults, however, higher self-ratings of memory were associated with poorer performance on the prospective memory test.

DISCUSSION: The results suggested that both healthy and cognitively impaired older adults perform better on prospective memory tasks than retrospective memory tasks, but both types of memory deteriorate with the onset of dementia. Subjective memory appraisal is not related to objective memory performance in healthy older adults, but is negatively associated with prospective memory performance in cognitively impaired older adults. Findings were discussed in relation to previous research, along with a review of the strengths and limitations of the study. Clinical implications and directions for future research are also suggested.

CHAPTER 1 – INTRODUCTION

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

Lewis Carroll (1871) *Through the Looking Glass.*

1.1 What is memory?

1.1.1 Definition of memory

Memory can be defined as the acquisition and retention of information (Loring, 1999). It is 'central to all cognitive functions and probably to all that is characteristically human' (Lezak *et al*., 2004).

Memory has been discussed, deliberated and debated from the ancient world to the current day; from classical philosophy, through medieval theology, to modern neuroscience. Memory is fundamental to our sense of self and our ability to cope with everyday life. It accounts for all of our tastes, preferences, personal history and anticipated future, and its dysfunction can be devastating.

1.1.2 Taxonomy of memory

Theoretical models of memory can be divided into 'process' or 'systems' theories. Process theorists, such as Roediger (1990), postulate that memory processing is either data-driven or conceptually-driven. Data-driven processing is the analysis of physical features, whereas conceptually-driven processing requires analysis of meaning (Blaxton, 1989). It is thought that implicit memory (memory that occurs without conscious meditation; Loring, 1999) relies on data-driven processes, whereas explicit memory (memory that can be consciously recalled) relies on conceptually driven processes. This process model is useful when considering amnesia, as

amnesiacs tend to perform well on tasks which involve implicit memory, but perform badly on tasks which involve explicit memory, which Roediger suggests is because of explicit memory's dependence on (impaired) conceptually driven processes and implicit memory's dependence on (intact) data-driven processes. There are, however, several shortcomings to the process approach (Roediger, 1990) such as dual processing phenomena, when both data-driven and conceptually driven processes are used, as it is rare that a task would involve only implicit or explicit memory.

Memory can be classified according to systems theories. Systems theories conceptualise memory as consisting of individual sub-systems. Squire (2004) told of the long history of this approach to understanding memory, stretching back to at least 1804, when Maine de Brian theorised that memory could be divided into 'mechanical', 'sensitive' and 'representative' memory. In 1890, William James described a difference between 'habit' and 'memory', a classification later supported by Bergson in 1910. In 1923, McDougall wrote of 'explicit' and 'implicit' recognition. In 1948, Tolman stated that there was 'more than one kind of memory'. In 1969, Bruner described 'memory with record' and 'memory without record' and later in 1975, Winograd described 'procedural knowledge' and 'declarative knowledge'.

In the mid 1980s, there was a shift away from a binary classification towards a multiple memory systems approach. In 1988, Squire and Zola-Morgan introduced a model of memory, which included 'non-declarative' memory and 'declarative' memory, with 'non-declarative' memory as an umbrella term to represent further memory sub-systems. This would seem to mimic Ryle's (1949) distinction between 'knowing that' and 'knowing how'. In 1993, Squire revised his model (Figure 1.1) to include Schacter's (1987) distinction of explicit versus implicit and Tulving's (1982) distinction of semantic and episodic memory.

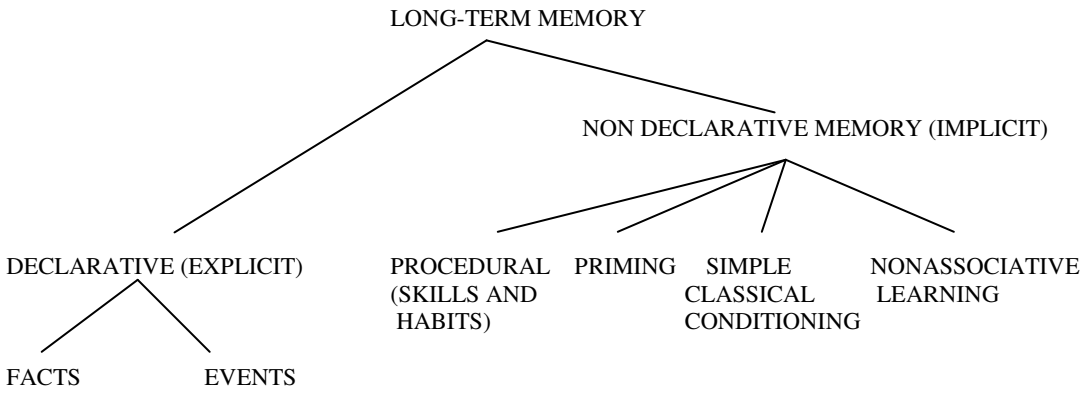

Figure 1.1: Squire's (1993) Taxonomy of Memory

More recently, memory has been classified by temporal direction (e.g. Maylor, 1993; Ferbinteanu & Shapiro, 2003; Burgess & Shallice, 1997). Memory has been divided into retrospective memory and prospective memory. Retrospective memory and prospective memory will now be considered in turn, focusing on the cognitive processes that underlie these types of memory and their neuroanatomical bases.

1.1.3 Retrospective memory

1.1.3.1What is retrospective memory?

Retrospective memory is the ability to remember information from the past, for example, what you ate for dinner last night. Retrospective memory is thought to recruit different memory functions or systems, such as explicit or implicit, semantic or episodic, depending upon the specific characteristics of the information to be remembered (Squire *et al*., 1993).

1.1.3.2 What are the cognitive processes underlying retrospective memory?

There are many theories of the underlying cognitive processes that govern retrospective memory. An early model of memory was the Atkinson-Shiffrin model

(Atkinson & Shiffrin, 1968), which suggested that information passes through three stages: sensory, short-term and long-term, and that it is the stage of processing which determines whether the information will be encoded and for how long. This model was criticised for being too crude and too focused on the structure, rather than the processes, of memory. Later models have become more specific and sophisticated, suggesting a complex interaction of various memory processes. Two examples of this are the Baddeley and Hitch (1974) model of working memory and Craik and Lockhart's (1972) levels of processing (LOP) model of memory.

In 1974, Baddeley and Hitch argued that the concept of short-term memory should be replaced with that of working memory. They described working memory as a limited capacity memory system that provides temporary storage to manipulate information for complex cognitive tasks such as learning and reasoning (Loring, 1999). Baddeley (1986) suggested that it has two main components: storage and the central executive. The 'phonological loop' provides temporary storage for phonetic information and the 'visuo-spatial sketch pad' provides temporary storage for visuo-spatial information. These two storage systems are passive slave systems to the 'central executive' or 'supervisory attentional system' (Norman & Shallice, 1980), which regulates their activity, according to the demands of the presenting situation.

The Baddeley and Hitch (1974) model has been criticised, however, for presenting the central executive as a sort of homunculus controlling the two storage systems (Donald, 1991). This unitary model was criticised and many favoured a 'distributed capacities' view (Monsell, 1984; Shah & Miyake, 1996), which suggested that central executive functions are fractionated and controlled by different subsystems. The central executive model has since been revised (Baddeley 1996, 1998) to include separable component functions (e.g. Shallice & Burgess, 1996). Baddeley (2003; 1998) advises that the central executive model should be considered to exist theoretically only and argues that the notion of a central executive has proven to be a useful concept, both theoretically and clinically (Baddeley, 1998).

Craik and Lockhart (1972) suggested that memory retention is dependent upon the depth of processing, where greater 'depth' means greater semantic or cognitive analysis (Craik & Lockhart, 1972). Thus, information that is analysed on the basis of its semantic or conceptual features is processed to a greater depth than information analysed on the basis of its perceptual features.

Craik and Tulving (1975) reported ten experiments, which, they argued, provided support for the LOP model. They designed a study that manipulated the depth of processing of words over three levels: shallow, intermediate and deep. Shallow processing involved asking the participant questions about the typescript of the words; intermediate processing involved questions about the acoustics of the words, and deep processing involved questions about the semantic category or meaning of the word. They reported that deeper encoding led to greater recall on a later memory test.

Craik and Tulving (1975) also reported, however, that participants spent longer studying the words when asked 'deeper' questions. It is arguable, therefore, that it is not the greater 'depth' of the processing that leads to greater recall, but the longer time spent encoding the information. The authors defended the LOP model by completing a further experiment (Craik & Tulving, 1975) which manipulated the length of time spent analysing the words, spending longer analysing perceptual features and a shorter time spent analysing semantic/conceptual features. They reported that, still, the deeper encoding led to a greater recall on a later memory test.

Their paradigm, however, assesses recall of words based on different types of sensory analysis: visual features, phonological features and semantic features. It is possible that different types of sensory analysis will have different levels of connection with memory systems, irrespective of their 'depth'. Moreover, does the quality of retrieval depend upon whether the retrieval context matches that at encoding, irrespective of its 'depth'? Some theorists believe that information to be remembered is bound with the contextual information in which it occurs, and that it is this package that is stored as a memory trace. This memory trace will be retrieved

only when the retrieval context matches that at the time of encoding (Roediger *et al.*, 2002). This phenomenon has been termed 'Transfer-Appropriate Processing (TAP)' (Morris *et al*., 1977; Bransford *et al.*, 1979) or 'encoding specificity' (Tulving, 1982, 1983). Morris *et al*. (1977) found that when participants encoded words phonetically or semantically, they demonstrated greater recall of the semantically-encoded words and lesser recall of the phonetically-encoded words. This is consistent with the LOP account of memory. They also found, however, that when the recall question referred to phonetic aspects of the words, e.g. does this word rhyme with a word seen during encoding, participants demonstrated greater recall of the phonetically-encoded words and lesser recall of the semantically-encoded words. This is not consistent with the LOP account of memory, but is consistent with TAP/encoding specificity hypotheses. Craik (2002) suggested that these two ostensibly opposing theories, the LOP model and the encoding specificity principle, were, in fact, synergistic. It was argued that retrieval of information that is encoded deeply is enhanced by a retrieval environment which matches the environment at encoding.

An outstanding issue, however, is how to quantify 'depth'. Is there a falsifiable index of depth of processing? Baddeley (1978) criticised LOP theory and claimed it was an invalid syllogism; the fact that deeper processing leads to better retention, does not mean that better retention requires deeper processing. Furthermore, the argument can be considered circular as there is no measure of depth other than memory performance.

Craik (1979) responded to this criticism by citing an experiment by Seamon and Virostek (1978) that asked experimental participants to agree on the relative depth of encoding processes. The depth that they agreed upon matched later performance on a retrieval task, with greater depth being associated with better retention. It is possible, however, that performance on the retrieval task could have been biased by the earlier discussion about the depth of the processing, by priming oneself to spend more or less time analysing the information accordingly. Craik (2002) admits that a testable index of depth of processing would benefit the model and further research in this area.

Perhaps the greatest legacy of the working memory model (Baddeley & Hitch, 1974) and the LOP model (Craik & Lockhart, 1972) is the encouragement to move away from the traditional notion of memory as information being held in the short-term memory before being consolidated into the long-term memory stores, as a unitary memory trace or 'engram' (Roediger *et al.,* 2002). The working memory model (Baddeley & Hitch, 1974) and the LOP model reformulated our understanding of memory, conceptualising it as being dependent upon activation of specific memory processes dealing with perceptual or conceptual aspects of incoming stimuli (Craik, 2002).

Our understanding of memory processes has been furthered by parallel distributed processing models and connectionist theories (McClelland & Rumelhart, 1988; Rumelhart, Hinton *et al*., 1986; Rumelhart, Smolensky *et al*., 1986; Rumelhart & McClelland, 1986). Parallel distributed processing models propose that information is processed not sequentially, as theorised by earlier stage models (Atkinson & Shriffin, 1968), but simultaneously and in parallel, through an interconnected network of neural units. Connectionist networks assume that information to be remembered is stored in several interconnected units, rather than a unitary store (McClelland, 1994). Each unit can be accessed independently, but as they occur within a network, individual unit activation leads to increased activation of all the other units within that network. Such networks can be useful as theoretical models of memory and are a current hotbed of research (e.g. Maia & Cleeremans, 2005; Murre *et al*., 2006; Cowell *et al*., 2006).

These parallel distributed processing models (McClelland & Rumelhart, 1988; Rumelhart, Hinton *et al*., 1986; Rumelhart, Smolensky *et al*., 1986; Rumelhart & McClelland, 1986) are given greater weight by electrophysiological data that seem to suggest that human neural activity also occurs in parallel (Crowe *et al.*, 2005; Miller & Desimone, 1994). Parallel processing models of human memory, rather than serial models, are also consistent with our experience of memory processing as being plastic and resilient (Rolls, 2000). An example of this resilience can be seen in the

effect of the massive loss of brain cells as we get older (Buckner, 2004; Terry *et al*., 1987). We could assume, within serial processing models, that memory would be affected hugely. Evidence suggests, however, that brain function is affected only slightly. This 'graceful degradation' (Fuster, 2002; Rolls, 2000) as it is known, is consistent with what we would expect within a parallel distributed processing model of memory (Fuster, 2002).

Parallel distributed processing models may be a useful way of conceptualising memory, but there are several drawbacks to the connectionist approach. There is a necessary simplification when describing abstract, diffuse and invisible processes and packaging them into a concrete model and it is, therefore, reductionist in its biological realism (Martin, 2003). Artificial neural networks have networks of up to 1000 neurons, whereas the neocortex has up to 100,000 neurons in each cubic millimetre (Martin, 2003). Some suggest that connectionism is useful only with simple systems or specific modules, not with more complex systems, and that it is futile to try to pin nodes within a PDP model into higher-order constructs (Martin, 2003). Furthermore, although connectionist models are used to model behavioural data patterns from cognitive tasks, such as the phonological loop model by Burgess and Hitch (1992), they often do not consider biological plausibility, which makes this approach difficult to evaluate.

1.1.3.3 What is the neuroanatomical basis of retrospective memory?

There is a long and ongoing debate over whether cognitive processes can be pinned down to specific locations. Current neuroimaging methods allow us to generate detailed images of the brain's structure. Brett *et al*. (2003) describe how one can use these structural images (from Computerised Tomography (CT) and structural Magnetic Reasonance Imagery (MRI) scans) and combine them with other imaging methods, such as Positron Emission Tomography (PET) or functional MRI (fMRI) to make inferences about functional architecture of the brain. Usually, each subject has a series of scans: structural scans to depict the neuroanatomy, and functional scans to identify the neuroanatomical location, or time course, of activity in the brain during

imaging. Because the size, shape and precise neural architecture varies from one individual to another, the structural images from each participant are transformed through a process called spatial normalisation to match a 'standard' template brain, such as that provided by Talairach and Tournoux (1988). This makes it easier to identify specific brain structures and to compare to other studies which use images that have also been transformed in this way. This normalisation is then applied to the functional scans. Obviously, this normalisation process can lead to a huge loss of rich data about specific individuals' anatomy and their effect on brain function, but individual variation in brain structure would make it difficult to interpret these data.

The next stage of the functional localisation process is the labelling of areas of activity, according to their stereotaxic coordinates, anatomy or function (Brett *et al.*, 2003). This is relatively straightforward with some areas of activity, such as basic motor processes, but more difficult, however, with higher-order constructs, such as memory, as it involves many abstract processes and their interaction with specific parts of a highly convoluted cortical map. When one remembers that this cortical map has been transformed and normalised to match a template brain, the prospect of accurate activation labelling appears to become even more remote.

There is some consensus between researchers that deal with neuroimaging data, however, that explicit memory formation tends to be associated with activity in the structures of the medial temporal lobe and its interrelation with the prefrontal cortex (Squire & Zola-Morgan, 1991; Gabrieli *et al*., 1997; Dove *et al*., 2006). De Haan *et al*. (2006) describe how memory is mediated by the medial temporal lobe circuit involving the hippocampus and the perirhinal, entorhinal and posterior parahippocampal cortices.

This locationist approach has its fans and critics. Some, such as Ward and Frackowiak (2004), have embraced functional localisation and generated maps of cortical function. Whereas, others, such as Brett *et al.* (2003) and Heeger and Ress (2002), are more cautious and cite the current methods' technical and conceptual

flaws or, indeed, its limited usefulness in delineating between psychological theories (Coltheart, 2006).

1.1.3.4 Summary

Retrospective memory can be understood using the stage model (Atkinson & Shriffin, 1968), the Baddeley and Hitch (1974) model of working memory, the LOP model (Craik & Lockhart, 1972), the PDP model and connectionist models (McClelland & Rumelhart, 1988; Rumelhart, Hinton *et al.*, 1986; Rumelhart, Smolensky *et al.*, 1986; Rumelhart & McClelland, 1986). Memory has three main stages: encoding, storage and retrieval. The quality and content of a memory trace depends on several factors: characteristics of the information to be remembered (Craik & Lockhart, 1972), the surrounding context (Tulving, 1982, 1983; Morris *et al.*, 1977; Bransford *et al.*, 1979) and integrity of memory processes. Such processes seem to be associated with the structures of the medial temporal lobe and its interrelation with the prefrontal cortex (Squire & Zola-Morgan, 1991; Gabrieli *et al.*, 1997; Dove *et al.*, 2006; De Haan *et al.*, 2006).

1.1.4 Prospective memory

1.1.4.1 What is prospective memory?

Prospective memory is the ability to remember to do previously planned actions in the future, (Groot *et al*., 2002) for example, remembering to go to the shop to get the ingredients for dinner tonight. Although an everyday type of memory, it is an area of research that is still in its infancy (Groot *et al.*, 2002). It has various labels, dependent on the investigating researcher. Its labels include: remembering a plan of action (Cohen, 1996); intention memory (Kuhl & Kazen, 1999); remembering intentions (Kvavilashvili, 1998; Einstein *et al*., 1998); realising delayed intentions (Ellis, 1996) and memory for future actions (Einstein & McDaniel, 1996). Some authors have even argued that the ‘memory’ of ‘prospective memory’ is a misnomer, as they believe its underlying cognitive processes extend far beyond memory (Dobbs

& Reeves, 1996), and that it may be better to refer to prospective 'remembering' than 'memory' as it less likely to infer a specific memory system and more likely to indicate a type of cognitive task.

Prospective memory has been delineated into various subtypes. Meacham and Leiman (1982) divided prospective memory tasks into habitual and episodic tasks. Habitual tasks being those that are routine, such as remembering to brush your teeth before you go to bed. Episodic tasks are less frequent tasks, such as remembering to buy a birthday card for your mother's birthday. This distinction mirrors Tulving's (1972) episodic versus semantic distinction of memory (Graf & Uttl, 2001). Harris (1984) divided prospective memory into simple tasks (the cues for which occurred in the context of an ongoing activity) and compound tasks (the cues for which have to be monitored outside the context of the ongoing activity). Ellis (1988) divided prospective memory tasks into pulses and steps. She defined pulses as those that must be completed at a particular time, whereas steps are those that must be completed within a much broader time frame. Einstein and McDaniel (1996) suggest that tasks could be termed time or event tasks according to whether the cue for task completion is a particular time or in association with a particular event.

The numerous ways of describing the taxonomy of prospective memory, and the little ostensible agreement between researchers on its terminology, perhaps signifies the relative infancy of this research. As described above, a prospective memory task can be described according to the nature of the trigger/cue to the task and the nature of the delayed intention. The qualities of the trigger and the delayed intention can vary hugely and it may be reductionistic or overly-simplistic to try to distil the large number of variables that could be associated with a specific prospective memory into binary or categorical groups.

1.1.4.2 What are the cognitive processes underlying prospective memory?

There is some dispute about what the underlying cognitive processes of prospective memory are. Baddeley (1990) stated that 'retrospective and prospective memory do

not differ only with respect to their past versus future time orientation'. Ellis and Kvavilashvili (2000) also discuss the question of whether there is a false dichotomy between retrospective and prospective memory, with some researchers (Burgess, 2000; Ellis, 1996) suggesting that they involve the same processes.

Certainly, there are similarities between retrospective and prospective memory processes: for example, they seem to involve similar neural structures (Ferbinteanu & Shapiro, 2003; West & Krompinger, 2005). There is, however, evidence of a dissociation between these two types of memory. Kvavilashvili (1987) found that people's ability to perform a prospective memory task was unrelated to their ability to do an associated retrospective memory task, suggesting a clear dissociation between these two types of memory. Furthermore, Burgess and Shallice (1997) demonstrated a double dissociation between retrospective and prospective memory, using participants with damage to the temporal lobe (known for its involvement in retrospective memory) and participants with damage to the frontal lobe (known for its involvement in prospective memory). This would seem to suggest that although there is some crossover between these two types of memory, there are dedicated cognitive processes for each (Burgess, 2000).

Craik and Kerr (1996) reviewed the differences between retrospective memory and prospective memory in encoding, retention and retrieval processes. They suggest the basic processes do not differ, except for a few details. At the encoding phase, differences include: an increased dependence on planning processes, dependence on external cues and encoding intentions rather than events or facts. During retention, differences include: necessity of monitoring and possible reduction in either remembering the prospective memory or the ongoing task. At the retrieval phase, differences include external cues that may act as triggers of the intention, increased dependence on self-initiation and a potential trade-off between performance on the prospective memory task and performance on the other ongoing activities. Einstein *et al*. (1997) also noted the increased effort required at encoding and retrieval of prospective memory as opposed to retrospective memory.

McDaniel and Einstein (1992) suggested that successful prospective memory involves two related processes: a prospective component and a retrospective component. They developed this theory further into the 'noticing + search' model (Einstein & McDaniel, 1996; McDaniel, 1995). This model proposes that the 'noticing' component reflects the prospective component, which functions by monitoring the contextual conditions for the appropriate cue for completion of the prospective memory task. 'Searching' is proposed to reflect the retrospective component, which functions by retrieving the appropriate content of the prospective memory task, linking the cue with the delayed intention.

Whilst there is great variance between the natures of different prospective memory tasks, it is accepted that there are some commonalities across these (Burgess *et al.*, 2001; Ellis, 1996). Dobbs and Reeves (1996) suggest that there are at least six stages of any prospective memory. These are:

1. Metaknowledge (knowledge about the memory task)
2. Planning (formulation of a plan to meet the needs of the memory task)
3. Monitoring (to determine whether the current context matches that required)
4. Content recall (remembering the task demands)
5. Compliance (performing the task demands) and
6. Output monitoring (determining whether the task had been performed at the right time).

These stages would seem to work within a feedback loop, for correct execution of the prospective memory task. This characterisation of prospective memory involves processes that are more executive and less mnemonic in nature (i.e. metaknowledge, planning and monitoring), perhaps supporting the argument that prospective 'memory' is something of a misnomer (Dobbs & Reeves, 1996).

Various other cognitive functions have been described as being central to successful completion of a prospective memory task. Graf and Uttl (2001) suggested that there might be a continuum between sustained attention and prospective memory, with

varying attentional resources devoted to the prospective memory task within the monitoring period. Similarly, Burgess and Shallice (1997) posited that the monitoring required within a prospective memory task would necessitate the involvement of the 'supervisory attentional system', to coordinate the prospective memory task with ongoing activity. Moreover, Graf and Uttl (2001) questioned whether a completely different set of cognitive processes and structure would be required to underpin prospective memory, separate from those required for retrospective memory.

1.1.4.3 What is the neuroanatomical basis of prospective memory?

As prospective memory is a multicomponent process (Dobbs & Reeves, 1996; Graf & Uttl, 2001; Burgess & Shallice, 1997), it is perhaps unlikely that it will be located to one specific neuroanatomical location. Several groups have found the frontal lobes to be involved in prospective memory (McDaniel *et al*., 1999; Burgess *et al*., 2001; Burgess *et al*., 2003; Kesner, 1989). Within the frontal lobes, performance on a prospective memory task has been associated with activation of the medial and lateral prefrontal cortices (Kesner, 1989; Burgess *et al*., 2003). Burgess *et al*., (2003) found evidence for two different sets of neuroanatomical sites to mediate maintenance of an intention and the realisation of a prospective memory task. Using PET imaging, they found an increase in activation of the frontal pole (Brodmann's area 10) bilaterally, right lateral prefrontal and inferior parietal regions, and the precuneus in the maintenance of an intention. They found activation in the thalamus and a decrease of activation in the right lateral prefrontal cortex.

This association between prospective memory and the prefrontal cortices is not surprising, perhaps, considering its probable reliance on planning and organising abilities. The hippocampus, also, is said to play a role in prospective memory (Cohen & O'Reilly, 1996; Ferbinteanu & Shapiro, 2003). McDaniel *et al.* (1999) suggest that this may be primarily because of its role in remembering the content of the prospective memory task. West *et al*., (2000) went on to report that neural activity associated with the prospective and retrospective components of prospective

memory can actually be dissociated using event-related brain potentials, supporting the claim that prospective memory is interrelated with retrospective memory, but that they are dissociable neuropsychological constructs.

Critics may suggest, however, that any memory task may involve frontal lobe functioning, to monitor and guide encoding and retrieval. Cockburn (1995) described a case study of a 45 year old woman with bilateral frontal lobe infarcts, who had intact retrospective memory, but demonstrated poor planning, initiation and inhibition, leading to impaired prospective memory performance. Cockburn's (1995) case study demonstrates eloquently the dissociation between the executive functioning and retrospective memory in prospective memory.

1.1.4.4 Summary

Prospective memory is certainly a multicomponential process (Dobbs & Reeves, 1996; Graf & Uttl, 2001; Burgess & Shallice, 1997), but what the processes are, or what they are termed, differ according to the researcher and their theoretical slant (Craik & Kerr, 1996; McDaniel & Einstein, 1992; Einstein & McDaniel, 1996; McDaniel, 1995; Dobbs & Reeves, 1996). Generally, prospective memory can be described as having three core stages. Firstly, the formation of a future intention. Secondly, remembering the intention during an intervening period and, thirdly, to perform the intention at the right time. Prospective memory appears to be associated with more diffuse neuroanatomical areas. Several studies, however, have reported the importance of the frontal lobes (McDaniel *et al.*, 1999; Burgess *et al.*, 2001; Burgess *et al.*, 2003; Kesner, 1989) and the hippocampal formation (Cohen & O'Reilly, 1996; Ferbinteanu & Shapiro, 2003; McDaniel *et al.*, 1999).

1.2 Memory and normal ageing

1.2.1 Normal ageing

'Normal ageing' theories of higher cognitive functioning suggest changes in cognitive function are part of the life span and not because of any disease process (Small *et al*., 2002). Some theorists believe, however, that 'normal ageing' is just the start of the downward trajectory into mild cognitive impairment, before developing dementia (Brayne & Calloway, 1988). Out of all of the higher cognitive functions, Small *et al.* (2002) suggested that it was memory that was the most sensitive to the ageing process. They used an fMRI method to depict the basal metabolism of subregions of the hippocampi, which assumes that subregions with lower basal metabolisms are dysfunctional. They found quantitative differences between the patterns of hippocampal metabolism in healthy younger adults and healthy older adults. They reported that basal metabolism, and therefore function, decreases with age in two hippocampal subregions: the subiculum and the dentate gyrus, and, in some older adults, reduces further in the entorhinal cortex. When patterns of basal metabolism were compared with performance on cognitive assessment, performance on the memory assessments was found to be correlated with hippocampal basal metabolism.

Small *et al.* (2002) acknowledged that 'normal ageing' is a concept which is difficult to test empirically as older adults tend to be more susceptible to disease processes. This methodology also involves assuming that lower metabolism infers dysfunction, a possibly incorrect assumption, as low metabolism and poor performance may both be triangulated by a third, or more, unidentified factor(s). Furthermore, their study involved two participant samples that had very different age ranges. The younger adults' ages ranged from 21 to 62 years, whereas the older adults' ages ranged from 71 to 88 years. This imbalance in age ranges may have led to incorrect assumptions about the differences between the two samples. Furthermore, Sliwinski *et al*. (2003)

found, when using a longitudinal approach, that preclinical dementia made a large contribution to what we consider to be 'normal ageing'.

1.2.1.1 What is the neuroanatomical basis of 'normal ageing'?

It has long been accepted that aging is associated with a reduction in brain volume (Haug, 1985; Kemper, 1994; Morrison & Hof, 1997; Uylings *et al*., 2000). It is thought that this reduction in volume is not because of neuronal loss (Kemper, 1994), but a consequence of cell shrinkage, dendritic regression and reduction in synaptic density (Tisserand & Jolles, 2003). This volumetric reduction is not consistent over the brain, however, but larger in specific areas (Tisserand & Jolles, 2003).

A large proportion of the neuroimaging research has sought to identify the neuroanatomical basis of the effects of normal ageing on memory and, thus, the focus has predominantly been on the structures of the medial temporal lobe (MTL) (Tisserand & Jolles, 2003). A volume reduction has been found in the MTL structures (Murphy *et al*., 1996; De Leon *et al*., 1997; Raz *et al*., 1997; and Jack *et al.*, 1992). These findings, however, have not been consistent across all studies, as some fail to find any age-related volumetric change in the hippocampus or surrounding areas of the MTL (Grady & Craik, 2000; Greenwood, 2000; Tisserand & Jolles, 2003). Good *et al*. (2002) scanned 465 normal ageing adults using magnetic resonance imaging methods and analysed the volume of each voxel (unit of brain volume) of their brains. They found ageing was associated with a linear decrease in grey matter volume and some areas of accelerated loss. These were: the insula, superior parietal gyri, central sulci, and cingulate sulci. Small or no differences were found in the amygdala, hippocampi, or entorhinal cortex, providing support for the claim that there are minimal age-related changes in the MTL.

There is increasing evidence, however, for a 'frontal ageing hypothesis' (Greenwood, 2000), with age-related volumetric decreases found in the prefrontal cortex (Logan *et al.*, 2002; Grady & Craik, 2000; Coffey, 1993; Cowell *et al*., 1994; Raz *et al*., 1997; Tisserand *et al*., 2001). The frontal ageing hypothesis supposes that the frontal cortex

is disproportionately sensitive to age-related deterioration (Greenwood, 2000), leading to a reduced performance on tasks that require executive processing.

Ohnishi *et al*. (2001) found that in their comparison of 92 normal ageing older adults with 26 older adults with mild-moderate dementia of the Alzheimer's type (DAT), the normal ageing older adults demonstrated selective age-related decline in the prefrontal cortex, insula, anterior cingulate gyrus, superior temporal gyrus, inferior parietal lobe and precuneus. The older adults with DAT demonstrated volumetric reductions in the hippocampus and the entorhinal cortex bilaterally, providing evidence, perhaps, for the frontal ageing hypothesis and against the hypothesis that hippocampal volume reduces in normal ageing.

Critics of the Ohnishi *et al.* (2001) study may suggest that the unequal groups, with relatively low subject numbers, may have led to an inaccurate evaluation of brain differences. Furthermore, Tisserand and Jolles (2003) criticised volumetric analyses that are based on cross-sectional studies, as, they suggest, their findings are of limited use when considering age-related changes. Without a longitudinal design, one cannot exclude the possibility of idiosyncratic pre-morbid differences. They also describe the importance of the effect of gender on age-related structural change studies. They state that males tend to demonstrate greater volumetric reduction than females (Tisserand & Jolles, 2003). They state that this must be taken into account when interpreting the results of volumetric analyses of brain structure in ageing, which Ohnishi *et al*. (2001) failed to do.

Several authors have criticised the 'frontal aging hypothesis', stating that the frontal cortex is only one of a number of neuroanatomical areas to be affected structurally and functionally by ageing and that intact cognitive functioning requires intact functioning of many cortical areas (Greenwood, 2000; Rubin, 1999; Braver *et al*., 2001). Moreover, some suggest that a locationist perspective underestimates the complexity of interconnections within the brain and believe a network or connectivist approach to be superior in explaining age-related deficits (Greenwood, 2000).

1.2.1.2 Summary

'Normal ageing' is a debatable construct, but characterises the (at least, initially) benign changes in neuropsychological functioning that are associated with getting older (Small *et al.,* 2002). These include a linear decrease in grey matter volume (Haug, 1985; Kemper, 1994; Morrison & Hof, 1997; Uylings *et al*., 2000) and some areas of accelerated loss. These are: the pre-frontal cortex (Logan *et al.*, 2002; Grady & Craik, 2000; Coffey, 1993; Cowell *et al.*, 1994; Raz *et al.,* 1997; Tisserand *et al.*, 2001), the insula, superior parietal gyri, central and cingulate sulci (Good *et al*., 2002).

1.2.2 Retrospective memory and normal ageing

Substantial deficits in retrospective memory are associated with normal ageing, mostly in the declarative memory system and, specifically, in episodic memory (Backman, Small & Wahlin, 2001; Craik & Jennings, 1992; Hultsch & Dixon, 1990). Nilsson (2003) discussed the divergence between cross-sectional and longitudinal studies of the effect of age on memory. Cross-sectional studies suggest that memory deteriorates, gradually and linearly, whereas longitudinal studies suggest that memory abilities remain relatively stable until past middle age, when memory steeply deteriorates (Ronnlund *et al*., 2000). Nilsson (2003) used a longitudinal design, as described in Nilsson *et al*. (1997) to study the effect of age on Tulving's (1987, 1991) five memory functions (procedural memory, perceptual representation system, semantic memory, working memory and episodic memory). The study had four different sample groups (recruited a few years apart), which had 1000 participants in groups 1 – 3 and 600 participants in group 4. Nilsson (2003) concluded that there was a clear age effect demonstrated on tasks assessing episodic memory, but not on tasks assessing procedural memory, perceptual representation system, semantic memory or working memory.

A major criticism of this work is its limited reproducibility. Nilsson *et al.* (1997) do not describe the method they use to assess the different memory functions. They do

not cite standardised tests or provide examples of any idiosyncratic testing materials, thus making their work impossible to duplicate. Furthermore, Nilsson (2003) describes the exclusionary criteria for the study as being: 'severe visual or auditory handicaps, mental retardation or dementia, and a mother tongue other than Swedish'. They do not exclude other people with history of head injury, neurological, medical or systemic conditions, psychotropic medication use or psychological/psychiatric disorder, all of which could interfere with memory functioning.

Longitudinal studies are particularly useful when examining which factors have a significant effect on cognitive ageing. Deary *et al*., (2004) assessed 784 people who took part in the Scottish Mental Surveys, two IQ-type tests carried out on all Scottish 11-year-olds in 1932 and 1947, and found evidence to support the stability of psychometric intelligence differences across the life span. Moreover, they found that childhood IQ was an important factor influencing adult performance on cognitive testing, which, they argue, may provide support to the cerebral reserve hypothesis of cognitive ageing. The cerebral reserve hypothesis suggests that people with higher IQs have a greater buffer against brain disease or injury, and thus less vulnerable to pathological ageing processes. Some may argue, however, that those with higher IQs have further to fall before their performance is considered to be pathological, despite the presence of a disease process.

Evidence suggests older adults tend to perform less well on standard laboratory memory assessments, such as free recall, cued recall and recognition memory for word or sentence learning, as well as on tests with a greater purported ecological validity (Goodman & Zarit, 1995), such as remembering information from simulated medicine labels (Morrell *et al*., 1989).

Light (1991) discusses and discounts the four main hypotheses of why memory deteriorates with age. These four hypotheses are:

1. Failures of metamemory
2. Defective semantic encoding
3. Failures of deliberate recollection
4. Diminished processing resources.

The term 'metamemory' refers to the knowledge that we have about our own memory, how it works and what helps it to function effectively. The metamemory theory assumes that memory deteriorates with age because we hold erroneous beliefs about our memory or have difficulty using appropriate strategies to help us remember information. Dixon and Hultsch (1983) developed a 120 item questionnaire assessing metamemory across the lifespan, which incorporated eight dimensions. These were: the use of memory strategies; knowledge of memory tasks; knowledge of own memory capacities; attitudes toward own memory: perception of change; activities supportive of memory; memory and state anxiety; memory and achievement motivation; and locus of control in memory abilities. They found that older adults tended to demonstrate less knowledge of memory tasks, memory capacity, memory change and less sense of control of memory abilities. This study, however, was based on a cross-sectional analysis, which limits the utility of its findings. Moreover, the questionnaire's eight dimensions were not found through analysing its latent structure, but were developed *a priori* from theoretical interest and not subject to confirmatory analysis, which may have led to a type I error. This opens the question of how one should operationalise the abstract notion of 'metamemory'.

Little evidence has been found to support this hypothesis of age-related change in metamemory. For example, Goodman and Zarit (1995) found little correlation between measures of memory performance with a measure of metamemory in 93 community-dwelling women, aged 75 years and older.

The semantic deficit hypothesis postulates that our memory changes with age because of a reduced level of semantic processing of the memory trace at the stage of encoding. This may be because of changes in language functioning or difficulties with encoding. Little evidence, again, has been found to support this hypothesis as the basis of age-related memory decline (Light, 1991).

Deliberate recollection is the conscious recall of declarative information. Older adults tend to have most difficulty with this type of recall, as demonstrated in verbal fluency tasks, confrontation naming and tip-of-tongue phenomena. Older adults appear to be as good as their younger counterparts, however, on indirect assessments of memory, when non-conscious recall is required, such as in perceptual learning or classical conditioning paradigms. The unknown theoretical underpinnings of such difficulties are discussed within a potential 'multiple memory systems' model, which assumes the degeneration of one system (namely declarative) and the preservation of another (namely non-declarative; Light, 1991).

The reduced processing resource hypothesis suggests that reduction in more basic cognitive processing accounts for the age-related changes in memory, perhaps because of a reduced attentional or working-memory capacity, or an overall reduction in speed of information processing. Proponents of this hypothesis include Salthouse (1996) and Rabbitt (2005). Salthouse (1996) believes slowed processing speed to be the superordinate factor dominant in age-related cognitive changes. He suggested that a slower execution of cognitive operations and a loss of information from earlier processing impair older adults' cognitive performance.

Studies have suggested some support for a global age-related change in cognitive function, with evidence of a decrease in speed (Salthouse, 1996) and executive functioning (Zacks *et al*., 2000) with increasing age. The evidence, however, is at times ambiguous and peppered with conceptual or methodological flaws. Conceptual flaws include the operationalisation of 'processing': what is it and what cognitive functions does it include? (Light, 1991). Salthouse (1988) suggests processing encompasses speed of processing, attention and working memory, whereas others

have debated whether speed of processing is itself a cognitive function, or a mediator of functions (Light, 1991). Furthermore, can one dissociate speed, attention and working memory? Some theorists, such as Baddeley (1986) suggest that attention and working memory are interdependent and cannot be dissociated. Methodologically, although evidence has been found to suggest that older adults' processing speed is slower, this has not been found to be the sole cause of memory differences in old age (Salthouse *et al*., 1988).

This global age-related change in cognitive function hypothesis can be contrasted against the patterned age-related change hypothesis, which suggests that some areas or functions are differentially affected. Perhaps resolving this dichotomous viewpoint, Rabbitt (2005) suggests that on top of global age-related change, some cognitive skills' changes may occur earlier and be more severe than others; namely, executive functioning. Rabbitt (2005) summarised some research by Duncan and colleagues (Duncan *et al*., 1995; Duncan & Owen, 2000 and Duncan *et al*., 2000) that illustrated that older adults tend to perform more poorly on tests assessing executive functioning and, using fMRI, these tasks tend to be associated with activity in the mid-dorsolateral, mid-ventrolateral and dorsal anterior cingulated cortex, suggesting that functioning in these areas is affected by ageing.

Naveh-Benjamin *et al*. (2003) list two further hypotheses of why memory deteriorates with age. These are:

1. Failure of inhibitory processes
2. The associative-deficit hypothesis.

The inhibitory process failure hypothesis proposes that older adults may be more distracted at the stage of encoding, because of inhibitory processing failures, leading to poorer recall later, compounded by a failure of inhibitory processes to inhibit irrelevant information, causing further distraction. Mather and Carstensen (2003) reported that older adults tend to have better recall of positive emotions and events linked to them than negative emotions and events linked to them. Mather and

Cartensen (2003) suggest that this 'positivity effect' may be associated with a change in cognitive control mechanisms abilities, caused by increasing age, leading to biased recall.

The associative-deficit hypothesis refers to how older adults appear to demonstrate difficulty in linking unrelated attributes into a cohesive unit. The associative-deficit hypothesis may be associated with the theory of reduced processing abilities (Light, 1991), however, as difficulty in linking unrelated attributes into a cohesive unit may be caused by a failure to hold several unrelated attributes in mind at one time, a failure of working memory.

1.2.2.1 Summary

Retrospective memory deteriorates with age, particularly episodic memory (Backman, Small & Wahlin, 2001; Craik & Jennings, 1992; Hultsch & Dixon, 1990). None of the above theories, either alone or in combination, provides a sensitive or comprehensive account of why retrospective memory deteriorates with age (Light, 1991). The exact reason or reasons, however, for the decline in retrospective memory associated with healthy ageing remains to be agreed (Light, 1991), but, perhaps, it is likely to reflect the systemic and dynamic nature of ageing on attention, memory and executive functioning domains (Winocur *et al.*, 2007).

1.2.3 Prospective memory and normal ageing

In Craik's (1986) functional model of age differences in memory, he suggested that as memory tasks become less automatic and more dependent on self-initiation, they become more difficult and vulnerable to age-related decline. Craik (1986) described prospective memory as being more dependent on self-initiated activity than retrospective memory, and thus postulated that it was therefore more prone to age-related memory impairment than retrospective memory. Maylor (1996) summarised Craik's (1986) functional account of age differences in memory tasks (Table 1.1).

Table 1.1: Maylor's (1996) Summary of Craik's Functional Account of Age Differences in Memory Tasks (adapted from Craik, 1986).

Task	Environmental Support	Self-Initiated Activity	Age-Related Differences
Prospective memory	Low	Maximal	Large
Free recall	¦	¦	¦
Cued recall	¦	¦	¦
Recognition	¦	¦	¦
Relearning	¦	¦	¦
Priming	High	Minimal	Small

It has been argued further that within prospective memory itself, time-based prospective memory tasks would be especially affected. This is because, unlike event-based prospective memory, time-based prospective memory is not triggered by an external cue and thus requires greater autonomy and self-initiation (Maylor, 1996). Across time-based prospective memory tasks, however, varying degrees of self-initiation is required, according to the level of environmental support available. A clock, for example, may act as an external cue for some time-based tasks. Indeed, Ellis and Milne (1996) suggest that a time-based task that is associated with a specific time is more likely to be completed than a time-based task that can be done 'at any time'.

Maylor (1998) reported some experimental findings that supported Craik's (1986) hypothesis. She stated that although older adults do not show an age-related difference on prospective memory tasks outside the laboratory, they make more use of external environmental support, e.g. diaries, alarm clocks, etc., which improves their performance by reducing the amount of self-initiated activity. She also reported, however, that within the laboratory, where the use of external environmental support is controlled, there is less evidence for Craik's theory. In Einstein and McDaniel's (1990) study of prospective memory across the life span, participants were asked to memorise a list of words and later recall these. They were also asked to press a

keyboard key every time they were presented with a word from a specific list. No age-related differences were found on the prospective memory task, but were found on the retrospective memory task. The methodology of the Einstein and McDaniel (1990) paper can be criticised for basing their findings on performance on one prospective memory test, rather than a compendium of tests, which may provide a more sensitive analysis of prospective memory performance. Their findings, however, may suggest a minimal age-related difference on event-based prospective memory tasks.

In contrast, however, Maylor (1993, 1998) found clear evidence for age-related differences in performance on event-based prospective memory tasks. She reported that when asking participants to name 30 famous people four times over an hour and to respond to two targets (beard and pipe) by marking the trial number on the response sheet, older participants marked significantly less trial numbers than the younger participants. It is possible that poorer performance is associated with forgetting the task demands and thus a factor of retrospective memory rather than prospective memory. Maylor (1998) reports, however, that most could remember the instructions, but simply forgot when to perform the task, suggesting impaired prospective memory and intact retrospective memory.

Maylor (1998) attempted to reconcile the contrasting findings as to whether or not aging is associated with a reduction in prospective memory performance by suggesting that the findings were dependent upon the age of the control group. Einstein and McDaniel (1990) compared very young adults to older adults, whereas she compared middle-aged adults to older adults. She suggested that prospective memory performance across the life span may fit an inverted U-shape. Her hypothesis was supported by Mantyla and Nilsson (1997) who found evidence that middle-aged adults were better at a prospective memory performance than younger adults and older adults, but not Maylor (1998) who found a general decline in event-based prospective memory across adulthood. The contrasting findings of Einstein and McDaniel (1990) and Maylor (1993) may also be explained, however, by variations in the difficulty of the background distracter task used during the

prospective memory assessment. More demanding background distracter tasks may be associated with poorer prospective memory task performance (Maylor, 1998). The findings of Mantyla and Nilsson (1997) and Maylor (1998), who used the same distracter tasks with all age groups and still found age-related differences, may suggest that the background distracter task is not the crucial factor in accounting for these differences. Their findings have been based on comparing performance on non-standardised idiosyncratic tests with minimal ecological validity. Perhaps using a larger compendium of ecologically valid prospective memory assessments, which has been standardised, using healthy participants across the life span, would shed light on how, if at all, prospective memory changes with age.

Salthouse (1991) suggests further reasons why prospective memory should deteriorate with age. He states that basic neuropsychological processing resources, such as speed of information processing, attention and working memory capacity, reduce with age. With decreasing basic processing resources, complex higher order functions, such as memory, are likely to be exponentially affected because they function as a factor (though not exclusively) of the basic neuropsychological processes. We can predict, therefore, that ageing processes will impact on memory functioning, if basic processing resources are compromised.

Maylor (1996) and Craik and Kerr (1996) argued further that any changes in attention and executive functioning with age would affect prospective memory tasks more negatively than retrospective memory because of their inherent necessity to switch attention in such task within the interval period between the foreground and prospective task. Some studies seem to support this hypothesis. Kliegel *et al*. (2003) reported that, in their study, performance on a prospective memory task is associated with performance on measures of executive functioning. Furthermore, Logie, Maylor *et al*. (2004) found that prospective memory performance was disrupted significantly by a concurrent working memory load.

In contrast, errors of omission and commission are more frequent in the older adult population, which Maylor (1996) suggests may be because of reduced reality

monitoring and output monitoring. Reality monitoring, the ability to dissociate between real and imagined events, and output monitoring, the ability to remember what one has done and what one hasn't done, are both known to deteriorate with age (LaVoie *et al*., 2006; Cohen & Faulkner, 1989; Koriat *et al*., 1988).

In summary, therefore, increasing reliance on self-initiation, reduced processing resources and reduced reality and output monitoring would suggest that prospective memory performance may be affected negatively by ageing.

Most studies of ageing effects on memory are concerned with retrospective memory, so few studies examining age-related changes in prospective memory have been published. A recent meta-analysis of age effects on prospective memory suggested that older adults tend to perform less well than younger adults on prospective memory tasks in laboratory settings (Henry *et al*., 2004). A possible confound of the Henry *et al*. (2004) meta-analysis, however, is the inclusion criterion which states that studies were only included if they had a research design that compared healthy young with older groups. They did not separate young, middle and older groups, perhaps missing the hypothesised inverted U-shaped function of prospective memory performance across the life span. Furthermore, they did not take any steps to avoid the 'filing cabinet' effect on meta-analyses, which refers to when only published studies are used, leading to a publication bias on the selection of papers for review.

Huppert *et al*. (2000) reported also that prospective memory ability decreases with age. They examined the prevalence of prospective memory impairments in the older adult population by assessing 13,009 older adults aged 65 years and above. They found that only 54 per cent of this sample achieved the event-based prospective memory test that they had designed. They explored the risk factors associated with poorer performance on prospective memory tasks using a logistic regression analysis and reported that these were: male sex, less years in education and lower socio-economic status. These demographic factors are also known to be associated with performance on the Mini-Mental Status Examination (MMSE). They suggested that this had huge implications for the safety and well-being of many older adults at

home. An obvious flaw to their study's design, however, is that their classification of prospective memory ability was dependent on performance on one task, rather than a comprehensive assessment of the older adult's ability based on their performance on several prospective memory tasks. Furthermore, the risk factors listed seem to be social factors and not neuropsychological or physical factors. This may suggest that these studies have methodological limitations, where only the more able or more literate are able to participate in the cognitive assessment.

The converse has been found, however, on tests with greater ecological validity, those in more naturalistic settings (Moscovitch, 1982; Moscovitch & Winocur, 1992). On such naturalistic tests, older adults tended to perform better than younger adults. Einstein *et al*. (1995) found that these age benefits on naturalistic prospective memory tasks were only with time-based tasks, however, and not on event-based tasks. Henry *et al*. (2004) suggested several possible reasons for such a disparity between performance on laboratory assessments and naturalistic paradigms: older people may have more experience of time management, better knowledge of their own memory abilities and weaknesses, have less demands on their time, more time to plan how to perform a prospective memory task and have more experience of, or be more efficient at using, compensatory strategies. Certainly, Maylor (1996) found evidence to suggest that reliance on external memory aids, to aid prospective memory task performance, increases with age. Interestingly, this increased use of memory aids was the reason why Moscovitch (1982) supposed that older adults would be better at prospective memory tasks than their younger counterparts. Alternatively, older adults may also be more motivated than younger adults to perform well on cognitive assessments than their younger counterparts. Further, instructions for more ecologically valid assessments may be less complex and more familiar, thus leading to improved performance.

Several authors have found evidence of greater age-related decline in prospective memory than in retrospective memory (Cockburn & Smith, 1991; Mantyla & Nilsson, 1997 and Maylor, 1993), whereas other authors find that retrospective memory is affected more by age than prospective memory (Einstein & McDaniel,

1990 and Maylor, 1990). Henry *et al.* (2004) summarised in their meta-analysis that there is more of an age-related decline in retrospective memory, as measured by free recall, than there is in time-based or event-based prospective memory. In addition, the group found greater age effects on event-based, rather than time-based, tasks. These findings seem to contradict the previous suggestion that greater self-initiation will be associated with greater age-related decline (Craik, 1986).

These seemingly contradictory findings may be explained by heterogeneous methodologies. Maylor *et al*. (2002) suggest that the nature of the specific prospective memory task may be the governing variable affecting age-related performance, as they explain that prospective memory tasks vary widely in their demands and how dependent they are on self-initiation. Prospective memory has been assessed within a multitude of different paradigms, e.g. being instructed to watch a film and remember to note the time on each occasion that a specific stimulus appears on the film, or, alternatively, having to remember to ask for a personal item that was given to the researcher to hide at the beginning of the assessment (Wilson *et al.*, 1995).

The varying paradigms include different conditions for meeting the criteria of a 'successful' prospective memory performance. These different conditions include, amongst numerous others, varying interval periods, prompting and repetitive tasks. Various different interval periods are used, which introduces the possibility that shorter interval periods may engage different prospective memory processes than longer interval periods (Craik & Kerr, 1996). Prompting may or may not be used in eliciting the prospective memory trace and associated action; is this still an assessment of prospective memory, or should it be considered a function of retrospective memory, when the need to remember the conditions for action are removed? Prospective memory tasks that have to be repeated also require different processing than one-off prospective memory tasks, which may affect performance on such a task (Craik & Kerr, 1996).

Maylor *et al.* (2002) states that there is anecdotal evidence that people tend to consult their doctors first because of their relatives' prospective memory failures, not their retrospective memory failures. This may suggest, therefore, that prospective memory failures are more concerning to people and their significant others than retrospective memory failures, irrespective of their frequency.

1.2.3.1 Summary

There is some evidence that prospective memory deteriorates with age (Huppert *et al.*, 2000). This age difference is more apparent when using laboratory assessments as opposed to more naturalistic assessment paradigms (Henry *et al.*, 2004). It is difficult to ascertain if prospective memory or retrospective memory is more affected by age, because of heterogeneous methodologies (Maylor *et al.*, 2002). Prospective memory errors, however, may be more concerning and salient than retrospective memory errors (Maylor *et al.*, 2002).

1.3 Non-age associated memory decline

1.3.1 Causes of non-age associated memory decline

1.3.1.1 Drug, functional, traumatic and organic

Causes of non-age associated memory decline can be separated into four distinct groups: drug, functional, traumatic and organic (Lezak *et al.*, 2004). Drug causes of non-age associated memory decline include effects of substance misuse. Functional causes of non-age associated memory decline include emotional distress and mental health difficulties, such as anxiety, depression, PTSD and severe and enduring mental illness. Traumatic causes of non-age associated memory decline involve external mechanical force, such as motor vehicle collisions, falls or interpersonal violence (Loring, 1999). Organic causes of non-age associated memory decline include brain disease, which may be caused by genetic disorder (e.g. Huntington's

disease), infections (e.g. meningitis), autoimmune diseases (e.g. AIDS; multiple sclerosis) or degenerative conditions (e.g. dementia of the Alzheimer's type; Wilson, 1999).

Of course, overlap may occur between groups, leading to difficulties making diagnoses or delivering appropriate treatments. In particular, depression in older adults can mimic the symptoms of dementia (a presentation termed 'pseudodementia'), leading to possible misdiagnosis and treatment.

1.3.1.2 Mild Cognitive Impairment

Mild Cognitive Impairment (MCI) is said to be the transitional state between normal ageing and dementia (Burns & Zaudig, 2002). Many people with MCI go on to develop dementia (Petersen *et al*., 1999). Petersen *et al.* (1999) found that 80 per cent of people diagnosed with MCI developed dementia within the following six years. MCI is a term that is used loosely to describe a number of disorders and, because of this, it is a contentious label and its diagnostic criteria have yet to be decided (Rosler *et al*., 2004).

Burns and Zaudig (2002) write that for a strict 'amnestic' mild cognitive impairment the diagnostic criteria are: subjective memory complaints, corroborated by family accounts; impaired memory function for age and education; preserved general cognitive function; intact activities of daily living and no evidence of dementia.

Although the label of MCI may be contentious, such a diagnosis may be useful for a number of reasons. It may validate someone's concerns about a person's memory; identify such clients for monitoring of their cognitive functioning and help promote the fostering of coping skills for any further memory loss. Thompson and Hodges (2002) suggest potential benefits may include: giving the client greater choice and autonomy when making plans for their future care, if needed.

1.3.1.3 Dementia

'Dementia' is a generic term used to describe a loss of intellectual functions, including memory (Scottish Intercollegiate Guidelines Network, 2006). There are several different types of dementia, with different causes. These include dementia of the Alzheimer type (DAT), vascular dementia, dementia with Lewy bodies, frontotemporal lobar degeneration, mixed dementias and Creutzfeldt-Jakob disease (Scottish Intercollegiate Guidelines Network, 2006). Dementia is more common in later life, but can occur in younger people, those under 65 years of age (Directorate of Information and Clinical Effectiveness, 2002). Dementia has an impact on social, family and financial domains, and can be extremely difficult to come to terms with (Brown & Hillam, 2004). Furthermore, the costs of care provision are estimated to be twice that for coronary heart disease and one third more than for stroke (Directorate of Information and Clinical Effectiveness, 2002). In Scotland, the current cost of providing drug treatments people with DAT is £2.94 million per annum (Alzheimer Scotland) and the cost of providing residential care to people with dementia in 2002 alone was £60.9 million (Scottish Executive, 2002).

In people aged over 65 years, DAT is the most frequent cause of dementia (55 per cent). Vascular dementia is the next most common (20 per cent), followed by dementia with Lewy bodies (15 per cent) and fronto-temporal dementia (5 per cent). Other dementias account for the remaining 5 per cent (Directorate of Information and Clinical Effectiveness, 2002).

In people aged under 65, DAT is also the most frequent cause of dementia (34 per cent), followed by vascular dementia (18 per cent), frontotemporal dementia (12 per cent), alcohol-related dementia (10 per cent), dementia with Lewy bodies (7 per cent) and other dementias make up the other 19 per cent (Directorate of Information and Clinical Effectiveness, 2002).

25 million people have a dementia worldwide (Burns & Zaudig, 2002). In Scotland, 64,000 people are affected by dementia. Kapp *et al.* (2007) reported that in the UK

the prevalence of dementia is 1.1 per cent. Over the next 30 years, the prevalence of DAT is expected to triple (Knapp *et al*., 2007; Rosen *et al*., 2002) as over the same period of time, the number of people aged 65 years and over is expected to rise from 12 per cent to 22 per cent in Europe. It is predicted that in Scotland, 100,331 people will have dementia in year 2026 (Alzheimer Scotland, 2006) and 192,000 in year 2040 (NHS Health Scotland, 2003). In Highland alone, 3500 people are predicted to be affected by DAT in the year 2024, nearly doubling the current numbers (Vaughan, 2006).

Hejl *et al*. (2002) described the early symptoms of DAT as being: forgetfulness that interferes with activities of daily living; word-finding difficulties; reduced initiative and interest; and decreased judgement. Brown & Hillam (2004) state that patients typically present with memory loss for recent events and for recently acquired information. Such difficulties may co-exist with language impairment: reduced articulation, fluency and word-finding. Brown & Hillam (2004) also point out that it is often a significant-other, relative or carer who first seeks medical advice, as the person with the difficulties may not be aware of them.

DAT progresses from such early symptoms to complete inability to perform any activities of daily living and eventually the inability to mobilise (Directorate of Information and Clinical Effectiveness, 2002). Lezak *et al.* (2004) describes the progression of cognitive dysfunction from early difficulties, with memory, complex mental tracking and verbal fluency, to mid-stage difficulties of aphasia, apraxia and various agnosias to end-stage difficulties with so many functions that assessment becomes more challenging. This end stage is often associated with partial or complete mutism.

The Scottish Intercollegiate Guideline Network (2006) state that diagnosis of DAT should follow thorough history-taking and differential diagnosis, initial cognitive assessment, screening for comorbid conditions (such as depression), structural imaging and neuropsychological assessment. Diagnosis of Alzheimer's disease, using the DSM-IV (APA, 2000) requires the presence of a memory disturbance and

one or more of the following cognitive disturbances: aphasia, apraxia, agnosia or disturbance in executive functioning, to such a degree that it causes significant impairment in social or occupational functioning domains and represents a change from a pre-morbid level of ability. This cognitive disturbance should have had an insidious onset and gradually worsened. Such difficulties should not be because of another neurological degenerative or systemic condition that could cause dementia, such as HIV, or substance-induced conditions. The symptoms should not be present only within a delirium or be explained better by another axis I disorder, such as schizophrenia.

Clinician accuracy in diagnosis of DAT, when these diagnoses were later confirmed by autopsy, has been found to be as high as 86 per cent (Tierney *et al.,* 1988) and even 100 per cent in a couple of studies (Martin *et al*., 1987). Of course this may suggest that clinical assessment could be specific to DAT, but not sufficiently sensitive. Moreover, Fowler *et al*. (2002) state that by the time such a clinical diagnosis can be made, extensive neuropathology has already occurred with widespread damage to the temporoparietal cortices.

Early diagnosis is useful for symptom delay, using pharmacotherapy to maintain cognitive function at a higher level for longer (Directorate of Information and Clinical Effectiveness, 2002). Early diagnosis may also be useful for cognitive rehabilitation – helping the person with DAT develop compensatory strategies to help them cope with changing cognitive abilities. A recent Cochrane review (Clare, Woods *et al.*, 2005) concluded that there was no firm evidence for the effectiveness of cognitive retraining. They stated that there was insufficient evidence available to evaluate the effectiveness of individualised cognitive rehabilitation, but they had found several reports suggesting that it was helpful. This equivocal evidence to support cognitive rehabilitation may be because Cochrane reviews base their evaluation on randomised controlled trials, which, arguably, individualised cognitive rehabilitation does not lend itself to. Moreover, there is evidence to suggest that those at the earlier or prodromal stages may be the most likely to benefit from some

therapies (Giacobini, 2000). Early diagnosis can also be useful for planning for future care.

There have been attempts to classify the different stages of dementia. The Mini Mental State Examination (MMSE; Cockrell & Folstein, 1988), a commonly used bedside assessment of cognitive functioning, quantifies cognitive impairment as normal, mild, moderate or severe. The MMSE focuses exclusively on cognitive dysfunction, however, and does not reflect functional or behavioural disturbance. Furthermore, performance on this test is affected by educational level. Feldman and Woodward (2005) combined MMSE scores with qualitative descriptions of functional and behavioural disturbance to reflect DAT symptom progression, see Figure 1.2.

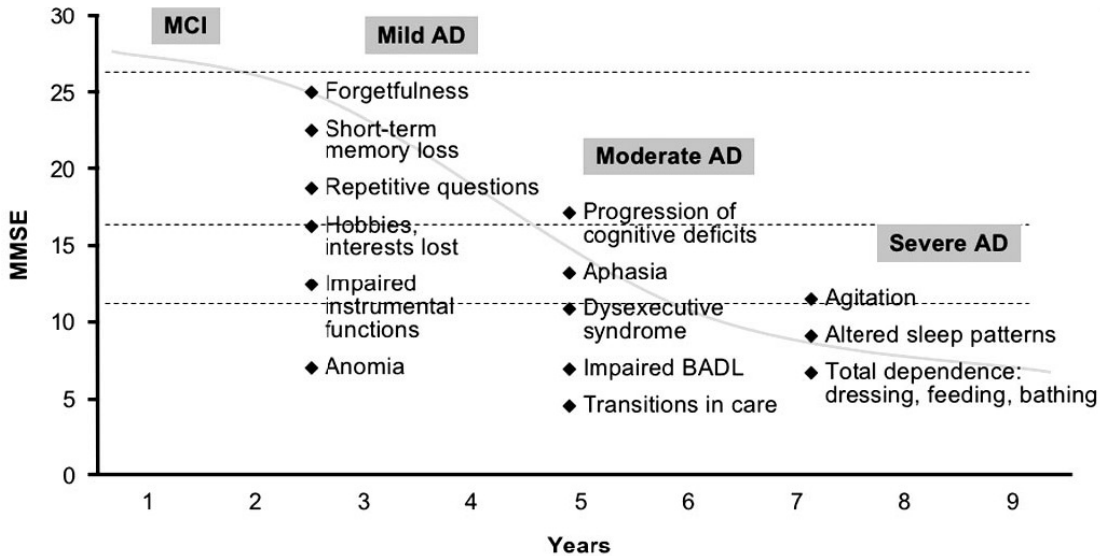

Figure 1.2: Feldman and Woodward's (2005) Portrayal of DAT Symptom Progression, as Quantified by the MMSE. (BADL = basic activities of daily living).

Further tools, specific to dementia, have been developed, such as the Clinical Dementia Rating Scale (CDR; Berg, 1988), the Global Deterioration Scale (GDS; Reisberg *et al*., 1982) and the Functional Assessment Staging Test (FAST; Sclan & Reisberg, 1992), to aid classification of the dementia severity. These assessments are

global assessments, which rate cognitive, functional and behavioural symptoms. The stages of DAT, as quantified by these three tools, are described in Table 1.2.

Table1.2: Stages of DAT, as Classified by the Clinical Dementia Rating Scale, the Global Deterioration Scale and the Functional Assessment Staging Test.

CDR		GDS		FAST	
0	None	1	No cognitive decline	1	No difficulties
0.5	Questionable	2	Very mild cognitive decline	2	Subjective complaints
1	Mild	3	Mild cognitive decline	3	Decreased job functioning; difficulty travelling to new places
2	Moderate	4	Moderate cognitive decline	4	Decreased ability to perform complex tasks
3	Severe	5	Moderately severe cognitive decline	5	Requires assistance in choosing proper clothing for the season or occasion
		6	Severe cognitive decline	6a	Difficulty putting clothing on without assistance
				6b	Unable to bathe properly; will usually require assistance adjusting bath water temperature
				6c	
				6d	
				6e	Inability to handle mechanics of toileting
					Urinary incontinence, occasional or more frequent
					Faecal incontinence, occasional or more frequent
		7	Very severe cognitive decline	7a	Ability to speak limited to about half a dozen words in an average day
				7b	Intelligible vocabulary limited to a single word in an average day
				7c	
				7d	Nonambulatory
				7e	Unable to sit up independently
				7f	Unable to smile
					Unable to hold head up

Katzman (1993) presented a stage model of DAT that is analogous to cancer models, which includes initiating and promoting factors, pre-and postclinical phases of the disorder and its progression (see Figure 1.3).

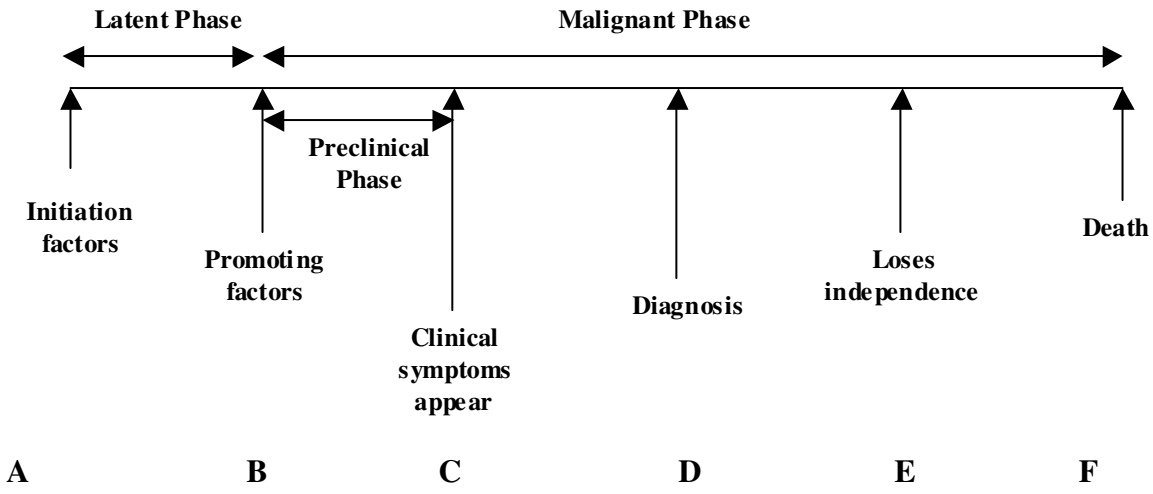

Figure 1.3: Katzman (1993) Model of DAT.

Classification of the stages of DAT, however, can be criticised for being user-friendly caricatures. The dementia process interacts with the person's biological, social and psychological systems, resulting in an individual and unique experience, not easily quantified by generic stage models (Kitwood, 1987). As evidence of several sub-types of DAT have been found, including a early onset sub-type, uni- or bi-hemispheric subtypes, frontal subtype and a parietal or posterior subtype (Lezak *et al.*, 2004), the usefulness of a broad classification tool is minimised further. Moreover, the neuropathology of DAT has been found to be present in vascular dementia (Brown & Hillam, 2004), leading to the possibility that there is greater overlap between these two types of dementia than previously thought, again suggesting that a generic Alzheimer's disease classification tool is of minimal utility.

1.3.1.4 Neuroanatomy of dementia of the Alzheimer type

DAT is characterised by specific neurological and neuroanatomical changes. These include the presence of specific neuropathology, widespread neuronal loss, a reduction in the production of neurotransmitters and a loss of functional synapses (Lezak *et al*., 2004).

DAT is associated with the presence of β-amyloid plaques and neurofibrillary tangles (Lezak *et al*., 2004). It is thought that abnormal processing, of no known cause, of the normal body protein 'amyloid precursor protein' leads to the formation of excess β-amyloid, which aggregates into plaques in extracellular spaces of the cerebral cortex (Brown & Hillam, 2004). These plaques seem to form first in the temporal lobes. Intracellular neurofibrillary tangles are thickened and twisted strands of neural elements within neurons (Loring, 1999), formed from abnormally phosphorylated tau protein, which disrupts cellular architecture and its consequent functioning (Brown & Hillam, 2004). Neurofibrillary tangles are perhaps the most devastating of these two neuropathological cortical lesions (Nagy *et al*., 1995), as hippocampal tangle density is correlated with neuroanatomical pathology in the medial temporal lobe and subsequent memory loss (Smith, 2002; Smith & Jobst, 1996).

Massive cell loss occurs in the temporal lobes, brainstem and thalamus. This leads to an increase in ventricular space and shrinkage of the cortical mantle (Lezak *et al*., 2004). The hippocampus, amygdala, anterior cingulate cortex and the entorhinal limbic system are the worst affected (Bradshaw & Mattingley, 1995).

There is massive cell loss in the cholinergic nucleus basalis of Meynert and the nucleus of the diagonal band complex, leading to dysfunctional modulatory and activating cholinergic input to the hippocampus and other areas (Bradshaw & Mattingley, 1995). Noradrenergic, serotenergic and dopaminergic neurotransmitter modulation is also affected (Bradshaw & Mattingley, 1995).

There is a loss of functional synapses in the midfrontal and lower (inferior) parietal areas, surrounding the temporal lobes. This serves to disconnect the temporal lobe structures from the rest of the cerebral cortex (Lezak, 2004).

1.3.1.5 Summary

Reasons for non-age associated memory decline may be drug, functional, traumatic or organic (Lezak, 2004). Organic causes include mild cognitive impairment and dementia. There are several different types of dementia (Scottish Intercollegiate Guidelines Network, 2006), but DAT is the most common (Directorate of Clinical Effectiveness, 2002). DAT progresses from mild forgetfulness that interferes with activities of daily living (Hejl *et al.*, 2002) to the complete inability to perform any activities of daily living, mobilise or speak (Directorate of Clinical Effectiveness, 2002). Diagnosis using the DSM-IV (APA, 2000) requires the presence of memory disturbance and one of the following: aphasia, apraxia, agnosia or executive dysfunction. Early diagnosis is useful for symptom delay, using pharmacotherapy (Directorate of Clinical Effectiveness, 2002; Giacobini, 2000), and planning of future care. The stages of dementia can be characterised by tools such as the MMSE, FAST, GDS or CDR, but although these stages are user-friendly, they lead to a generic formulation of each individual's difficulties and dementia process and, thus, may be of limited utility. The neurology and neuroanatomy of DAT is characterised by the presence of distinct neuropathology of β-amyloid plaques and neurofibrillary tangles (Lezak, 2004), massive neuronal loss in the temporal lobes, brainstem and thalamus (Lezak, 2004), affecting neurotransmitter function, as well as a loss of functional synapses.

1.3.2 Retrospective memory and dementia of the Alzheimer type

Retrospective memory difficulties can be the first indicator of DAT (Hejl *et al.*, 2002; Brown & Hillam, 2004; Backman, Small & Fratiglioni, 2001). Fox *et al.* (1998) assessed 63 people who were at high risk of developing DAT (because they were blood relations of at least two people who had developed early-onset DAT and

were in five years of their family members' age of onset). They assessed these people twice over a mean time period of four years and found that people who went on to develop DAT within this time frame had significantly lower verbal memory at initial assessment. The findings of this specific study may be, of course, limited to early-onset DAT, rather than DAT generally, but further evidence from other researchers tends to point at early deficits in verbal memory abilities in DAT generally (Bondi *et al.*, 1995; Bondi *et al.*,1999; and Collie & Maruff, 2000).

Elias *et al.* (2000) studied 1076 people aged 65 to 94 who were free from stroke or dementia at baseline, over 22 years, testing their cognitive functioning at least every two years. They reported that measures of retention of information and abstract reasoning were the strongest predictors of development of probable Alzheimer's disease. Performance on these measures of retention of information and abstract reasoning is thought to reflect retrospective memory and executive functioning respectively. Crawford *et al.* (2000) demonstrated a strong association between general cognitive ability and performance on tests of episodic memory, but reported that this relationship is mediated by performance on tests of executive functioning.

Johnson *et al.* (2003) examined such memory difficulties further. They found that people with DAT performed poorly on the Logical Memory subtest of the Wechsler Memory Scale by making errors of omission at immediate recall. The researchers suggest that such errors probably reflect 'difficulty with attentional control rather than with memory *per se*'. Such research suggests that attentional difficulties may be the primary deficit causing the memory problems characteristic of DAT. Linn *et al.* (1995) reported that prodromal people who later develop DAT tend to demonstrate impaired auditory attentional span. Furthermore, Logie, Cocchini *et al.* (2004) found that when they compared people with DAT to healthy older adults and healthy younger adults, only the people with DAT demonstrated a dual task deficit. Some may suggest that such results are an artefact of the increasing difficulty of doing two tasks at once. Logie, Maylor *et al.* (2004) tested this hypothesis, but found that the people with DAT were no more sensitive to a task of varying demand than the healthy older and younger adults. Such attentional difficulties may be a marker of

DAT. Currently, episodic memory failure is considered to be the primary early symptom of dementia (Hejl *et al.*, 2002; Brown & Hillam, 2004; Bondi *et al.*, 1995; Bondi, *et al.*, 1999; and Collie & Maruff, 2000) but it is also common in depression and healthy old age. It may be concluded, therefore, that episodic memory failure is sensitive, but not specific, to DAT. Dual task deficits, however, may be sensitive and specific to DAT (Logie, Cocchini *et al*., 2004).

1.3.2.1 Summary

Retrospective memory difficulties (Hejl *et al.*, 2002; Brown & Hillam, 2004), particularly verbal memory difficulties, may be the first indicator of DAT (Bondi, *et al.*, 1995; Bondi, *et al.*, 1999; and Collie & Maruff, 2000), but such difficulties may be mediated by or triangulated with impaired attentional control or executive functioning (Johnson *et al*., 2003; Linn *et al*., 1995).

1.3.3 Prospective memory and dementia of the Alzheimer type

Jones *et al*. (2006) examined the patterns of retrospective and prospective memory impairment in preclinical DAT. They initially screened 1810 people aged over 75 to identify potential participants and reassessed them three years later. They found that 46 of those had preclinical DAT and compared those to 188 of the apparently healthy-ageing older adults, matching for age and sex. The people with preclinical DAT demonstrated deficits on both retrospective and prospective memory tasks, but performance on the prospective memory tasks made an independent contribution to the prediction of DAT over and above that of retrospective memory. This would suggest that prospective memory is impaired with the onset of the Alzheimer's disease process and performance on prospective memory tasks is not solely dependent upon retrospective memory ability. Although Jones *et al.* (2006) only used one measure of prospective memory, their task, to ask the experimenter to make a phone call at the end of the testing session, was analogous to an everyday prospective memory task and, thus, had higher ecological validity than other more computer-

based tasks, commonly used within the prospective memory literature (Einstein *et al*., 1992; Einstein & McDaniel, 1990; Mantyla, 1994).

Huppert and Beardsall (1993) also examined the nature of the deterioration of prospective memory with the onset of DAT. They found that older adults tend to perform gradually more poorly on prospective memory assessments, but people with minimal DAT performed as poorly as those with mild or moderate dementia (as defined by a clinician's diagnosis), suggesting that there is an abrupt change to prospective memory functioning with the onset, or during the preclinical phase, of DAT. Similarly, the Oxford Project to Investigate Memory and Ageing study found an abrupt neuropathological change, a thinning of the medial temporal lobes, preceded the clinical manifestation of DAT (Jobst *et al*., 1994). Huppert and Beardsall (1993) suggested that the abrupt change to the prospective memory functioning may be caused by the abrupt change to the medial temporal lobes preceding the onset of DAT. They concluded, therefore, that prospective memory assessments may be particularly sensitive to the early stages of dementia and, perhaps, even more so than standard retrospective memory assessments. Huppert *et al*. (2000) suggested that this may be because prospective memory involves, arguably, more components than retrospective memory and, therefore, is more vulnerable to impairment.

Huppert and Beardsall (1993) based their findings on the performance of sixteen people with minimal dementia and five people with mild/moderate dementia on one event-based prospective memory task (and various other cognitive assessments). The study has three subtests of prospective memory, which provides more data for analysis than performance on one test alone, which appears to be the standard in prospective memory studies. The Huppert and Beardsall (1993) study does suffer, however, from low participant numbers, which limits the generalisation of their findings. Moreover, Maylor (1996) questioned the nature of the prospective memory tasks chosen to illustrate prospective memory ability. The tasks chosen were the three prospective memory subtests of the Rivermead Behavioural Memory Test (Wilson *et al*., 1985). Maylor (1996) suggested that as one of these tasks,

remembering to deliver a message, was prompted by the examiner, it could be equally thought of as part of a serial recall test of retrospective memory for a list of actions and, therefore, it should not be considered to be a marker of prospective memory. Data from the other two remaining tasks chosen to assess prospective memory, the 'appointment' and 'belonging' subtests, however, also support Huppert and Beardsall's (1993) findings. Although this side-steps Maylor's (1996) criticisms, two exemplars of prospective memory is still more than is usually used in prospective memory research.

More recently, Driscoll *et al*. (2005) found that healthy older adults who carried the $\epsilon 4$ allele of apolipoprotein E, a known risk factor for DAT, performed less well than healthy older adults without the allele on a task of prospective memory. Their study was based on performance on several prospective memory tasks, but these were all event-based prospective memory tasks, leading to possible inaccurate extrapolations about prospective memory as a whole.

Some of the evidence appears to suggest that with the onset of DAT, people have more difficulty with prospective memory than retrospective memory (Huppert *et al*., 2000). These results seem to mirror subjective experience of people with DAT. Smith *et al*. (2000) used a questionnaire that they had developed to explore retrospective and prospective memory. They found that carers of people with DAT tended to rate the person in their care as suffering equally from prospective and retrospective memory failures in every day life. Subjective opinion of mnemonic function, however, may be influenced by context and saliency (Smith *et al*., 2000). A separate rating in the same study showed that carers felt that prospective memory failures were more frustrating than were retrospective memory failures. It is possible therefore that prospective memory errors may be more salient because of the risk associated with them, i.e., forgetting to take medication, to turn off gas, etc. and therefore more likely to prompt the carer to ask advice from a GP or other medical professional.

Furthermore, prospective memory difficulties in DAT may be because of difficulties in executive functioning. Logie, Maylor *et al*. (2004) argued that if working memory has a key role in monitoring ongoing activities, it should be involved in prospective memory. They compared the performances of 40 young and 40 older adults on two concurrent tasks: either an event- or time-based prospective memory tasks and an arithmetic verification task. They found that prospective memory performance was higher when the arithmetic task was low demand than when it was high demand and younger adults were faster than older adults, but age did not interact with prospective memory task overall. They concluded, therefore, that working memory, and thus executive functioning, is an important factor in prospective memory.

Alberoni *et al*. (1992) reported that people with DAT demonstrated impairments in the central executive component of working memory, which made them less able to coordinate information from different sources. The ability to switch or monitor two different tasks may be considered to be core to prospective memory and this evidence, therefore, may suggest that prospective memory performance in people with DAT may be affected negatively by working memory/executive functioning deficits. Considering that prospective memory is conceptualised as comprising retrospective memory also, which is (by definition) deficient in DAT, it may not be surprising if prospective memory is more damaged by DAT than retrospective memory.

1.3.3.1 Summary

Research suggests that prospective memory may be more vulnerable to damage than retrospective memory with the onset of DAT (Huppert *et al*., 2000). This may be because of several reasons. It may be because prospective memory consists of several components; each one vulnerable to damage associated with the onset of DAT (Huppert *et al.*, 2000) or because it requires working memory, apparently deficient in DAT (Logie, Cocchini *et al.*, 2004). Alternatively, it may be an inaccurate conclusion, derived from weak experimental paradigms (e.g. Huppert & Beardsall, 1993; Driscoll *et al.*, 2005). Experimental paradigms assessing prospective

memory appear to be hindered by the heterogeneous methodologies (Maylor *et al.*, 2002), caused by the lack of a standardised assessment of prospective memory.

1.4 Assessment of memory

Memory can be assessed using both subjective and objective methods. Subjective assessment may consist of self and significant others' reports or 'metamemory' (Dixon, 1989; Smith *et al.*, 2000). Objective assessment may involve laboratory tasks, paper and pencil tests or specific tests of performance in specific areas of functioning (Hertzog *et al*., 1994; McDonald-Miszczak *et al*., 1995). Each will be reviewed in turn.

1.4.1 Subjective assessment of memory

Metamemory awareness of memory functioning comprises awareness of semantic, visual, and spatial memory, episodic and prospective memory, new learning and short-term memory (Efklides *et al*., 2002). Many assessments of metamemory are available, but do not tend to assess all types of memory.

Older adults appear to be similar to younger adults in their accuracy of self-report of their memory abilities. Older adults accurately describe greater difficulty with memory in old age. Furthermore, people who report subjective memory difficulties have been found to have poorer objective memory performance (Wang *et al*., 2000) and be at significantly higher risk of developing dementia (Treves *et al*., 2005; Wang *et al*., 2004; Geerlings *et al*., 1999). Treves *et al*. (2005) found that people who were at a higher risk for developing dementia tended to be less cognitively able and older at initial assessment. In addition, their complaints tended to be more recent in their onset.

The study by Treves *et al*. (2005) was a longitudinal study using patients who were referred to their memory clinic. Longitudinal studies are preferable to cross-sectional

methodologies. Cross-sectional studies tend to predict little correlation between subjective memory complaints and objective memory performance (Schofield *et al*.,1997), and higher correlation with measures of depression (McGlone *et al*., 1990), use of memory strategies and perceived memory strategy efficacy (Brustrom & Ober, 1998). The Treves *et al*. (2005) study is limited, however, as the participants of the study were patients who had been referred to a memory clinic, rather than a community sample, and therefore may have been more likely to have, or develop, memory problems. Schofield *et al*. (1997) aimed to avoid such limitations and assessed 364 nondemented community-dwelling older adults. After cognitive assessment, they categorised their sample into those with cognitive impairment and those without. At this time, more people (47 per cent versus 31 per cent) of people with cognitive impairment reported memory complaints than people without cognitive impairment. After a three year follow-up, those who had memory complaints and baseline cognitive impairment had demonstrated greater deterioration on cognitive assessment, suggesting that memory complaints do predict later cognitive decline (Schofield *et al.*, 1997). Furthermore, people may be aware of a decline in cognitive functioning before such decline can be illustrated using cognitive assessments (Geerlings *et al.*, 1999).

Subjective assessments assess everyday memory functioning and therefore may not correlate highly with objective assessments that are laboratory based cognitive assessments, rather than more ecologically-valid objective assessments, which assess everyday cognitive failures (Manytla, 2003).

This would suggest that there is a preservation of insight or awareness of memory difficulties. This intact insight, however, may also be protective, by motivating or facilitating greater use of external compensatory strategies, such as note taking, to minimise the impact of such deficits (McDonald-Miszczak *et al.*, 1999). It is possible though, that self-report is influenced by the person's context. Carers of people with DAT tend to report fewer memory failures than do people of a similar age who are not caring for someone with dementia (Smith *et al.*, 2000). The authors suggest that

this may be because the carers compare themselves with the person with DAT, or because they have to remember for themselves and for the person in their care.

With the onset of dementia, however, the evidence becomes more ambiguous (Zanetti *et al*., 1999). Some research suggests that there is a direct relationship between subjective and objective measures of neuropsychological functioning in dementia, with reduced insight being associated with poorer performance (Zanetti *et al.*, 1999; McDaniel *et al*., 1995). Other research suggests no relationship between severity of dementia and insight (Efklides *et al.*, 2002). These varying reports may suggest that there is some flexibility in metamemory, until the disease erodes the neuroanatomical areas responsible for this.

1.4.1.1 Summary

Memory can be assessed using both subjective and objective methods. Older adults tend to be as accurate as younger adults in their subjective assessment of memory when compared to objective assessment. In older adults, subjective reports of memory difficulties and evidence of memory disorder, is correlated with later development of dementia (Treves *et al*., 2005; Wang *et al*., 2004 and Geerlings *et al*., 1999). In people with dementia, insight appears to be negatively correlated with dementia severity (Zanetti *et al.*, 1999; McDaniel *et al.,* 1995), but this may not be a unimodal relationship (Efklides *et al.,* 2002).

1.4.2 Objective assessment of memory

There are many neuropsychological assessments that quantify mnemonic performance (the Rey Auditory Verbal Learning Test, the Californian Verbal Learning Test, the Wechsler Memory Scale, the Autobiographical Memory Interview, the Rivermead Behavioural Memory Test, etc.). Older adults consistently perform poorly on standardised objective tests of retrospective memory, including those with greater ecological validity (Light, 1991). No one test, however, has been singled out as being a good early indicator of DAT (Gifford & Cummings, 1999). It

is now increasingly recognised that multiple indicators of cognitive function should be utilised for accurate neuropsychological assessment (Crawford *et al.*, 2003). Moreover, tests chosen to assess cognitive function should be ecologically valid, that is, be analogous to everyday tasks, in order to be predictive and representative of everyday behaviour (Knight, 1992).

Prospective memory has been less well researched than retrospective memory (Kliegel & Martin, 2003; Maylor, 1996). Maylor (1996) suggests that one of the reasons that may explain why there has been little research into prospective memory may be because it is difficult to assess in the research laboratory. Laboratories, rather than naturalistic studies, tend to be used in scientific research because of the possibility of controlling most of the external variables (Maylor, 1996). Prospective memory does not tend to lend itself to artificial paradigms because of its inherent properties of waiting for the right context. Research into prospective memory has been carried out using varying and numerous experimental paradigms (Maylor, 1996). Although there has been a considerable increase in interest into the theoretical underpinnings of prospective memory, there has been little clinical manifestation of this (Wilson *et al*., 2005).

When people complain of memory problems, however, they tend to describe problems with prospective memory rather than problems remembering a list of words, which is the mainstay of most retrospective memory assessments (Wilson *et al.*, 2005). Prospective memory, however, is not often formally assessed, despite being a useful predictor of independence (Wilson, 1991) and employability (Schwartz & McMillan, 1989).

1.4.2.1 Summary

There are many objective assessments of memory available, but no one test has been singled out as a good indicator of DAT (Gifford & Cummings, 1999). Most tests assess retrospective memory only, and not prospective memory. This may be because of the inherent difficulties in assessing prospective memory in the research

laboratory, leading to the development of multiple and noncomparable experimental paradigms (Maylor, 1996).

1.5 Current study

1.5.1 Aim

Prospective and retrospective memory are known to deteriorate with age, and deteriorate further with the onset of dementia, but as previous studies have used idiosyncratic and heterogeneous methodologies, it is not known whether this deterioration in retrospective and prospective memory is equal or how such deterioration is related to insight into mnemonic performance. The aim of this study, therefore, is to explore whether retrospective and prospective memory functioning deteriorate with the onset of dementia, whether they are equal, both in healthy old age and in dementia, and whether insight into memory functioning deteriorates as cognitive functioning deteriorates.

1.5.2 Hypotheses

1.5.2.1 Does retrospective and prospective memory functioning deteriorate with the onset of dementia?

Retrospective and prospective memory are known to deteriorate with age (Backman, Small & Wahlin, 2001; Craik & Jennings, 1992; Hultsch & Dixon, 1990; Henry *et al.*, 2004; Maylor *et al.*, 2002) and deteriorate further with dementia (Hejl *et al*, 2002; Brown & Hillam, 2004; Huppert *et al.*, 2000).

Hypothesis 1: Healthy older adults will perform better than the older adults with cognitive impairment on the objective measures of retrospective and prospective memory.

1.5.2.2 Are retrospective and prospective memory functioning equal in healthy old age?

Both retrospective memory and prospective memory deteriorate with age (Backman, Small & Wahlin, 2001; Craik & Jennings, 1992; Hultsch & Dixon, 1990; Huppert *et al.*, 2000). Some studies have found retrospective memory to deteriorate more (Einsein & McDaniel, 1990; Maylor, 1990; Henry *et al.*, 2004), but other studies have found the opposite: prospective memory deteriorates more (Cockburn & Smith, 1991; Mantyla & Nilsson, 1997 and Maylor, 1993). Maylor *et al.* (2002) suggest these conflicting findings have been caused by heterogeneous methodologies (Maylor *et al.*, 2002).

Hypothesis 2: Healthy older adults will perform similarly on retrospective and prospective memory assessments.

1.5.2.3 Are retrospective and prospective memory functioning equal in dementia?

Research suggests that prospective memory may be more vulnerable to damage than retrospective memory with the onset of DAT (Huppert *et al*., 2000). This may be because of several reasons. It may be because prospective memory consists of several components; each one vulnerable to damage associated with the onset of DAT (Huppert *et al.*, 2000) or because it involves working memory/executive functioning, apparently deficient in DAT (Logie, Cocchini *et al.*, 2004).

Hypothesis 3: Older adults with cognitive impairment will perform differentially on retrospective and prospective memory assessments, performing better on retrospective memory assessments than on the prospective memory assessments.

1.5.2.4 Is insight into mnemonic functioning associated with severity of cognitive impairment?

Older adults tend to be as accurate as younger adults in their subjective assessment of memory when compared to objective assessment. In older adults, subjective reports

of memory difficulties and evidence of memory disorder, is correlated with later development of dementia (Treves *et al.*, 2005; Wang *et al.*, 2004 and Geerlings *et al.*, 1999). In people with dementia, insight appears to be negatively correlated with dementia severity (Zanetti *et al.*, 1999; McDaniel *et al.*, 1995), but this may not be a unimodal relationship (Efklides *et al.*, 2002).

Hypothesis 4: Insight into mnemonic performance will be inversely associated with severity of cognitive impairment.

CHAPTER 2 – METHODOLOGY

2.1 Design

2.1.1 Literature review search strategy

The theoretical assumptions and arguments within this thesis are drawn from a wide range of empirical research findings, gathered through literature searches, personal communication and previous personal research.

2.1.1.1 Literature review

Relevant papers were found using regular literature searches using the OVID databases (Ovid Medline, Books @ Ovid, Journals @ Ovid Full Text, Your Journals @ Ovid, EBM Reviews – Cochrane register of Controlled Trials, EBM Reviews – Cochrane Database of Systematic Reviews, EMBASE and psycINFO), PubMed database, ProQuest Research Library and Google Scholar search engine, using search terms 'memory', 'prospective memory', 'memory for intentions', 'delayed memory', 'delayed intentions', 'remembering a plan of action', 'intention memory', 'remembering intentions', 'realising delayed intentions', 'memory for future actions', 'retrospective memory', 'prospective and retrospective memory', 'insight' 'metamemory' alone and also combined with search terms 'age', 'aging', 'aged', 'old', 'older', 'elderly' and 'geriatric' in all permutations. This search was repeated regularly to identify any new research. It is recognised that this literature search strategy is vulnerable to a bias of detecting published research only, which is why the generic search engine 'Google' was also used, to search for any unpublished data, such as conference proceedings, that may be accessible via the world wide web, although, of course, this does not eliminate the publication bias completely.

2.1.1.2 Personal communication

Personal communication was with Professor Logie, Professor of Human Cognitive Neuroscience and thesis academic co-supervisor, who highlighted several key texts, including 'Prospective memory: Theory and applications' (Brandimonte *et al.*, 1995), studies and authors.

2.1.1.3 Previous research

Previous personal research findings from both published research (Wilson *et al.*, 2005; Foley *et al.*, 2005; and Wilson *et al.*, 2004) and an unpublished pilot study informed this thesis.

This pilot study was submitted to the University of Edinburgh/NHS (Scotland) D.Clin.Psychol. Clinical Psychology Training Course as a Small Scale Research Project. It evaluated prospective and retrospective memory in healthy older adults using objective and subjective assessments. Unfortunately, the time limitations of this project meant that the study was only able to recruit five participants. The pilot study suggested some tentative relationships, but as the number of participants was so low, these relationships must only be considered speculative. The main aim of the pilot study, however, was to explore the feasibility of a larger study into the relationship between subjective and objective assessment of retrospective and prospective memory in a larger sample of healthy older adult and a patient group of people with cognitive impairment. The experimental paradigm appeared to be sensitive to the variables of interest, the older adult participants appeared to find the assessments manageable and it was user-friendly for the researcher. The pilot study allowed, therefore, for the development of a sensitive experimental paradigm.

2.1.2 Current study design

The current study employs a mixed, cross-sectional design, in which a sample of cognitively impaired older adults and a sample of healthy older adults are assessed

using a number of subjective and objective assessments of memory functioning. The independent variable is the presence of cognitive impairment. The dependent variables are objective evaluation of prospective and retrospective memory and subjective evaluation of prospective and retrospective memory.

2.1.3 Ethical considerations

The study examines subjective opinion of memory ability and compares this with actual performance on objective memory assessments. The most pertinent ethical concern, therefore, was whether participants should be informed of how they performed on the assessments. This raised a number of concerns for several reasons and caused some disagreement in the research team, with different members having different, and sometimes polar, opinions.

It was suggested that if the participants knew, in advance, that they would be advised of how they performed on the assessments, this may have introduced a sampling bias and have increased performance anxiety. Healthy older adult participants may have elected to take part because they were concerned about their memory and hope that the assessment will have provided clarification of their abilities or disabilities. As subjectively reported memory problems appear to be correlated with objective problems (Treves *et al*., 2005; Wang *et al*., 2004; and Schofield *et al.,* 1997), this may have led to a sample of supposedly healthy older adults actually having memory problems and thus constituting a poor control group. Furthermore, being told that they will be advised of how they performed may have increased performance anxiety. Anxiety is known to have a deleterious effect on memory and thus this approach may have led to a type I error.

It was emphasised, therefore, on the healthy older adult participant information sheet, and in the advertisement brochure, that the assessments were not diagnostic of any memory or cognitive impairment. Poor performance on the tests may be because of a number of factors, e.g. low effort, not paying attention to or non-compliance with test instructions, anxiety or memory difficulties. Moreover, the test results could not be

used diagnostically in the absence of a full clinical history and wider medical and psychological assessment. The study was for research purposes only and not clinically relevant.

The duty of care of the researcher, however, was also discussed. If an ostensibly healthy older adult performed very poorly on the objective assessments of memory, indicating severe memory difficulties, should the researcher withhold that information? Following guidance from the Research Ethics Committee, it was agreed that should a participant complain to the researcher that they experienced memory or psychological difficulty, or have a profile score less than or equal to 9 on the Rivermead Behavioural Memory Test (suggestive of severe memory difficulties) or score equal or less than 82 on the Addenbrooke's Cognitive Examination Revised (suggestive of severely impaired cognition), they will be advised to speak to their GP to discuss such issues. Furthermore, consent was also sought from all participants at the beginning of the assessment to allow the researcher to contact the participant's GP, if necessary.

Ethical concerns about the capacity to consent were avoided as all of the participants were in the minimal to mild stages of dementia, and able to provide consent. Consent was also gained from a significant other/family member. All of the GPs of the cognitively impaired older adults were informed of the participants' involvement in the research, but details of how they performed were not given unless the participant had given written consent to this.

The study was granted favourable ethical approval from Highland Research Ethics Committee (see appendix 1).

2.2 Materials

Participants were asked to provide some demographic information and to complete five standardised assessments.

2.2.1 Demographic information

Demographic information, on age, sex, level of education, occupation, health status and name and practice of GP, was collected from all participants. In addition, information on diagnosis and name of consultant was also collected from the patient participants.

2.2.2 Standardised assessment

The standardised assessments measured: general cognitive functioning; premorbid level of intellectual functioning; subjective opinion of prospective and retrospective memory ability; retrospective memory and prospective memory respectively. The assessments were:

1. The Addenbrooke's Cognitive Examination Revised (ACE-R; Mioshi *et al.*, 2006)
2. The National Adult Reading Test (NART; Nelson & Willison, 1991)
3. The Prospective and Retrospective Memory Questionnaire (PRMQ; Smith *et al.*, 2000)
4. The Rivermead Behavioural Memory Test (RBMT; Wilson *et al.*, 1985)
5. The Cambridge Prospective Memory Test (CAMPROMPT; Wilson *et al.*, 2005).

Each measure will now be described and discussed in turn.

2.2.2.1 Addenbrooke's Cognitive Examination Revised (ACE – R; Mioshi *et al.*, 2006).

In 2000, John Hodges's team developed the Addenbrooke's Cognitive Examination (ACE; Mathuranath *et al.*, 2000). It is a bedside assessment of cognitive functioning, sensitive to mild dementia. It provides an objective index to differentiate

Alzheimer's disease from fronto-temporal dementia in mild dementia. The ACE incorporates the 30 point Mini-Mental Status Examination, but expands it to 100 points, assessing six cognitive domains: attention, orientation, language, memory, fluency and visuo-spatial ability.

Mathuranath *et al.* (2000) described the validation of the ACE. They reported that out of 210 new patients who attended the Cambridge memory clinic, 139 people met their inclusion criteria and were assessed using clinical, neurological, laboratory, extensive neuropsychiatric and neuropsychological examinations, including the ACE and the Clinical Dementia Rating (CDR) scale. One hundred and fifteen of these people were diagnosed with dementia. Mathuranath *et al.* (2000) compared the performance of patients diagnosed with dementia with those of healthy participants matched for education, age and sex. Mathuranath *et al.* (2000) calculated that the mean performance of the healthy participants minus two standard deviations was 88. This score, therefore, was used as a cut-off score for predicting probable dementia. A further, more sensitive, cut-off score was also calculated. This was done by estimating the probability of diagnosing dementia in the 139 patients. A score of 83 was found to have an optimal sensitivity (93%) at a specificity of 71%. The statistical properties of the ACE appeared to meet the criteria for a useful screening test for dementia, which Gifford and Cummings (1999) describe as being: detecting most of the cases being sought (high sensitivity) and having few false positives (high specificity). The ACE was found to have good construct validity, demonstrating a high correlation with performance on the story recall subtest of the Wechsler's Memory Scale - Revised, the Controlled Oral Word Association Test, the Graded Naming Test and the Rey Complex Figure Test. It has high reliability (Cronbach's alpha = .78) and high sensitivity (93%, using the 88 as the cut-off), which is much better than the Mini-Mental Status Examination, which is used most in clinical practice, despite its low sensitivity (Lezak *et al.*, 2004).

In 2006, Hodges and his team revised the ACE (see appendix 2.1), in order to make the test easier to administer, improve its cross-cultural utility and sensitivity, and produce parallel forms for repeated assessment. This revision is described by Mioshi

et al. (2006). They recruited 421 people with varying types of cognitive impairment (Alzheimer's disease, frontotemporal dementia, dementia of Lewy Bodies and mild cognitive impairment) as well as healthy controls. They modified the memory, fluency, language and visuo-spatial ability domains and these changes were subject to various pilots and several revisions before the final revision was drafted. Mioshi *et al.* (2006) calculated two cut-off scores (88 and 82) for the prediction of dementia. The first cut-off score (88) was found to have better sensitivity (94 per cent), but poorer positive prediction value (89 per cent). The second cut-off score (82) has poorer sensitivity (84 per cent), but better specificity (100 per cent), which is higher than the ACE. Furthermore, it has superior reliability to the ACE, with a Cronbach's alpha of 0.80 (which, statistically, is considered to be very good). Additionally, performance on the ACE-R is correlated with CDR scale ($r = .321$, $p < .001$).

The ACE-R has a few potential drawbacks. In a subtest assessing repetition ability, it asks the participant to repeat the word 'hippopotamus'. In the next subtest, which assesses naming ability, it asks the participant to name accurately a drawing of a rhinoceros. It is possible that the previous repetition of the word hippopotamus primes the participant to respond 'hippopotamus', when presented with the picture of the rhinoceros. Although such an intrusion could be thought of as a perseveration, and may act qualitatively as evidence for the presence of dysexecutive symptoms, it could be interpreted also, perhaps inaccurately, as evidence for difficulty with language and not as a false negative for the 'language-naming' task. Furthermore, the comprehension subtest asks the participant four questions about the objects and animals depicted in the previously seen drawings. Some of the questions could be thought of as assuming an advanced reading age, as it includes words such as 'marsupial' and 'nautical', which are low frequency words. It is possible that errors here might not represent a change in language comprehension *per se*, but perhaps indicate a low level of premorbid intellectual functioning. Moreover, as a screen for dementia, it only has one subtest assessing executive functioning, which is often affected by dementia.

The ACE-R takes around 20 minutes to administer and score. It contains five sub-scores for each of the five domains (attention and orientation having become one domain rather than two): attention and orientation (18 points), memory (26 points), fluency (14 points), language (26 points) and visuo-spatial (16 points). These points add up to 100 points: the maximum score on the ACE-R.

In sum, this test is a sensitive and specific predictor of dementia, which has high reliability and validity. It is easy to administer and takes a relatively little time to provide a comprehensive assessment of cognitive function.

2.2.2.2 National Adult Reading Test, Second Edition (NART; Nelson & Willison, 1991).

This assessment asks the participant to read aloud 50 increasingly difficult irregular words, i.e. those that don't follow the general rules of grapheme–phoneme correspondence, and, thus, the correct pronunciation cannot be reached without previous knowledge of that word. Scoring of this test provides a quick index of reading ability, which is thought to be relatively resistant to the effects of brain pathology and dementia (Nelson & McKenna, 1975): a so-called 'hold' test. As such, it can provide an estimate of the premorbid level of intellectual functioning, to which to compare current levels of functioning.

The NART has high reliability (Cronbach alpha = .93) and the test standardisation suggested that the NART had high validity, as it was demonstrated that dementia had a negligible effect on reading ability (Nelson & O'Connel, 1978). There is some emerging evidence, however, that this test is actually not as resistant to the dementia process as once thought, as performance on the NART is less than demographic data would suggest in mild dementia (MMSE = 14-23; McFarlane *et al.*, 2006). Furthermore, the test should only be used with people aged between 20 and 70, as this was the age range of the standardisation sample. This may mean that assessment of people aged 70 years and over may underestimate their premorbid level of

intellectual functioning. These are two possible confounding variables which must be considered when evaluating the results.

An estimate of premorbid level of intellectual functioning is required for the interpretation of performance on The Cambridge Prospective Memory Test (CAMPROMPT). There are a number of indices of reading ability available on the current market, but this was the index used when developing the normative data for the CAMPROMPT, and, thus, is the most appropriate index to use. This test was selected, therefore, for accurate interpretation of performance on the CAMPROMPT, rather than for its psychometric properties *per se*.

Participants are asked to read aloud the 50 irregular words, although they are forewarned that they are not expected to know all of the words listed. The assessment takes a few minutes only to administer. The tester must be familiar with the correct pronunciations of the words in order before administering the test, in order to score accurately the performance.

2.2.2.3 The Prospective and Retrospective Memory Questionnaire (PRMQ; Smith *et al.*, 2000).

This questionnaire is a self-report measure of prospective and retrospective memory failures in everyday life (see appendix 2.2). It is the only instrument available that assesses subjective opinion of prospective and retrospective memory in equal depth. Other tools, such as the Cognitive Failures Questionnaire (Broadbent *et al.*, 1982), tend to assess subjective opinion of retrospective memory in great detail and ignore prospective memory (Smith *et al.* 2000).

The questionnaire consists of 16 questions. Half of these questions refer to prospective memory failures and half refer to retrospective memory failures. The questions are divided further into event-based/time-based and short-term/long-term memory tasks, with two questions in each of the eight categories (prospective memory/retrospective memory x event-based/time-based x short-term/long-term).

Crawford *et al.* (2003) collected normative data for the PRMQ using 551 healthy participants aged 17 to 94. Using this normative data, they explored the structure of the questionnaire by using ten competing models of latent structure. By using confirmatory factor analysis, they found it to consist of a general memory factor, which all of the items loaded on, and orthogonal specific factors of prospective and retrospective memory. They estimated the reliability of the questionnaire using Cronbach's alpha: .89 for the Total scale, .84 for the Prospective scale and .80 for the Retrospective scale. They calculated mean scores and standard deviations for each of these scales. Age and sex were not found to have a significant effect on performance on the PRMQ.

The participant is asked to answer each of the 16 questions by rating the frequency with which they make the described error, e.g. 'Do you decide to do something in a few minutes' time and then forget to do it?' Answers to chose from are: very often, quite often, sometimes, rarely, never. The questionnaire takes only a few minutes to complete.

2.2.2.4 The Rivermead Behavioural Memory Test (RBMT; Wilson *et al.*, 1985).

The RBMT is a paper-and-pencil test of everyday memory ability. It consists of 12 subtests that are analogous to everyday activities, e.g. remembering names, appointments and faces (Makatura *et al.*, 1999). It is a test of retrospective memory primarily, although three of the subtests assess prospective memory. There is some controversy, however, about whether one of these three subtests is actually a test of prospective memory (Maylor, 1995), or, rather, a test of serial recall of retrospective memory for a list of actions.

Wilson *et al.* (1995) collected normative data for this assessment from 118 healthy participants aged 16–69 years old with a mean IQ of 106 (range 68–136). They calculated the mean performance and established cut-off points for 'mild', 'moderate' and 'severe' memory problems. Wilson *et al.* (1995) assessed the validity

of the RBMT by comparing the performance of people with brain injury with performance on existing tests, subjective ratings from patients and carers and observation by therapists of memory lapses. Subjective ratings of relatives and self-ratings correlated significantly with RBMT scores (Schwartz & McMillan, 1989). Therapists' observations were also found to correlate significantly with performance on the RBMT (r = .70). Thus the RBMT has high criterion and ecological validity. Parallel form reliability ranged from .65 to .85, inter-rater reliability was 1.0 and test-retest reliability (testing one week apart) was .96. Construct validity was lower, with convergent correlation between the Wechsler Memory Scale delayed logical memory (.72) and Warrington Memory Test (.53), but divergent correlation with the Wechsler Adult Intelligence Scale Full Scale IQ (.18). Furthermore, Makatura *et al.* (1999) found the RBMT to be superior to the Wechsler Memory Scale – Revised (Wechsler, 1987) and the Luria Nebraska Neuropsychological Battery – Memory Scale (Golden *et al.* 1985) in assessing everyday memory functioning.

The RBMT provides a screening score and a standardised profile score. The screening score is derived from pass/fail scoring of all of the subtests, whereas the standardised profile score is a composite of the each subtest's score of 0, 1 or 2. The test takes around 25 minutes to complete.

In sum, the RBMT is an ecologically valid and reliable assessment of everyday memory.

2.2.2.5 The Cambridge Prospective Memory Test (CAMPROMPT; Wilson *et al.*, 2005).

This newly developed test is the first standardised objective assessment of prospective memory. This test asks the participant to complete a booklet of distracter paper and pencil puzzles at the same time as remembering to perform six prospective memory tasks. These prospective memory tasks consist of three event-based tasks (i.e. successful completion of the tasks being dependent upon activation of an action when a specific event occurs), such as remembering to tell the examiner to phone the

garage when an alarm sounds, and three time-based tasks (i.e. successful completion of the tasks being dependent upon activation of an action at a specific time), such as remembering to change tasks in seven minutes' time.

The tasks were designed to be analogous to everyday situations to maximise their ecological validity. The test was also found to be highly reliable, with an inter-rater reliability of .99. As expected, a practice effect was detected on test-retest reliability studies, but no significant differences were found between performances on the two parallel forms.

The participant is asked to work on a number of distractor pencil and paper tasks for a 20 minute period. While they are doing this, they are asked to do various tasks, such as reminding the tester of something, either during the 20 minutes or at the end of it. The participant is allowed use any strategy they want to help them remember, such as writing a reminder on the paper provided. Performance is scored on whether they remember to do something, whether this was correct or not, or correct after some prompting. The assessment takes about 25 minutes to complete.

2.3 Participants

The sample drawn was purposive and sought participants for two independent groups: healthy older adults and cognitively impaired older adults.

2.3.1 Healthy older adult participants

Inclusion criteria for the healthy older adults group were: being aged 65 and over; fluent in English; able to read and healthy for age. The exclusion criteria were: history of neurological insult, brain injury or degenerative neurological disease; history of significant psychiatric illness or chronic substance misuse; learning disability; significant visual or hearing impairment; significant physical illness or dyspraxia. Participants were located through the Edinburgh University Department

of Psychology Panel. The panel consists of volunteers who have agreed to be approached to be asked if they would like to participate in psychological research. Participants were remunerated any travel expenses.

2.3.2 Cognitively impaired older adult participants

Inclusion criteria for the cognitively impaired older adults group were: being aged 65 and over; fluent in English; able to read and diagnosed with cognitive impairment by their Consultant Psychiatrist. Participants had been told of their diagnoses, but not all agreed with them. The exclusion criteria were: history of neurological insult or brain injury; history of significant psychiatric illness or chronic substance misuse; learning disability; significant visual or hearing impairment; significant physical illness or dyspraxia. Participants were located through colleagues in the Inverness and Ross-shire Community Mental Health Teams, day hospitals and care homes, Clinical Psychology Service for Older People and the Old Age Psychiatry department of New Craigs Hospital, Inverness, who identified appropriate patients and sought their agreement to participate in the research. These participants all opted to be assessed at home, so did not incur any travel expenses and thus were not provided with any financial remuneration.

2.3.3 Determining sample size and power

Kazui *et al.* (2005) found that healthy older adults performed significantly better than cognitively impaired older adults on the RBMT. This is the closest study to the proposed study, although it evaluates retrospective memory only. The difference between the two groups' mean standardised profile scores was .95, representing a large effect size. G*power, general power analysis program (Erdfelder *et al.*, 1996), was used to calculate the minimum number of participants required to detect a large effect size when using 2-tailed independent *t*-tests. A large effect size and a significance criterion of .05, at power of .80, would predict that to detect a large difference between two groups, a sample size of 19 is required in each group. A total

of 20 people in both groups (healthy older adults and cognitively impaired older adults) participated in the study, thus meeting the conditions for detecting a large effect.

2.4 Procedure

2.4.1 Contacting research participants and obtaining their consent

2.4.1.1 Healthy older adults

The healthy older adult participants' details were provided by the manager of the University of Edinburgh Department of Psychology Volunteer Panel. The principal researcher then contacted each of the potential participants to discuss the research with them, offer a healthy participant information sheet (appendix 3.1) and answer any queries they may have about the research. The potential participants were given at least 24 hours to consider their participation. If the older adult then contacted the principal researcher and agreed to participate, an appointment was made either at the University of Edinburgh Department of Clinical Psychology, or at their home, where they were given a written participation information sheet if they had not had one sent to them and, if they agreed, asked to sign the letter of consent (see appendix 4) and complete the assessments.

2.4.1.2 Cognitively impaired older adults

The cognitively impaired older adult participants were approached initially by their Community Mental Health Team or Psychiatrist, who asked them if they would like to participate in the research and gave them a patient information sheet (see appendix 3.2) describing the details of the study. If they were agreeable to participating in the research, the clinician (e.g. Community Psychiatric Nurse or Psychiatrist) contacted the principal researcher to inform her of that person's contact details. The potential participant was then contacted by the principal researcher to discuss any concerns or

queries that they or their friends/family may have about the research. If the older adult then agreed to participate in the research, an appointment was made either at New Craigs Hospital or their home, according to his/her preference, to sign the letter of consent (appendix 4) and complete the assessments.

2.4.2 Administration of the measures

Participants were administered the five standardised measures consistent with the individual administration protocols. The measures were always given in the same order, so not to advantage or disadvantage any participant: ACE-R, PRMQ, RBMT, NART and CAMPROMPT. Testing took about an hour and a half in total.

Participants were not advised of their performance on the tests. No healthy participants disclosed any concern about their memory or had a profile score of less than or equal to 9 on the RBMT (suggestive of severe memory difficulties) or score equal or less than 82 on the ACE-R (suggestive of severely impaired cognition). One healthy older adult described feelings of grief and loneliness. Some time was spent identifying ways of seeking help and support, and urging her to discuss these feelings with her GP.

Following completion of the tests, participants were thanked for their time and any travel expenses were remunerated. A letter was sent to the GPs of all of the cognitively impaired older adults to inform them of the older adult's participation in the research study (appendix 5). Details of how they performed were not given unless the participant had given written consent to this. The consent forms were stored separately from the test results, so participants could not be identified. Participants were allocated a number written on their test results, ready for entry into a database.

CHAPTER 3 – RESULTS

The analytical strategy will be presented first, followed by a descriptive analysis of the sample characteristics. This will be followed by inferential statistical analyses of the sample data, to determine if the data support the experimental hypotheses and research questions.

3.1 Analytical strategy

The current study examines the differences between retrospective and prospective memory in two groups: healthy older adults and cognitively impaired older adults. Descriptive analyses were performed separately for these two groups, but inferential statistical analyses were performed within and between groups, according to the experimental hypothesis under discussion.

The objective assessments of retrospective and prospective memory have different scoring scales, and thus were not directly comparable. Scores were converted, therefore, into *T* scores, to ease assimilation and allow comparison, as recommended in Crawford (2004), Crawford *et al*. (1998), and Lezak (1995). *T* scores are favoured, over percentiles or *z* scores, as the common metric because 'the graduation between *T* scores is neither too coarse, so that potentially meaningful differences between raw scores are obscured… nor too finely graded, so as to lend a spurious air of precision' (Crawford, 2004). Test scores were converted using the following formula:

$$X\text{new} = \frac{S\text{new}}{S\text{old}}\left(X\text{old} - \overline{X}\text{old}\right) + \overline{X}\text{new}$$

where X_{new} = the transformed score, X_{old} = the original score, S_{old} = the standard deviation of the original scale, S_{new} = the standard deviation of a T score (10), $\overline{X}_{old}$ = the mean of the original scale and $\overline{X}_{new}$ = the mean of the *T* score (50).

These data were analysed using SPSS for Windows (version 11). Statistical tests may be parametric or non-parametric. Parametric tests are more power efficient and robust than their non-parametric counterparts, but their use is restricted to data that are: at least interval level, drawn from a normally distributed population, and where the variances of the two samples are not significantly different (Coolican, 1994; Field, 2005). All data were assessed to determine whether they departed significantly from the assumptions of normality and equal variance.

Normality was assessed using the Kolmogorov-Smirnov test. Although this test may confirm the presence of a significant deviation, it does not indicate whether the deviation is large enough to bias statistical analyses. Data were analysed further, therefore, by assessing the degree of skewness and kutosis present. Skewness and kurtosis indices were converted into z scores, using the following formulae:

$$z_{\text{skewness}} = \frac{S}{\text{SE}_{\text{skewness}}} \qquad z_{\text{kurtosis}} = \frac{K}{\text{SE}_{\text{kurtosis}}}$$

where S = skewness index, K = kurtosis index and SE = standard error. Field (2005) suggests in small samples, data should be considered to be significantly skewed or kurtic if the z scores are greater than 2.58 at $p<.01$. In such instances, the non-parametric tests were used. Unless stated otherwise, all data met the assumption of normality.

Homogeneity of variance was assessed using Levene's test. Similar to the Kolmogorov-Smirnov test, this test may confirm that group variances are significantly different, but does not indicate whether this difference is large enough to bias statistical analyses. Furthermore, parametric tests are considered to be fairly robust when there are equal numbers in each condition and, thus, violation of this assumption is not considered to be too severe (Dancey & Reidy, 2004; Kinnear & Gray, 2000). If the Levene's test is significant ($p<.05$), violating the assumption of equal variances, this violation can be corrected by reporting the parametric test

statistic which does not assume equal variance. Unless stated otherwise, all data met the assumption of homogeneity of variance.

3.2 Descriptive statistical analysis

3.2.1 Total sample

In total, 89 older adults were invited to participate in the study, with 40 agreeing to participate: 20 healthy and 20 cognitively impaired older adults.

3.2.2 Healthy older adult participants

Forty three healthy older adults were invited to participate in the study. Twenty three declined to participate. Twenty one of those who declined were unavailable for participation at that time, and two people stated that they did not wish to take part as they no longer wished to be a member of the Edinburgh University Department of Psychology Panel. Twenty participants, therefore, were recruited. Further demographic information for this group can be found in Table 3.1.

3.2.3 Cognitively impaired older adult participants

Forty six cognitively impaired older adults were invited to participate in the study. Twenty nine of these were invited to participate by the Consultant Psychiatrist in Old Age Psychiatry, by letter, but only four of those who were invited replied. All replies were from people who wished to participate in the study. Eight people were recruited by colleagues in the Clinical Psychology Service for Older People. Four people were recruited from a Ross-shire care home. Three people were recruited by the Inverness and Ross-shire Community Mental Health Teams, but one had to be excluded from the study, as she did not meet the inclusion criteria. A further two people were

recruited from a Ross-shire day hospital. In total, therefore, twenty participants were recruited.

Six of the cognitively impaired older adults had a diagnosis of Dementia of the Alzheimer's Type (30 per cent). Three had a diagnosis of vascular dementia (15 per cent). Diagnoses were not available for the remaining 11 cognitively impaired older adults (55 per cent). Further demographic information for this group can be found in Table 3.1.

Table 3.1: Demographic Characteristics of the Healthy and Cognitively Impaired Older Adults.

Characteristic	Healthy		Cognitively Impaired		Summary Statistics		
	Mean	SD	Mean	SD	*df*	*t*	*P*
Age	73.80	5.87	77.15	5.61	38	-1.84	.073
Predicted Full Scale IQ	122.89	4.51	107.70	11.42	36	5.28	**.0005**
	%	N	%	N	*df*	χ^2	*P*
Age Category					2	4.98	.083
65-74	55	11	25	5			
75-84	45	9	65	13			
85+	0	0	10	2			
Gender					1	0.92	.337
Male	35	7	50	10			
Female	65	13	50	10			
Education					1	5.23	**.022**
High School	20	4	55	11			
Higher/Further Education	80	16	45	9			
Social Class Category					5	7.93	.160
I: Professional	50	10	20	4			
II: Managerial/ Technical	25	5	40	8			
IIINM: Skilled Non-Manual	0	0	5	1			
IIIM: Skilled Manual	0	0	10	2			
IV: Partly Skilled	20	4	10	2			
V: Unskilled	5	1	15	3			

3.2.4 Group comparison

As detailed in Table 3.1, there was a significant difference between the two groups in full scale IQ, as predicted by performance on the National Adult Reading Test (NART; $t(36) = 5.28$, $p < .001$; 2 tailed), and a significant association between participant group and education (χ^2 (1) = 5.23, $p = .022$).

3.3 Inferential statistical analysis

3.3.1 Hypothesis 1: Healthy older adults will perform better than the older adults with cognitive impairment on the objective measures of retrospective and prospective memory.

Retrospective memory was assessed objectively using the Rivermead Behavioural Memory Test (RBMT; Wilson *et al*., 1985). Prospective memory was assessed objectively using the Cambridge Prospective Memory Test (CAMPROMPT; Wilson *et al*., 2005).

These two tests have different scales and, therefore, test scores were converted into *T* scores in order to make performance on these two tests directly comparable. RBMT scores were converted into *T* scores using the profile total mean and standard deviation, as published in Wilson *et al*. (1989). CAMPROMPT scores were converted in to *T* scores using different mean and standard deviations, according to IQ band (above 110, 90-110 or below 90, as predicted by performance on the NART). The mean and standard deviations for the different groups were supplied by the lead statistician involved in the development of the CAMPROMPT (P. Watson, personal communication, 30 May 2007).

Means and standard deviations of the *T* scores of the healthy and cognitively impaired older adults' performances on these two tests can be found in Table 3.2.

Table 3.2: Means and Standard Deviations of the *T* Scores of the Healthy and Cognitively Impaired Older Adults' Performances on the RBMT and CAMPROMPT.

Test	Healthy		Cognitively Impaired		Summary Statistics		
	Mean	SD	Mean	SD	*df*	*t*	*p*
RBMT	43.59	15.14	-39.32	21.37	34.24	14.16	**.0005**
CAMPROMPT	49.34	8.78	29.00	8.97	38.00	7.25	**.0005**

As seen in Table 3.2, the mean performance of the healthy older adults is higher than the mean performance of the older adults with cognitive impairment on the objective measures of retrospective and prospective memory.

The two participant groups differed significantly in mean full scale IQ (as predicted by performance on the NART) and education (as described in section 3.2.4). A one-way analysis of covariance (ANCOVA) was used to partial out any significant effects of these possible covariates. Only data from 38 of the participants were used, however, as two of the healthy older adult participants were not assessed using the NART (once because of experimental error and once because the older adult had reading problems). The data met the assumptions of homogeneity of regression and equality of variance. Unadjusted and adjusted mean *T* scores (following the ANCOVA) are found in Table 3.3.

Table 3.3: Unadjusted and Adjusted Mean RBMT and CAMPROMPT *T* Scores in Healthy and Cognitively Impaired Older Adults.

Test	RBMT *T* scores		CAMPROMPT *T* scores	
	Unadjusted Mean	Adjusted Mean	Unadjusted Mean	Adjusted Mean
Healthy	43.27	41.64	49.61	51.60
Cognitively Impaired	-39.32	-37.85	29.00	27.21

As Table 3.3 illustrates, no significant relationships were found to exist between IQ or education and performance on the RBMT or CAMPROMPT. Independent *t*-tests were used, therefore, to analyse whether there was a statistically significant difference between the mean performances of the healthy older adults and the cognitively impaired older adults, on the measures of retrospective and prospective memory.

As a Levene's test revealed that, for the RBMT *T* scores, the group variances were significantly different ($F(1,38) = 5.12$, $p = .029$), the violation of the assumption of homogeneity of variance was corrected by reporting the test statistic which did not assume equal variances.

On the RBMT, the healthy older adults performed significantly better than the older adults with cognitive impairment ($t(34.24) = 14.16$, $p<.001$; 2 tailed), representing a large sized effect ($r = .92$). Similarly, on the CAMPROMPT, the healthy older adults performed significantly better than the older adults with cognitive impairment ($t(38) = 7.25$, $p<.001$; 2 tailed), representing a large sized effect ($r = .76$).

3.3.1.1 Interim summary

Healthy older adults performed better than the older adults with cognitive impairment on the objective measures of retrospective and prospective memory. Thus, hypothesis 1 has been upheld and the null hypothesis can be rejected.

3.3.2 Hypothesis 2: Healthy older adults will perform similarly on retrospective and prospective memory assessments.

Dependent *t*-tests were used to determine whether there was a statistically significant difference between the mean of the *T* scores of the healthy older adults' performances on the retrospective and prospective memory assessments. These tests revealed that the healthy older adults performed significantly better on the

CAMPROMPT than on the RBMT ($t(19) = 2.09$, p=.05; 2 tailed), representing a medium sized effect ($r = .43$).

The RBMT has 12 subtests, three of which are purported to assess prospective memory (Appointment, Belonging and Message subtests). These three subtests should have been excluded from the RBMT total in order to have a clean measure of retrospective memory. It was not possible, however, to convert RBMT subtotal scores into *T* scores, as subtotal means and standard deviations are not published. Pearson correlations and multiple regression analyses were used, therefore, to elucidate the relationship between the healthy older adults' performances on these three subtests and on the CAMPROMPT. It is recognised, however, that when using powerful multiple regression analyses, it is important to have an adequate sample size. The sample size in this analysis is very small and, thus, all findings should be interpreted with caution.

Pearson correlations revealed a significant relationship between the CAMPROMPT *T* scores and performance on the RBMT Belonging ($r = .52$, $p = .010$; 1 tailed) and Appointment subtests ($r = .42$, $p = .032$; 1 tailed), but not with the Message subtest ($r = .18$, $p = .221$; 1 tailed).

A backward multiple regression analysis was used to calculate the contribution of each of these subtests on healthy older adults' CAMPROMPT *T* scores. A backward method is preferable to a forward one as it is less likely to exclude predictors involved in suppressor effects and thus less likely to make a Type II error (Field, 2005).

Table 3.4: Multiple Regression Model of RBMT Belonging, Appointment and Message Subtests on CAMPROMPT *T* Scores in Healthy Older Adults.

	Summary Statistics			
	B	*SE B*	*β*	*p*
Step 1				
Constant	32.47	6.93		
Belonging	6.10	2.04	0.57	**.009**
Appointment	6.07	2.30	0.48	**.018**
Message	-0.76	3.43	-0.04	.828
Step 2				
Constant	31.39	4.74		
Belonging	5.94	1.85	0.56	**.005**
Appointment	6.03	2.23	0.47	**.015**

R^2 = .49 for Step 1; ΔR^2 = -.00 for Step 2

The model found the scores on the Message subtest to be a poor predictor of CAMPROMPT *T* score and excluded it from the second model, as shown in Table 3.4. In this second model, the association between the criterion and explanatory variables is moderately strong (Multiple R = .70). Together, performance on the RBMT Belonging and Appointment subtests accounted for 48.8 per cent of the variation in CAMPROMPT *T* scores. Both RBMT Belonging and Appointment subtest scores positively related to CAMPROMPT *T* scores. The regression coefficient for performance on the Belonging subtest was 5.94 (95% CI = 2.04 – 9.85) and for performance on the Appointment subtest was 6.03 (95% CI = 1.33 – 10.73). Since the confidence limits did not encompass a negative value, it can be concluded that the population regression coefficients for both performance on the RBMT Belonging and Appointment subtest are positive. Performance on RBMT Belonging ($t(17) = 3.21$, $p = .005$; 1 tailed) and Appointment subtests ($t(17) = 2.70$, $p = .015$; 1 tailed) are both significant predictors of CAMPROMPT *T* score, and both represented large sized effects of $r = .62$ and $r = .55$ respectively. The standardised regression coefficients shown that performance on the Belonging subtest is a stronger predictor of CAMPROMPT *T* score than performance on the Appointment subtest.

Both variables, however, are positively and significantly related to CAMPROMPT *T* score.

This regression model is likely to be generalisable beyond this sample, as the regression model met all of the necessary assumptions of normality, linearity and homoscedasticity, as described by Berry (1993).

3.3.2.1 Interim summary

Healthy older adults did not perform similarly on retrospective and prospective memory assessments. Healthy older adults performed significantly better on the CAMPROMPT, the measure of prospective memory, than on the RBMT, the measure of retrospective memory. The data, therefore, do not support hypothesis 2.

Furthermore, performance on RBMT Belonging and Appointment subtests are both significant predictors of performance on the CAMPROMPT. It can be concluded, therefore, that should performance on these two subtests be excluded from performance on the RBMT total, a greater difference between RBMT and CAMPROMPT scores would be seen, emphasising further the difference in healthy older adults' performances on the retrospective and prospective memory assessments.

3.3.3 Hypothesis 3: Older adults with cognitive impairment will perform differentially on retrospective and prospective memory assessments, performing better on retrospective memory assessments than on the prospective memory assessments.

Dependent t-tests were used to determine whether there was a statistically significant difference between the mean of the *T* scores of the cognitively impaired older adults' performance on the retrospective and prospective memory assessments. Cognitively impaired older adults performed significantly better on the CAMPROMPT than on

the RBMT ($t(19) = 2.09$, p=.050; 2 tailed), representing a medium sized effect ($r = .44$).

As three RBMT subtests (Appointment, Belonging and Message) are purported to assess prospective memory (as described in section 3.3.2), Pearson correlations and multiple regression analyses were used to elucidate the relationship between the cognitively impaired older adults' performances on the RBMT Belonging, Appointment and Message subtests and on the CAMPROMPT.

All cognitively impaired older adult participants scored 0 on the RBMT Appointment subtest, violating the assumption of non-zero variance. It was treated, therefore, as a constant and excluded from the analysis. Pearson correlations revealed no significant relationships between the CAMPROMPT *T* scores and performance on the RBMT Belonging ($r = -.08$, $p = .372$; 1 tailed) or Message subtest ($r = .32$, $p = .088$; 1 tailed).

A backward multiple regression analysis was used to calculate the contribution of the Belonging and Message subtests on healthy older adults' CAMPROMPT *T* scores.

Table 3.5: Multiple Regression Model of RBMT Belonging and Message Subtests on CAMPROMPT *T* Scores in Cognitively Impaired Older Adults.

	Summary Statistics			
	B	*SE B*	*β*	*p*
Step 1				
Constant	27.08	2.72		
Belonging	-0.59	3.25	-0.04	.859
Message	3.18	2.37	0.31	.197
Step 2				
Constant	26.90	2.46		
Message	3.23	2.29	0.32	.175
Step 3				
Constant	30.00	2.01		

R^2 = .10 for Step 1; ΔR^2 = -.00 for Step 2; ΔR^2 = -.10 for Step 3

The model found the scores on the Belonging and Message subtests to be poor predictors of CAMPROMPT *T* score and excluded them from the model, as shown in Table 3.5. In model 1, the association between the criterion and explanatory variables is low (Multiple R = .32). Together, performance on the RBMT Belonging and Message subtests accounted for only 10.1% of the variation in CAMPROMPT *T* scores. The regression coefficient for performance on the Belonging subtest was -0.59 (95% CI = -7.44 – 6.27) and for performance on the Message subtest was 3.18 (95% CI = -1.82 – 8.19). Performance on RBMT Belonging ($t(17) = 0.18$, $p = .859$; 1 tailed) and Message subtests ($t(17) = 1.34$, $p = .197$; 1 tailed) are not significant predictors of CAMPROMPT *T* score.

3.3.3.1 Interim summary

Cognitively impaired older adults did not perform similarly on the retrospective and prospective memory assessments. Cognitively impaired older adults performed significantly better on the CAMPROMPT, the measure of prospective memory, than

on the RBMT, the measure of retrospective memory. The data, therefore, do not support hypothesis 3.

Furthermore, performance on RBMT Belonging and Appointment subtests are not significant predictors of performance on the CAMPROMPT. It can be concluded, therefore, that should performance on these two subtests be excluded from performance on the RBMT total, no further difference between RBMT and CAMPROMPT scores would be seen.

3.3.4 Hypothesis 4: Insight into mnemonic performance will be inversely associated with severity of cognitive impairment.

In this study, insight may be quantified by comparing subjective assessment of memory to objective assessment of memory, to subjective proxy-rating assessment of memory or current level of cognitive functioning. Insight will be quantified using all of these methods, in order to determine any potential relationships between these factors.

3.3.4.1 Subjective assessment

Memory was assessed subjectively using the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith *et al.*, 2000). This questionnaire consists of 16 questions: eight of these questions refer to prospective memory failures and eight refer to retrospective memory failures. Responses (never, rarely, sometimes, often and very often) were quantified from 0 – 4 with increasing number referring to increasingly positive appraisal of mnemonic ability. Means and standard deviations for each group's (healthy older adults and cognitively impaired older adults) self-rated memory ability (total, prospective and retrospective) can be found in Table 3.6.

Table 3.6: Means and Standard Deviations of the Healthy Older Adults and Cognitively Impaired Older Adults Self-Rated Total, Prospective and Retrospective Memory Ability, as Measured by the PRMQ.

Test	Healthy		Cognitively Impaired		Summary Statistics		
	Mean	SD	Mean	SD	*df*	*t*	*p*
Total	42.05	9.46	38.05	12.83	38	1.12	.269
Prospective	21.20	5.16	19.10	7.05	38	1.08	.289
Retrospective	20.85	4.66	18.60	6.31	38	1.28	.207

As seen in Table 3.6, the mean Total, Prospective and Retrospective PRMQ self-ratings of the healthy older adults are higher than those of the cognitively impaired older adults.

The two participant groups differed significantly in mean full scale IQ (as predicted by performance on the NART), and education (as described in section 3.2.4). A one-way ANCOVA was used to partial out any significant effects of these possible covariates. Again, only data from 38 of the participants were used, however, as explained in section 3.3.1. The data met the assumptions of homogeneity of regression and equality of variance. Unadjusted and adjusted mean self-ratings (following the ANCOVA) on the Total, Prospective and Retrospective PRMQ scales are found in Table 3.7.

Table 3.7: Unadjusted and Adjusted Mean Self-Ratings on the PRMQ Total, Prospective and Retrospective Scales of the Healthy and Cognitively Impaired Older Adults.

Test	PRMQ total		PRMQ prospective		PRMQ retrospective	
	Unadjusted Mean	Adjusted Mean	Unadjusted Mean	Adjusted Mean	Unadjusted Mean	Adjusted Mean
Healthy	43.00	41.08	21.72	20.66	21.28	20.33
Cognitively Impaired	38.05	39.78	19.10	20.06	18.60	19.45

As Table 3.7 illustrates, no significant relationships were found to exist between IQ or education and self-ratings on the PRMQ Total, Prospective or Retrospective scales. Independent t-tests were used, therefore, to analyse whether there was a statistically significant difference between healthy and cognitively impaired older adults' self-ratings on the Total, Prospective and Retrospective PRMQ scales.

These tests revealed that there was no significant difference between the healthy and cognitively impaired older adults' self-ratings on the PRMQ Total ($t(38) = 1.12$, $p=.269$; 2 tailed), Prospective ($t(38) = 1.08$, $p=.289$; 2 tailed) or Retrospective scales ($t(38) = 1.28$, $p=.207$; 2 tailed).

3.3.4.2 Interim summary

Healthy older adults and cognitively impaired older adults do not differ in their self-rating of retrospective and prospective memory.

3.3.4.3 Subjective assessment compared with objective assessment

Pearson correlations were also used to determine whether there was an association between healthy older adults' PRMQ self-ratings and performance on the RBMT or CAMPROMPT.

Table 3.8: Correlation Matrix of the Relationship between Healthy Older Adults' Performances on the RBMT, the CAMPROMPT and the PRMQ Total, Prospective and Retrospective Scales.

		RBMT *T* score	CAMPROMPT *T* score	PRMQ Total score	PRMQ Prospective memory ratings	PRMQ Retrospective memory ratings
RBMT *T* score	Pearson Correlation	1	.583	.146	.140	.142
	Sig. (1-tailed)		**.004**	.269	.279	.275
CAMPROMPT *T* score	Pearson Correlation	.583	1	.258	.278	.217
	Sig. (1-tailed)	**.004**		.136	.118	.179
PRMQ Total score	Pearson Correlation	.146	.258	1	.967	.960
	Sig. (1-tailed)	.269	.136		**.0005**	**.0005**
PRMQ Prospective memory ratings	Pearson Correlation	.142	.278	.967	1	.858
	Sig. (1-tailed)	.275	.118	**.0005**		**.0005**
PRMQ Retrospective memory ratings	Pearson Correlation	.142	.217	.960	.858	1
	Sig. (1-tailed)	.275	.179	**.0005**	**.0005**	

Table 3.8 shows the relationships between the performances of the healthy older adults on the RBMT, the CAMPROMPT and the PRMQ Total, Prospective and Retrospective scales. Pearson correlations revealed that there were no statistically significant relationship between RBMT, CAMPROMPT and either Prospective or Retrospective scales on the PRMQ. There were, however, statistically significant

correlations between the healthy older adults' self-ratings on the PRMQ Prospective and Retrospective memory subscales.

Pearson correlations were also used to determine whether there was an association between cognitively impaired older adults' PRMQ self-ratings and performance on the RBMT or CAMPROMPT.

Table 3.9: Correlation Matrix of the Relationship between Cognitively Impaired Older Adults' Performances on the RBMT, the CAMPROMPT and the PRMQ Total, Prospective and Retrospective Scales.

		RBMT *T* score	CAMPROMPT *T* score	PRMQ Total score	PRMQ Prospective memory ratings	PRMQ Retrospective memory ratings
RBMT t score	Pearson Correlation	1	.435	-.301	-.273	-.260
	Sig. (1-tailed)		**.027**	.099	.122	.134
CAMPROMPT *T* score	Pearson Correlation	.435	1	-.425	-.347	-.412
	Sig. (1-tailed)	**.027**		**.031**	.067	**.035**
PRMQ Total score	Pearson Correlation	-.301	-.425	1	.957	.954
	Sig. (1-tailed)	.099	**.031**		**.0005**	**.0005**
PRMQ Prospective memory ratings	Pearson Correlation	-.273	-.347	.957	1	.839
	Sig. (1-tailed)	.122	.067	**.0005**		**.0005**
PRMQ Retrospective memory Ratings	Pearson Correlation	-.260	-.412	.954	.839	1
	Sig. (1-tailed)	.134	**.035**	**.0005**	**.0005**	

Table 3.9 shows the relationships between the performances of the healthy older adults on the RBMT, the CAMPROMPT and the PRMQ Total, Prospective and Retrospective scales. Pearson correlations revealed that there were statistically significant negative correlations between performance on the CAMPROMPT and the

PRMQ Total and Retrospective scales. There were also statistically significant correlations between the cognitively impaired older adults' self-ratings on the PRMQ Prospective and Retrospective memory subscales.

A *post-hoc* reliability analysis of the PRMQ data revealed high Guttman split-half (*r* = .96) and Cronbach's apha (r = .94) reliability coefficients, suggesting the PRMQ has high internal reliability.

3.3.4.4 Interim summary

In the healthy older adults, there were no statistically significant relationships between self-rated memory assessed by the PRMQ and objective memory performance as measured by the RBMT and CAMPROMPT. In the cognitively impaired older adults, there were statistically significant negative correlations between self-rated memory and prospective memory performance, as measured by the CAMPROMPT.

In addition, the prospective memory and retrospective memory self-ratings were significantly correlated and a *post-hoc* reliability analysis revealed that the PRMQ had high internal reliability.

3.3.4.5 Self-rating compared with proxy-rating

Insight can be evaluated further by comparing self-report to proxy-rating. The PRMQ can be completed by both the participant and a significant other to generate self- and proxy-ratings of subjective assessment of memory. Only the significant others of the cognitively-impaired older adults were asked to complete a proxy assessment of the PRMQ. Out of the 20 cognitively impaired older adults, only 17 significant others of these elected to provide proxy assessments. Means and standard deviations for these 17 cognitively-impaired older adults' self- and proxy-ratings of total, prospective and retrospective memory ability can be found in Table 3.10.

Table 3.10: Means and Standard Deviations for Each of the 17 Cognitively Impaired Participants' Self- and Proxy-Ratings of Total, Prospective and Retrospective Memory Ability, as Measured by the PRMQ.

Test	Cognitively Impaired Self-Ratings		Cognitively Impaired Proxy-Ratings		Summary Statistics		
	Mean	SD	Mean	SD	*df*	*t*	*p*
Total	37.59	9.64	14.88	11.96	32	6.09	**.0005**
Prospective	19.00	5.42	7.59	7.15	32	5.24	**.0005**
Retrospective	18.24	4.49	7.29	5.30	32	6.49	**.0005**

Independent *t*-tests revealed that, on the PRMQ Total, the cognitively impaired older adults' self-ratings were significantly higher than their proxy-ratings ($t(32) = 6.09$, $p<.001$; 2 tailed), representing a large sized effect ($r = .73$). On the PRMQ Prospective subscale also, cognitively impaired older adults' self-ratings were significantly higher than their proxy-ratings ($t(32) = 5.24$, $p<.001$; 2 tailed), representing a large sized effect ($r = .68$). Similarly, on the PRMQ Retrospective subscale, cognitively impaired older adults' self-ratings were significantly higher than their proxy-ratings ($t(32) = 6.49$, $p<.001$; 2 tailed), representing a large sized effect ($r = .75$).

Pearson's correlations were used to determine whether there was an association between PRMQ self- and proxy-ratings.

Table 3.11: Correlation Matrix of the Relationship between Cognitively Impaired Older Adults' Self- and Proxy-Ratings on the PRMQ Total, Prospective (PM) and Retrospective (RM) scales.

		PRMQ Total	PRMQ PM	PRMQ RM	Proxy rating of PRMQ Total	Proxy rating of PRMQ PM	Proxy rating of PRMQ RM
PRMQ Total	Pearson Correlation	1	.930	.918	-.078	.010	-.191
	Sig. (2-tailed)		**.0005**	**.0005**	.765	.969	.464
PRMQ PM	Pearson Correlation	.930	1	.708	-.170	-.071	-.287
	Sig. (2-tailed)	**.0005**		**.001**	.515	.787	.264
PRMQ RM	Pearson Correlation	.918	.708	1	.032	.096	-.056
	Sig. (2-tailed)	**.0005**	**.001**		.901	.714	.830
Proxy rating of PRMQ Total	Pearson Correlation	-.078	-.170	.032	1	.971	.947
	Sig. (2-tailed)	.765	.515	.901		**.0005**	**.0005**
Proxy rating of PRMQ PM	Pearson Correlation	.010	-.071	.096	.971	1	.843
	Sig. (2-tailed)	.969	.787	.714	**.0005**		**.0005**
Proxy rating of PRMQ RM	Pearson Correlation	.191	.287	.056	.947	.843	1
	Sig. (2-tailed)	.464	.264	.830	**.0005**	**.0005**	

Table 3.11 shows the relationships between the cognitively impaired older adults' self-ratings and proxy-ratings on the PRMQ Total, Prospective and Retrospective scales. Pearson correlations revealed that cognitively impaired older adults self-ratings were not associated with the ratings of proxy-ratings on the PRMQ Total Prospective or Retrospective scales.

3.3.4.6 Interim summary

Cognitively impaired older adults' self-ratings were significantly higher than proxy-ratings of retrospective and prospective memory. There was no significant association between self- and proxy-ratings of retrospective or prospective memory.

3.3.4.7 Subjective assessment compared with current level of cognitive functioning

In order to determine how subjective assessment of memory compared with current level of cognitive functioning, self-ratings on the PRMQ were compared with performance on the ACE-R.

The mean scores of the healthy older adults (M = 94.20, SD = 3.79) are higher than those of the cognitively impaired older adults (M = 66.75, SD = 13.56) on the ACE-R.

The two participant groups differed significantly in mean full scale IQ (as predicted by performance on the NART), and education (as described in section 3.2.4). A one-way ANCOVA was used to partial out any significant effects of these possible covariates. Again, only data from 38 of the participants were used, however, as explained in section 3.3.1. The data met the assumptions of homogeneity of regression and equality of variance. Unadjusted and adjusted mean ACE-R scores (following the ANCOVA) are found in Table 3.12.

Table 3.12: Unadjusted and Adjusted Mean ACE-R Scores of the Healthy and Cognitively Impaired Older Adults.

Test	ACE-R score	
	Unadjusted Mean	Adjusted Mean
Healthy	94.06	92.40
Cognitively Impaired	66.75	68.24

As Table 3.12 illustrates, no significant relationships were found to exist between IQ or education and ACE-R scores. An independent *t*-test was used, therefore, to analyse whether there was a statistically significant difference between the mean performance of the healthy older adults and the cognitively impaired older adults on the ACE-R.

A Levene's test revealed that the data violated the assumption of homogeneity of variance (F (1,38) = 15.01, $p < 0.001$) and, therefore, this violation was corrected by reporting the *t*-test statistic which does not assume equal variances. The tests revealed that there was a statistically significant difference between the healthy older adults' and cognitively impaired older adults' mean scores on the ACE-R (t (21.95) = 8.72, $p < .001$), and this represented a large effect size ($r = .88$).

Pearson correlations were used to determine whether ACE-R scores were associated with subjective assessment of memory, as measured by PRMQ self-ratings.

Table 3.13: Correlation Matrix of the Relationship between ACE-R Scores and Self-Ratings on the PRMQ Total, Prospective and Retrospective Memory Scales.

		ACE-R score	PRMQ total score	PRMQ prospective memory ratings	PRMQ retrospective memory ratings
ACE-R score	Pearson Correlation	1	.130	.107	.178
	Sig. (2-tailed)		.424	.512	.273
PRMQ total score	Pearson Correlation	.130	1	.962	.957
	Sig. (2-tailed)	.424		**.0005**	**.0005**
PRMQ prospective memory ratings	Pearson Correlation	.107	.962	1	.850
	Sig. (2-tailed)	.512	**.0005**		**.0005**
PRMQ retrospective memory ratings	Pearson Correlation	.178	.957	.850	1
	Sig. (2-tailed)	.273	**.0005**	**.0005**	

Table 3.13 shows the relationships between the ACE-R scores and self-ratings on the PRMQ Total, Prospective and Retrospective scales. Pearson correlations revealed that ACE-R self-ratings were not associated with self-ratings on the PRMQ Total, Prospective and Retrospective scales.

3.4.4.8 Interim Summary

Healthy older adults have significantly higher ACE-R scores than the cognitively impaired older adults. Performance on the ACE-R is not associated with subjective assessment of memory. The data, therefore, do not support hypothesis 4.

3.3.4.9 Factors predictive of insight

In order to determine which factors are predictive of insight, Pearson correlations and multiple regression analyses were used to elucidate the relationship between the cognitively impaired older adults' self-ratings, proxy-ratings, performance on the RBMT and the CAMPROMPT. As only 17 of the cognitively impaired older adults had proxy-ratings, only data from these 17 participants was used in this analysis.

Pearson correlations revealed a significant negative association between PRMQ self-ratings and CAMPROMPT *T* scores (r = -.57, p = .008; 1 tailed), and RBMT *T* scores (r = -.47, p = .030; 1 tailed), but no significant association between PRMQ self-ratings and PRMQ proxy-ratings (r = -.08, p = .382; 1 tailed).

A backward multiple regression analysis was used to calculate the contribution of cognitively impaired older adults' PRMQ proxy-ratings, RBMT *T* scores and CAMPROMPT *T* scores on PRMQ self-ratings.

Table 3.14: Multiple Regression Model of PRMQ Proxy-Ratings, CAMPROMPT *T* Scores, RBMT *T* Scores and PRMQ Self-Ratings in Cognitively Impaired Older Adults.

	Summary Statistics			
	B	*SE B*	*B*	*p*
Step 1				
Constant	46.94	10.52		
CAMPROMPT *T* score	-0.50	0.25	-0.46	.064
RBMT *T* score	-0.14	0.11	-0.32	.202
PRMQ Proxy	0.05	0.18	-0.06	.783
Step 2				
Constant	48.11	9.34		
CAMPROMPT *T* score	-0.50	0.24	-0.47	.053
RBMT *T* score	-0.13	0.10	-0.30	.193
Step 3				
Constant	56.46			
CAMPROMPT *T* score	-0.62	-0.57	-2.70	**.017**

R^2 = .41 for Step 1; ΔR^2 = -.00 for Step 2; ΔR^2 = -.02 for Step 3

The model found PRMQ proxy-ratings and RBMT *T* scores to be poor predictors of PRMQ self-ratings, and excluded these from the second and third model respectively, as shown in Table 3.14. In this third model, the association between the criterion and explanatory variables is moderately strong (Multiple R = .57). Performance on the CAMPROMPT accounted for 33% of the variation in PRMQ Total self-ratings. CAMPROMPT *T* scores were negatively related to PRMQ Total self-ratings. The regression coefficient for performance on the CAMPROMPT was -0.62 (95% CI = -1.11 – -0.13). Since the confidence limits did not encompass a positive value, it can be concluded that the population regression coefficients for

performance on the CAMPROMPT is negative. Performance on CAMPROMPT ($t(15) = -2.70$, $p = .017$; 1 tailed) is a significant predictor of PRMQ self-ratings.

This regression model is likely to be generalisable beyond this sample, as the regression model met all of the necessary assumptions of normality, linearity and homoscedasticity, as described by Berry (1993).

3.3.4.10 Interim Summary

Performance on the CAMPROMPT is a significant predictor of subjective assessment of memory. Performance on the RBMT, and proxy-ratings of mnemonic ability, are not significant predictors of subjective assessment of memory.

3.3.5 Overall Summary

This study aimed to elucidate which aspects of memory change with age and with the onset of dementia. The study found the healthy older adults performed better than the cognitively impaired older adults on the objective measures. Both the healthy and cognitively impaired older adults performed better on the prospective memory assessment than the retrospective memory assessment.

There was no correlation between how healthy older adults rated their own memory and how they performed on the memory tests. There was a significant negative correlation, however, between how cognitively impaired older adults rated their own memory and how the performed on the prospective memory test and further analyses revealed that performance on the prospective memory assessment was a significant predictor of self-rating of memory functioning. Cognitively impaired participants rated themselves as having better memory ability than their partners/carers did. Self-ratings were not correlated with proxy-ratings or overall severity of impairment.

CHAPTER 4 – DISCUSSION

4.1 Discussion of main findings

The aim of this study was to explore whether retrospective and prospective memory functioning deteriorate with the onset of dementia, whether they are equal, both in healthy old age and in dementia, and whether insight into mnemonic functioning deteriorates as cognitive functioning deteriorates.

4.1.1 Does retrospective and prospective memory functioning deteriorate with the onset of dementia?

Retrospective and prospective memory are known to deteriorate with age (Backman, Small & Wahlin, 2001; Craik & Jennings, 1992; Hultsch & Dixon, 1990; Henry *et al.*, 2004; Maylor *et al.*, 2002) and deteriorate further with dementia (Hejl *et al.*, 2002; Brown & Hillam, 2004; Huppert *et al.*, 2000).

In this study, healthy older adults were found to perform better than cognitively impaired older adults on the objective measures of prospective and retrospective memory. This supports the previous findings that both retrospective and prospective memory deteriorate with the onset of dementia.

4.1.2 Are retrospective and prospective memory functioning equal in healthy old age?

Both retrospective memory and prospective memory deteriorate with age (Backman, Small & Wahlin, 2001; Craik & Jennings, 1992; Hultsch & Dixon, 1990; Huppert *et al.*, 2002). Some studies have found retrospective memory to deteriorate more (Einsein & McDaniel, 1990; Maylor, 1990; Henry *et al.*, 2004), but other studies have found the opposite: prospective memory deteriorates more (Cockburn & Smith,

1991; Mantyla & Nilsson, 1997 and Maylor, 1993). Maylor *et al.* (2002) suggests these conflicting findings have been caused by heterogeneous methodologies.

This study found, however, that when using standardised, ecologically valid, objective assessments, healthy older adults performed significantly better on the prospective memory test (the CAMPROMPT), than on the retrospective memory test (the RBMT).

The RBMT has three subtests, which are purported to assess prospective memory. A multiple regression analysis revealed that only two of these subtests were significant predictors of performance on the CAMPROMPT. Together, performance on the RBMT Belonging and Appointment subtests accounted for 48.8 per cent of the variation in performance on the CAMPROMPT. It may be concluded, therefore, that if these two subtests of prospective memory were omitted from the RBMT, to leave only measures of retrospective memory, there would be an even greater difference between performance on the prospective and retrospective memory assessments.

It is of note that only two of the three RBMT 'prospective memory' subtests (Appointment and Belonging, but not Message) were found to be significant predictors of performance on the CAMPROMPT. This lends support to Maylor's (1996) assertion that the Message subtest could be equally thought of as part of a serial recall test of retrospective memory for a list of actions. Although it is possible that the Message subtest could assess both prospective and retrospective memory, it does not appear to be a significant predictor of performance on the CAMPROMPT, and, therefore, should not be considered to be a marker of prospective memory.

The finding that healthy older adults perform better on the prospective memory assessment than the retrospective memory assessment may suggest that retrospective memory deteriorates more than prospective memory in healthy ageing. Indeed, Einstein and McDaniel (1990) and Maylor (1990), and a meta-analysis by Henry *et al.* (2004) found that prospective memory deteriorates more than retrospective memory in healthy ageing. Cockburn and Smith (1991), Mantyla and Nilssson

(1997) and Maylor (1993), however, found the opposite: retrospective memory deteriorates more than prospective memory.

It has been postulated that prospective memory is more vulnerable than retrospective memory to age-related decline because it is less automatic and more dependent on self-initiation (Craik, 1986). Einstein and McDaniel (1990) suggested that conflicting findings of whether retrospective or prospective memory deteriorate more in healthy ageing may be caused by assuming that all prospective memory tasks are highly dependent upon self-initiated retrieval. Einstein *et al.* (1995) argue that prospective memory, similar to retrospective memory, should be considered to have lesser or greater dependency on self-initiated retrieval processes, depending on the nature of the memory task.

This argument has been supported by Maylor (1998), who reported that older adults do not demonstrate this age-related difference on prospective memory tasks outside the laboratory. She speculated that this was because, outside of the laboratory, older adults are able to make use of external environmental support e.g. diaries, alarm clocks, etc., which reduces the amount of self-initiated activity. Further, older adults may be more inclined to use, or be more efficient at using, external memory aids than they younger counterparts (Maylor, 1996; Henry *et al*., 2004), perhaps because they have more experience of time-management or have better knowledge of their own memory abilities and weaknesses (Henry *et al*., 2004).

The CAMPROMPT, the measure used to assess prospective memory in this study, was designed to have high ecological validity. As such, its tasks are analogous to everyday memory tasks, e.g. remembering to phone the garage to ask if the car is ready, and it allows the participant to use external environmental support, such as notes. It is possible, therefore, that the results reflect a higher than expected performance on the prospective memory tasks because of a high reliance on environmental support and, thus, a reduced amount of reliance on self-initiated activity. Within the World Health Organisation's International Classification of Impairment, Disability and Handicap (1980) framework, ecological valid

assessments, such as the CAMPROMPT, may be thought of as assessing disability (functional consequence), rather than impairment (abnormality of structure/function), unlike the more traditional theoretically-driven memory tests, such as the Wechsler Memory Scale (Wechsler, 1999).

Further, Henry *et al.* (2004) argued that some prospective memory tasks can be supported in two ways: strategically monitoring the environment for the presence of the prospective cue or by relying on the prospective cue to automatically prompt the target action. If prospective memory was supported by a multi-process activating network, rather than as by a number of processes operating in series, it is possible that deterioration in one function could be compensated for by the remaining sub-components, leaving prospective memory more protected from, rather than more vulnerable to, age-associated decline.

As described in section 2.2.2.2, there is an important caveat to these findings. Interpretation on the CAMPROMPT requires an estimation of the participant's IQ. The NART was used for this purpose. The NART's normative data, however, cover a sample of people aged between 20 and 70. As the mean age of the healthy older adults in this study was 73.80 years, it is possible that there is inaccurate interpretation of performance on the NART leading to an underestimation of their full scale IQ. As quantification of CAMPROMPT performance is dependent upon using IQ-specific normative data, inaccurate interpretation of performance on the NART may lead to inaccurate quantification of CAMPROMPT performance, perhaps leading to performances being labelled, incorrectly, as being high. In contrast, performance on the RBMT does not use IQ-specific normative data and thus would not be subject to this artificial elevation. A way of assessing this hypothesis further would be to extend the normative data for the NART to include older ages, or use an IQ measure which has better normative data for older people, and reinterpret performance on the CAMPROMPT as appropriate. This should clarify further why the older adults in this study appear to have performed better on the test of prospective memory than on the test of retrospective memory.

4.1.3 Are retrospective and prospective memory functioning equal in dementia?

Research suggests that prospective memory may be more vulnerable to damage than retrospective memory with the onset of DAT (Huppert *et al*., 2000). This may be because of several reasons. It may be because prospective memory consists of several components; each one vulnerable to damage associated with the onset of DAT (Huppert *et al.*, 2000) or because it involves working memory/executive functioning, apparently deficient in DAT (Logie, Cocchini *et al*., 2004).

In this study, however, older adults with cognitive impairment performed better on the prospective memory assessment (CAMPROMPT) than on the retrospective memory assessment (RBMT). Furthermore, performance on the RBMT subtests purported to assess prospective memory was neither correlated with, nor predictive of, performance on the CAMPROMPT. It may be concluded, therefore, that should performance on these three subtests be excluded from the RBMT total, no further difference between RBMT and CAMPROMPT scores would be seen.

It is an important finding that performance on the three RBMT subtests purported to assess prospective memory was not associated with performance on the CAMPROMPT. Huppert and Beardsall (1993) based their finding that people with dementia perform better on retrospective memory than prospective memory tasks, by comparing their participants' performance on these three subtests with their performance on the other RBMT subtests. This study suggests that performance on these three subtests is not even associated with performance on the prospective memory measure, and, thus, Huppert and Beardsall's conclusions can hardly be valid.

The finding from the study suggests that retrospective memory deteriorates more than prospective memory in dementia. Similarly, Beardsall and Huppert (1991) found that, when comparing older adults with and without dementia on clinical, psychometric and everyday memory tests, performance on the everyday memory test, specifically the RBMT, was the best discriminator between those with and

without dementia. It is possible, therefore, that general everyday memory performance, as assessed by the RBMT, is particularly sensitive to the onset of a dementia process.

Prospective memory is known to be a mulicomponent process (Dobbs & Reeves,1996; Graf & Uttl, 2001; Burgess & Shallice, 1997). If prospective memory was supported by a multi-process activating network, rather than by a number of processes operating in sequence (as described in section 4.1.2), it is possible that deterioration in one function could be compensated for by the remaining sub-components, leaving prospective memory more protected from, rather than more vulnerable to, dementia. This interpretation seems harmonious with neuropathology findings. DAT manifests initially as a focal disorder with early stage pathology restricted to the medial temporal lobe (MTL) (Bradshaw & Mattingley, 1995). Retrospective memory is dependent on the functions of the MTL (Squire & Zola-Morgan, 1991; Gabrieli *et al.*, 1997; Dove *et al*, 2006). Prospective memory, however, is a multicomponent process, which involves several neuroanatomical regions, some not affected by early DAT pathology (McDaniel *et al.*, 1999; Burgess *et al*, 2001; Burgess *et al.*, 2003). Thus, in the early stages at least, evidence from neuropathology suggests that prospective memory may be less vulnerable to DAT pathology.

In addition, performance on the CAMPROMPT may have been better than expected because of the test's naturalistic design, which allowed the use of environmental support to aid performance, perhaps leading to a reduction in dependence on self-initiated behaviour, as described by Craik (1986) and in section 4.1.2.

Furthermore, it is also possible that the limited normative data and effects of dementia may have led to inaccurate interpretation of performance on the NART and underestimation of full scale IQ. In addition, the NART was originally thought of as a 'hold' test, i.e. one that is relatively resistant to the effects of brain pathology and dementia (Nelson & McKenna, 1975), but more recent evidence has suggested that the test is not as resistant to the dementia process as once thought (McFarlane *et al.*,

2006). As quantification of CAMPROMPT performance is dependent upon using IQ-specific normative data, inaccurate interpretation of performance on the NART may lead to inaccurate quantification of CAMPROMPT performance, perhaps leading to performances being labelled artificially elevated, in comparison to performance on the RBMT, which does not use IQ-specific normative data.

It is also possible that the participants' heterogeneous diagnoses have disguised the effects of dementia on memory. The cognitively impaired sample consisted of six people with a diagnosis of DAT, three people with a diagnosis of vascular dementia and 11 people for whom diagnoses were not available. Previous studies have tended to use samples of homogeneous diagnoses, usually DAT. Recent evidence suggests, however, that there are several sub-types of DAT, including early onset, uni-hemispheric, bi-hemispheric, frontal and parietal/posterior (Lezak *et al*., 2004). Furthermore, the neuropathology of DAT has been found to be present in vascular dementia (Brown & Hillam, 2004), leading to the possibility that there is greater overlap between these two types of dementia than previously thought. The broad classifications used within this study, therefore, may be of minimal utility. Future research should perhaps focus on ensuring greater delineation of dementia (sub)types, in order to study their possible interaction with patterns of memory deterioration.

4.1.4 Is insight into mnemonic functioning associated with severity of cognitive impairment?

Previous findings suggest that older adults tend to be as accurate as younger adults in their subjective assessment of memory when compared to objective assessment. In older adults, subjective reports of memory difficulties and evidence of memory disorder, is correlated with later development of dementia (Treves *et al*., 2005; Wang *et al*., 2004; Geerlings *et al*., 1999). In people with dementia, insight appears to be negatively correlated with dementia severity (Zanetti *et al*., 1999; McDaniel *et al*.,

1995), but it has been suggested that this may not be a unimodal relationship (Efklides *et al*., 2002).

In this study, insight was quantified by comparing subjective assessment of memory to objective assessment of memory, to subjective proxy-rating assessment of memory and to current level of functioning.

There was no correlation between how healthy older adults rated their own memory and how they performed on the memory tests. There was a significant negative correlation, however, between how cognitively impaired older adults rated their own memory and how they performed on the prospective memory test. Further analyses revealed that performance on the prospective memory assessment was a significant predictor of self-rating of memory functioning.

Self-ratings of prospective memory and retrospective memory, however, were significantly correlated, in both the healthy and cognitively impaired older adults, and the measure of subjective opinion (the PRMQ) had high internal reliability. Thus, the PRMQ was a reliable measure of how good the participants thought their memory was, but not a good measure of how good their memory really was.

Previous research has tended to find that people who report subjective memory difficulties have poorer objective memory performance (Wang *et al.*, 2000). Zanetti *et al*., (1999) and McDaniel *et al*. (1995) reported a direct relationship between subjective and objective measures of neuropsychological functioning in dementia, with reduced insight being associated with poorer performance. This study did not find an association between subjective memory difficulties and memory performance in the healthy older adults, but did find that reduced insight was associated with poorer performance on the prospective memory assessment in the cognitively impaired older adults.

Cross-sectional studies tend to predict little correlation between subjective memory complaints and objective memory performance (Schofield *et al*., 1997) and higher

correlation with measures of depression (McGlone *et al*., 1990), use of memory strategies and perceived memory strategy efficacy (Brustrom and Ober, 1998). Longitudinal designs, however, tend to predict greater correlation between subjective memory complaints and objective memory performance (Treves *et al*., 2005). This study found that, even within a cross-sectional study, there was an association between subjective memory appraisal and objective memory performance in cognitively impaired older adults.

It is possible that this statistically significant correlation is (at least partly) explained by the assessments' high ecological validity. Mantyla (2003) suggested that there may be little correlation between subjective appraisal of everyday memory functioning and objective measures that are laboratory based, rather than those which have higher ecological validity. In order to understand fully the relationship between subjective memory appraisal and objective memory performance, future research should use a longitudinal design to study the relationship between subjective appraisal of memory and objective memory performance, in both healthy and cognitively impaired older adults, using standardised assessments with high ecological validity.

Further assessment revealed that cognitively impaired older adults tended to rate their memory as being significantly better than what their partners/carers do. There was no statistically significant association found between self- and proxy-ratings of retrospective and prospective memory ability.

Divergence between self- and proxy-ratings may be caused by a reduction in insight with the onset of dementia. Moreover, it is possible that level of insight is affected by specific type of dementia. In particular, people with DAT are thought to have less insight into their deficits than people with other types of dementia, especially vascular dementia (De Bettignies *et al*., 1990; Wagner *et al*., 2002). Aalten *et al*. (2005) point out, however, that diagnosis of vascular dementia, using the Hachinski criteria, necessitates 'preserved personality', which may be assumed to mean intact insight. They also suggest that as most research into insight in dementia uses people

with DAT, it is difficult to draw conclusions about the effects of other dementias on insight. Studies that have examined insight across different diagnoses have tended to find little difference between them (Verhey *et al*., 1993; Zanetti *et al*., 1999). It is possible, however, that the participants' heterogeneous diagnoses may have affected the findings. Future research should perhaps focus on ensuring greater delineation of dementia (sub)types, in order to study their possible interaction with level of insight.

The divergence between self- and proxy-ratings may also have been caused by the assumptions inherent to this study. Marková *et al*. (2005) argue that when insight is viewed as a neurological/neuropsychological construct, it tends to be equated with cognitive functioning. Clare, Marková *et al*. (2005) argue, however, that awareness is not a neuropsychological construct, solely dependent upon neuropathology, but a multi-dimensional phenomenon, affected also by psychological coping and social environment. Marková *et al*. (2005) describe how, within a psychoanalytical framework, insight is thought to be a product of one's experiences and the way in which the self relates to them. Clare, Markova *et al*. (2005) argue further that the researcher's theoretical stance affects the means of assessing insight, or its subcomponents, which shapes which aspects of awareness one assesses and, ultimately, the results found.

Insight may be assessed using clinical rating methods, questionnaires, performance-based methods, phenomenological methods, and multidimensional or combined methods (Clare, Marková *et al*., 2005). This study used a questionnaire methodology, which Clare, Marková *et al*. (2005) describes as having several advantages and disadvantages. Advantages include the opportunity to standardise assessment and data, enabling easier analysis. Disadvantages include the lack of clarity over how well responses to a questionnaire accurately reflect underlying awareness. Clare, Marková *et al*. (2005) speculate that responses may be influenced by avoidance or denial.

Howorth and Saper (2003) argue that self-description is likely to be determined by an interplay between organic changes, personality factors, attitudes to illness,

psychological defences and emotional reactions. They argue further that awareness can be implicit or explicit, similar to memory. Although the person may have an implicit awareness of memory difficulties, they may not be consciously aware of these difficulties. In support of this hypothesis, they cite a study by Moulin *et al*. (2000) who found some tentative evidence for the preservation of implicit awareness in people who explicitly deny their deficits.

Certainly, awareness in dementia has psychological and social correlates. Higher levels of awareness tend to be associated with low mood and anxiety (Aalten *et al*., 2005), whereas low awareness tends to be associated with apathy and psychosis, difficulties in daily life functioning, increased caregiver burden and deterioration in global dementia severity. Furthermore, people unaware of their deficits may resist treatment options or may harm themselves or others because they are not aware of the limitations to their abilities (Aalten *et al*., 2005).

Clare, Marková *et al*., (2005) also question the use of using proxy-ratings when evaluating awareness. It is assumed that the proxy is able to provide an honest and unbiased analysis of behaviour, so that any deviation between self- and proxy-ratings reflects a loss of awareness. Some studies have found that carer strain and depression can bias proxy-ratings (De Bettignies *et al*, 1990), possibly leading to inaccurate assessments of insight. In addition, and perhaps more controversially, Downs (2005) asks, 'whose interests do attributions of lack of awareness serve?' Woods and Pratt (2005) described the vicious cycle that can develop when attributions of lack of insight are made, where the person with dementia becomes increasingly socially excluded. Moreover, it is possible that even by asking a partner or carer to rate the person with dementia invokes the assumption that the person with cognitive impairment is not an accurate self-rater. The proxy-rater, may (even unconsciously) seek to meet the demands of this task by confirming this assumption, by inadvertently exaggerating the difficulties of the person with cognitive impairment. Clearly, these hypotheses need to be studied further, using a multi-faceted assessment of insight, to elucidate the interplay between biological, social and psychological factors.

The study also found healthy older adults to have significantly higher scores than the cognitively impaired older adults on the ACE-R, the test of general cognitive functioning, but found that ACE-R score was not associated with subjective assessment of memory. In fact, the only factor found to significantly predict self-ratings on the PRMQ, the subjective assessment of memory, was performance on the CAMPROMPT, the measure of prospective memory.

There is considerable evidence to link frontal or executive functions with insight (e.g. Michon *et al*., 1994; Lysaker *et al*., 1998), and to prospective memory (Burgess & Shallice, 1997; McDaniel *et al*., 1999, Kesner, 1989; Burgess *et al*., 2003). It is likely, therefore, that this correlation between insight and performance on the prospective memory assessment is because they both involve executive processes. This is a most interesting aspect of the study and warrants further study, to clarify further the relationship between executive functioning, prospective memory and insight.

4.2 Strengths and limitations of the study

4.2.1 Statistical power analysis

During the design of this study, a power analysis was performed to calculate the necessary sample size (see section 2.3.3). Previous research by Kazui *et al*. (2005) found that the difference between healthy and cognitively impaired older adults' performance on the RBMT represented a large sized effect. For this study, therefore, G*power, general power analysis program (Erdfelder *et al*., 1996), was used to calculate the minimum number of participants required to detect a large effect size when using 2-tailed independent *t*-tests. A large effect size and a significance criterion of .05, at power of .80, predicted that to detect a large difference between two groups, a sample size of 19 was required in each group. A total of 20 people in

both groups (healthy older adults and cognitively impaired older adults) participated in the study, thus meeting the conditions for detecting a large effect.

Subsections of the samples, however, were analysed further, reducing the sample size and power. Moreover, sample subsections were analysed using multiple regressions analyses, which are very powerful tests. Tabachnick and Fidell (2001) suggest that a rule of thumb for calculating the sample size required for a multiple regression is:

$$N \geq 104 + m$$

where N is total sample size and m = number of independent variables. Another popular rule of thumb is that there must be at least 20 times as many cases as independent variables. Bausell (1986) suggested even more stringent criteria, suggesting that there should be at least 200 participants, to ensure a participant to variable ratio of 25:1. Exploratory multiple regressions, however, may be permitted to have less stringent criteria. Garson (2007) stated that there must be at least five cases per independent variable. All of the multiple regression analyses in this study satisfied this minimum standard, however, the findings ought to be subject to cross-validation, ensuring the accuracy of the models across different samples, as a step towards generalisation. Indeed, all findings based on analyses of subsections of the sample, particularly within a cross-sectional study design, must be interpreted with caution.

4.2.2 Design

This study employed a cross-sectional design, where all data were gathered at a single time-point. Cross-sectional designs may reveal differences about two groups, but cannot make any conclusions about the nature of such differences. Thus, in this study, differences can be seen in prospective or retrospective memory in healthy old age and in dementia, but it is not possible to draw conclusions that such differences are caused by ageing or dementia, as such differences may be idiosyncratic or

associated with a third or other factor(s). Longitudinal studies are preferable to cross-sectional methodologies, as they allow directions of causality to be inferred, but unfortunately the time constraints on this study did not permit the use of a longitudinal design. Future research should seek to replicate or update the findings in this study using a longitudinal design.

4.2.3 Recruitment

There were significant difficulties recruiting the older adults with cognitive impairment. All older adults in Highland, who met the inclusion criteria, were sent a letter of invitation to participate in the study by their Consultant Psychiatrist. Only four people, out of the twenty nine invited (13.79 per cent), responded to this letter. Such low response rates may suggest that this was a poor method of recruitment: the letter of invitation, somewhat unadvisedly in retrospect, was asking the person with memory impairment to remember to get back in touch with the researcher. Such recruitment difficulties are commonplace and difficult to overcome when researching vulnerable groups and it is more important that they, like all individuals, are protected from pressure or harassment to participate.

Attempts were made to pre-empt such recruitment difficulties, by presenting the research proposal and rationale to the Old Age Psychiatry Department and Community Mental Health Teams, to help promote referrals to the study. Certainly, future studies should focus on building relationships with potential referrers, to side-step this obstacle to recruitment, and seek to maintain saliency of the research project, in order to increase recruitment rates.

4.2.4 Sample

A problem inherent to volunteer healthy control samples is that they are usually better educated, of higher socio-economic status and healthier than members of the general population (Huppert *et al*., 2000). Certainly, the healthy older adult group in this study was better educated than the cognitively impaired older adults (see Table

3.1). All of the healthy older adults were recruited through the Edinburgh University Department of Psychology Volunteer Panel, which potentially increases this risk of an education bias further, as people with better education are perhaps more likely to be aware of the University's volunteer panel.

Furthermore, it is possible that people who are either very unconcerned or very concerned about their memory are perhaps more likely to take part in a memory assessment, which could lead to an unrepresentative sample of 'healthy older adults'. Participants were advised that the study would not provide any individual analysis of memory or provide any clinically relevant information, but should performance on a test be so low as to warrant further investigation, this would be discussed with the participant and their GP, as appropriate. This potential selection bias is hard to avoid when attempting to recruit individuals to participate in memory studies. Financially remunerating participants may provide an alternative motivator to participation and potentially sidestep recruiting individuals who have concerns about their memory only. Huppert *et al*. (2000) argue, however, that studies of early-stage dementia need to be population-based. This should be the aim of future research.

4.2.4 Measures

This study used the RBMT and CAMPROMPT, both developed to be analogous to everyday memory tasks. The use of the RBMT as a measure of retrospective memory may be criticised. It incorporates subtests of prospective memory (as described in section 4.1.2 and 4.1.3), which thus reduces the tests' independence from one another. Attempts were made to filter out the effect of these prospective memory subtests, as described in section 4.1.2 and 4.1.3.

The use of the CAMPROMPT with this population may also be criticised. It requires an estimation of verbal IQ to interpret performance. Verbal IQ measures, particularly the NART, are not well suited to an ageing population, and especially not with older adults with dementia (as described in sections 4.1.2 and 4.1.3). McFarlane *et al.* (2006) suggested that a lexical decision task, such as Spot-the-Word subtest from the

Speed and Capacity of Language Processing Test (Baddeley *et al.* 1992), may be a more useful assessment of verbal IQ, although McFarlane *et al.* (2006) caution that this speculation has yet to confirmed.

A strength of this study perhaps is the use of ecologically valid, standardised assessment tools. This study sought to reduce the difference commonly seen between older adults' everyday memory ability and their performance on memory tasks in the laboratory, as described by Maylor (1998), Moscovitch (1982) and Moscovitch and Winocur (1992). These tests allow everyday memory ability to be observed, in distraction-free and controlled conditions, helping to elucidate the breakdown of memory in ageing and with the onset of dementia.

4.3 Future research

Future research should focus on examining: the effect of estimating IQ from performance on a lexical decision task on quantification of performance on the CAMPROMPT; dementia (sub)types' interaction with prospective and retrospective memory breakdown; a longitudinal design's illuminations on how prospective and retrospective memory breaks down in healthy ageing and in dementia; the utility of proxy-ratings in dementia; and the relationship between prospective memory, executive functioning and insight. Ideally, such research should be population-based, as suggested by Huppert *et al.* (2000).

4.4 Clinical implications

This study had three main findings, which have important clinical implications. Firstly, the study found that both retrospective and prospective memory deteriorate with the onset of dementia. This is the first study to use standardised assessment methodology to study retrospective and prospective memory and, as such, provides the first firm evidence that both types of memory change with the onset of dementia. This finding has important implications for clinical psychology. Although

retrospective memory problems are considered to be the benchmark of dementia, this study has found that prospective memory degrades also, and, therefore, it should also be assessed and monitored appropriately. This is especially important when one considers that prospective memory failures are potentially more dangerous than retrospective memory failures, e.g. forgetting to take medication or turn off the gas.

Secondly, the study found that retrospective and prospective memory functioning are not equal in neither healthy nor cognitively impaired older adults. Both groups were found to perform significantly better on the prospective memory test than on the retrospective memory test. It can be concluded, therefore, that prospective memory is not as sensitive to dementia as retrospective memory is. This may also have important implications for clinical psychology. It should be ensured that all older adults presenting with possible progressive memory loss should have their general everyday memory assessed, as this may be particularly sensitive to the onset of a dementia process. In addition, if older adults with dementia have preserved or protected memory ability, such as prospective and implicit memory ability, use of these types of memory should be maximised as a way of maintaining maximal cognitive functioning for as long as possible.

Thirdly, the study found that subjective opinion of mnemonic functioning is not correlated with objective memory performance in healthy older adults, but is negatively correlated with prospective memory performance in cognitively impaired older adults. These findings have important clinical implications. Cognitively impaired older adults who perform more poorly on the prospective memory test believe their memory to be better, suggesting that these older adults have a lack of insight. Lack of insight is correlated with greater perceived caregiver burden (De Bettignies *et al.*, 1990) and poorer response to cognitive rehabilitation (Clare *et al.*, 2004). Using an accurate, valid and reliable assessment of insight, such as the PRMQ, could help clinicians highlight the cognitively impaired older adults who are most likely to respond well to cognitive rehabilitation and those who may require further support.

4.5 Summary

The aim of this study was to illuminate which aspects of memory change with age and with the onset of dementia. Prospective and retrospective memory in healthy and cognitively impaired older adults was assessed using objective and subjective measures. The objective measures were standardised measures with high ecological validity. The subjective measures were used with both the healthy and cognitively impaired participants and, in addition, with the cognitively impaired older adults' partners/carers. The healthy older adults were found to perform better than the cognitively impaired older adults on the objective measures. Both the healthy and cognitively impaired older adults performed better on the prospective memory assessment than the retrospective memory assessment. This may have been because of the prospective memory assessment's high ecological validity, which allowed participants to use environmental support, thus reducing the reliance on self-initiated behaviour.

On the subjective measures, there was no correlation between how healthy older adults rated their own memory with how they performed on the memory tests. There was a negative correlation, however, between how cognitively impaired older adults rated their own memory and how the performed on the prospective memory test, and further analyses revealed that performance on the prospective memory assessment was a significant predictor of self-rating of memory functioning. This association may be because of the high load on executive functioning that both insight and prospective memory are purported to have. Cognitively impaired participants rated themselves as having better memory ability than their partners/carers did. Self-ratings were not correlated with proxy-ratings or overall severity of impairment.

In summary, the study suggested that both healthy and cognitively impaired older adults perform better on prospective memory tasks than retrospective memory tasks, but both types of memory deteriorate with the onset of dementia. Subjective memory appraisal is not related to objective memory performance in healthy older adults, but

is negatively associated with prospective memory performance in cognitively impaired older adults.

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APPENDICES

Appendix 1 – Ethics approval

Appendix 1.1 – Ethics Committee approval letter

Appendix 1.2 – Ethics Committee letter approving amendment to recruitment strategy

Appendix 1.3 – Management approval letter

Appendix 2 – Measures

Appendix 2.1 – Addenbrooke's Cognitive Examination Revised

Appendix 2.2 – Prospective and Retrospective Memory Questionnaire

Appendix 3 – Participant information sheet

Appendix 3.1 – Healthy participant information sheet

Appendix 3.2 – Patient participant information sheet

Appendix 4 – Consent form

Appendix 5 – GP Letter