USE-IT-OR-LOSE-IT: INVESTIGATING THE COGNITIVE RESERVE HYPOTHESIS AND USE-DEPENDENCY THEORY

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DECLARATION

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ABSTRACT

In popular psychology the use-it-or-lose-it theory has become accepted; that is, an increase in cognitive activity, particularly in later life, can reduce cognitive decline associated with both pathological and healthy aging. In the field of cognitive neuropsychology, the use-it-or-lose-it theory can represent either the cognitive reserve hypothesis or use-dependency theory. The cognitive reserve hypothesis states that an individual must be relatively cognitively active throughout life (particularly in early life) in order to build up a cognitive reserve to counter cognitive decline in old age. The use-dependency theory asserts that a high level of cognitive activity in later life is sufficient to attenuate or even reverse the cognitive aging process.

Even though a copious amount of research has provided support for both theories, the link between cognitive activity and cognitive decline remains tenuous with no clear causal relationship (e.g. Salthouse, 2006). This thesis has taken in consideration whether the use of a between-subjects design, the measures of cognitive activity and the assessment of cognitive functioning used in previous research may have produced a disproportionate postulation of the effect that cognitive activity can have on cognitive functioning and decline in healthy adults.

Questionnaire studies in this thesis have indicated that different cognitive activities have a greater effect on subjective measures of cognitive functioning. Specifically, the results showed that undertaking cryptic crosswords frequently appear to have a greater impact on cognitive awareness in older adults (compared to younger adults) than other cognitive activities. Furthermore, there was evidence that attempting cryptic crosswords encouraged older adults to form a realistic understanding of their current level of cognitive functioning, which suggested that such crosswords may be used as an intervention activity to promote cognitive functioning.

This was investigated by using a within-subjects intervention to examine the effect of regularly attempting cryptic crosswords on subjective and objective measures of cognitive functioning. The within-subjects approach eliminated potential mediating

factors that may have influenced the impact of cognitive activity of cognitive interventions in previous studies (e.g. Jopp & Hertzog, 2007). The results confirmed that cryptic crossword participation enhanced cognitive awareness in older adults, particularly in those who could be regarded as being at-risk of sudden cognitive decline. However, there was no evidence that the intervention activity promoted objective measures of cognitive functions, which are known to decline with age (e.g. episodic memory, metacognition).

A within-subjects design was also used to manipulate stimulus characteristics to produce analogies of the cognitive reserve hypothesis and use-dependency theory. This technique bypassed the use of self-report measures of both cognitive activity and cognitive functioning, which may be intrinsically linked (e.g. Hertzog, 2009). These studies provided a modicum of support for the cognitive reserve hypothesis but no support for the use-dependency theory.

A novel model of the cognitive reserve hypothesis and use-dependency theory is presented which implicated the metacognition system as a key component that mediates the effect of cognitive activity on cognitive functioning in later life. The overarching findings suggest that an increase in cognitive activity in later life can enhance cognitive awareness but, due to an age-related deficit in the metacognitive pathway, older adults are unable to modify their behaviour to compensate for age-related cognitive decline in memory functioning. Thus, it can be concluded that cognitive activity in later life can produce changes in subjective but not objective measures of cognitive functioning. Future research needs to use similar within-subjects techniques to develop accessible cost-effective cognitive interventions, which specifically target the metacognition system.

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ABBREVIATIONS

AoA – Age of Acquisition

BDNF – Brain Derived Neurotrophic Factor

BL – Baseline

EM – Episodic Memory

EMemSE – Episodic Memory Self-Efficacy

fMRI – Functional Magnetic Resonance Imaging

FOK – Feeling of Knowing

ITC – Intertrial Consolidation

ITE – Intertrial Encoding

ITR – Intertrial Recall

JOL – Judgement of Learning

MemSE – Memory Self-Efficacy

S.D. – Standard Deviation

S.E. – Standard Error

V – Visit

WF – Word Frequency

CHAPTER ONE
GENERAL INTRODUCTION: THE COGNITIVE RESERVE HYPOTHESIS AND USE-DEPENDENCY THEORY

1.1 Chapter overview

The focus of this thesis is cognitive decline in healthy aging and how it may be attenuated by cognitive activity/stimulation; the theory known as ‘use-it-or-lose-it’. Hebb (1949) was the first psychologist to acknowledge the theory of the biological consolidation of memory involving synaptic growth as a product of activation. This was supported by the view of Bliss & Lomø (1973) and the theory of Long-Term Potentiation (LTP). Bliss & Lomø (1973) produced evidence that synaptic stimulation produced neurogenesis i.e. the growth of new dendrites/synapses. As healthy aging and in particular dementia has the aetiology of neurodegeneration it has been hypothesised that cognitive stimulation could attenuate or reverse cognitive decline in healthy and/or pathological aging (e.g. Hertzog, Kramer, Wilson & Lindenberger, 2009; Salthouse, 1991; Schooler, 1987). This chapter begins with an overview of current knowledge of memory function in older adults, then goes on to describe how the cognitive reserve hypothesis and use-dependency theory may influence cognitive aging.

The use-it-or-lose-it theory was developed by psychologists such as Schooler (1987), Salthouse (1981) and Katzman (1993), and can be separated into either the cognitive reserve hypothesis or the use-dependency theory. The research and theoretical background into both theories are presented in this chapter. The chapter will also identify how this thesis used different methodologies to extend the findings of previous research.

1.2 Cognitive decline and aging

There are a number of reviews of cognitive decline in healthy aging, demonstrating clear deficits in episodic memory function (e.g. Craik, 2002; Craik & Jennings, 1992). Episodic memory refers to memory for events and specific instances with a prior study episode, such as the retrieval of a word from a previously presented list; or the recollection of a happy weekend spent in Tenerife. Episodic memory is the focus of this thesis – being that it is one of the most clear cut aspects of cognitive decline in healthy aging. For example, older adults have significant deficits in free recall of episodic memory compared to younger adults (e.g. Bleeker, Bolla-Wilson, Agnew & Meyers, 1988; Craik, 1977; Gordon & Clark, 1974 and Erber, 1974). A brief review is presented here, covering the neuroscience evidence for memory decline in this group, followed by an examination of memory performance on various forms of episodic task and some prominent theories are discussed. Finally, strategic and metacognitive aspects of memory function in healthy aging are discussed.

1.2.1 Neuroscience insights into memory dysfunction in healthy aging

Healthy aging has been shown to particularly affect the frontal lobes, especially the prefrontal cortex (PFC; Raz, 2000), which is closely associated with metacognition (discussed in Section 1.23), executive functioning and other aspects of episodic memory such as encoding and retrieval (e.g. Souchay & Isingrini, 2004; Kikyo, Ohki & Miyashita, 2002, Reuter-Lorenz, 2000; Shimimura, 1995). There is also clear neurological evidence of neuronal atrophy in the temporal lobe (particularly the medial temporal lobe/hippocampi region, Jessberger & Gage, 2008) and the PFC during the healthy aging process (e.g. Raz, 2000; Reuter-Lorenz, 2000). Both of these areas have been shown to be related to either the encoding, consolidation or retrieval of episodic memories (e.g. Logan et al., 2003; Cabeza, 2002; Reuter-Lorenz, 2000; Grady, McIntosh, Rajah, Beig & Craik, 1999). Therefore it is logical to assume that older adults will show deficits in episodic memory and that these deficits will include encoding, consolidation and retrieval.

1.2.2 Performance on tests of episodic memory

Episodic memory describes a system which necessitates the separate encoding and retrieval of information; both have to be intact in order for memory to function. Overall, the research shows that older adults have a deficit in both encoding and retrieval of episodic memories, however primary/short term memory appears to be relatively intact when measured by the recency effect (e.g. Semenza, Nichelli & Gamboz, 1996). For example, Craik, Byrd & Swanson (1987) showed how an increase in processing at the encoding/consolidation stage of learning promoting free-recall in older adults. Other results have indicated that the deficits in recall are due to a retrieval problem (e.g. Grady et al., 1999). As older adults show an improved episodic memory recall when using word-stem completion tasks and cued-recall/recognition other researchers have concluded that the episodic memory deficit apparent in healthy aging is due to a problem with retrieval (e.g. Park & Shaw, 1992); since the item is available to memory on implicit tasks, but not accessible in recall tasks. Overall, because older adults benefit from environmental support (see Section 1.24) it can be assumed that both the encoding/consolidation and retrieval mechanisms of episodic memory are compromised (e.g. Light, 1991).

The aging literature has typically used multi-trial tests to examine the separate contributions of acquisition of items into memory (a learning curve) and their retention from one trial to the next (e.g. Dunlosky & Salthouse, 1996; multi-trial learning tasks feature in Chapters Three, Four and Five). The use of the multi-trial technique enables experimental psychologists to differentiate between encoding, consolidation and retrieval/retention. For example, Dunlosky & Salthouse (1996) demonstrated that older adults showed a significant deficit in both gained and lost access over a five trial recall task (see Chapter Three for further detail). It is hypothesised that gained access represents encoding and lost access represents consolidation (e.g. Woodard, Dunlosky & Salthouse, 1999). Compared to younger adults (aged in their 20's) older adults (aged over 60) showed apparent deficit in encoding and consolidation. Dunlosky & Salthouse (1996) also showed that memory deficits were apparent over a longer time period for older compared to younger adults, which suggested that there is also a retrieval deficit contributing to the decline in episodic memory in healthy aging. The findings of Dunlosky & Salthouse (1996) are robust, in that younger adults show superior encoding, consolidation and retention of words when studying information in a multi-trial technique compared to older adults. Mitrushina, Satz, Chervinsky & D'Ella (1991) also showed that the encoding deficit of older adults continues to deteriorate after the age of 57.

Given the neuroscience evidence above, and what is known about the neuropsychology of memory, various theories of memory decline have been proposed. One theory which has the benefit of support from neuroscience is that older adults have a deficit in processes reliant upon the frontal lobe. In the following section, memory failures in healthy aging are characterised as having a frontal basis (see Perfect, 1997).

1.2.3 Frontal theory of cognitive aging

Rylander (1939) identified dysexecutive functioning syndrome which was associated with damage to the prefrontal cortex. Dysexecutive functioning syndrome is characterised by cognitive/memory deficits which are also shared by older adults who show the effects of healthy aging; that is, encoding/retrieval problems, attentional deficits, problems with inhibiting unwanted information and problems with overall executive functioning (as characterised by task switching tests and divided attention tasks). Therefore, cognitive psychologists (e.g. Kester, Benjamin, Castel & Craik, 2002; Perfect, 1997) have argued that cognitive decline associated with healthy aging is possibly due to neurodegeneration of the frontal lobes (e.g. Stuss & Levine, 2002).

Craik & Jennings (1992) demonstrated that healthy older adults show significantly poorer recall, but not recognition, than younger adults. This pattern of results is similar when comparing patients with Korsakoff's Syndrome (caused by chronic alcohol abuse which causes neurodegeneration of the frontal lobe, particularly the PFC) compared to controls (e.g. Warrington & Weiskrantz, 1970). This further supports the view that healthy aging is caused by deterioration in the frontal lobe.

Theories of cognitive aging have also supported this view. For example, older adults show a significant deficit in the ability to inhibit unwanted memory/thoughts (e.g. Hasher & Zacks, 1988). According to the inhibition theory of memory, older adults are unable to focus on a specific scenario or context which means that their memory is overloaded during encoding. This phenomenon is also apparent in patients who have frontal lobe damage (e.g. Stuss & Levine, 2002); therefore it can be argued that the inhibition theory of cognitive aging and the frontal theory of cognitive aging are not actually competing theories as suggested by Hasher & Zacks (1988), but that the inhibition associated with healthy aging is a product of frontal lobe degeneration. This can also be argued for an alternative theory of cognitive aging; the speed of processing theory. Salthouse (e.g. 1996; 1991) argued that cognitive decline in healthy aging can be traced back to a general decline in processing speed. The theory states that because it takes older adults longer to process information then aspects of memory and cognition (e.g. encoding and retrieval) become less efficient as information is degraded over the extended time the processes take compared to younger adults. However, once again there is evidence for a decrease in processing speed in patients with damage to the frontal lobes (e.g. Stuss & Levine, 2002); therefore it is also possible that the aetiology of a decrease in processing speed is associated with frontal lobe damage.

In conclusion, although patients with frontal lobe damage show a great deal of heterogeneity in terms of cognitive deficits displayed, there is a striking similarity between cognitive impairment of patients with frontal lobe damage and the cognitive deficits evident in healthy older adults (e.g. Perfect, 1997). The frontal theory of healthy aging can account for other theories of healthy aging, for example the inhibition of memory and the processing speed theories. Furthermore, neuroimaging studies have demonstrated that older adults show different patterns of activation of the frontal lobes, particularly the PFC, when undertaking cognitive tasks compared to younger adults (e.g. Cabeza, 2002; Grady et al., 1999). Therefore, it can be concluded that cognitive deficits apparent in healthy aging are due to a decrease in frontal lobe functioning.

1.2.4 Environmental support

Tulving (e.g. 1983) produced the encoding specificity principle (ESP) which predicted that matching environmental cues at encoding and retrieval would produce enhanced recall. This was also supported by the levels of processing (LOP) theory (Craik & Lockhart, 1972) which showed that enhanced processing at encoding can increase free recall. As older adults show a deficit in recall compared to recognition, it was hypothesised that this was due to an inability of older adults to encode information at a deep enough level and match it with context to aid retrieval (e.g. Craik, 1986).

Research has shown that processing demands are higher in older adults than younger adults, particularly on tasks that involve free recall and a required increase in attention (e.g. Craik & Anderson, 1999). Therefore, research has investigated whether environmental support at encoding and retrieval can boost memory performance in older adults.

The results show that, in healthy aging, cognitive deficits can be reduced by arranging the environment to provide cues for recall and enhance the encoding period (e.g. Charness & Bosman, 1995; Skinner, 1983). Skinner (1983) reported that it was important to arrange the environment of older adults to reduce processing demands, for example if older adults adopt a set routine for everyday tasks there is less chance of cognitive errors occurring (see Charness & Bosman, 1995). This theory is contrary to the use-dependency theory which predicts that an increase in cognitive activity (e.g. increasing processing demands) is required in older adults who show attenuation in cognitive and neurological decline associated with healthy and possibly pathological aging.

1.2.5 Strategy use and metacognition in healthy aging

First, and most importantly, healthy aging leads to subjective report of memory dysfunction, not just tests of objective memory. Critically, this means of assessing memory also echoes the theories above; subjective reports from older adults have indicated a greater decline in episodic memory compared to other memory systems (e.g. West, Bagwell & Dark-Freudeman, 2008; Zelinski & Gilewski, 2004; Bandura, 1989).

Second, somewhat paradoxically, older adults are also believed to have deficits in awareness – they have difficulties in metacognition – loosely defined as ‘knowing what you know’. There is adequate support from empirical research which has shown that older adults have significant deficits in metacognition and executive functioning (e.g. Souchay & Isingrini, 2004; Craik, 2000). This is a more specific formulation of the executive/frontal hypothesis articulated above (see Section 1.2.3).

1.2.6 Conclusion

In summary, empirical research has shown that older adults report a decline in episodic memory. This has been supported with empirical research which has shown that older adults show a deficit in recall both for words (e.g. Dunlosky & Salthouse, 1996; assessed in Chapter Three) and for proper names (e.g. Cohen & Faulkner, 1986; Chapter Four). This deficit is more apparent in free-recall than cued-recall or recognition due to a hypothesised weakness in encoding, consolidation and retrieval of information of older compared to younger adults. This has been supported by both multi-trial studies (e.g. Dunlosky & Salthouse, 1996; Chapters Three and Four) and studies which have used neuroimaging techniques that have highlighted that older adults show abnormal activity in areas of the brain which are known to be responsible for both encoding, consolidation and retrieval (e.g. Cabeza, 2002; Reuter-Lorenz, 2000; Raz, 2000; Grady et al., 1999). Furthermore, the neuronal atrophy in the frontal lobes, particularly the PFC, associated with healthy aging has supported evidence which has shown that older adults show deficits in executive functioning and metacognition (e.g. Souchay & Isingrini, 2004; Perfect, 1997). The deficits of the episodic memory system, in both healthy and pathological aging, are very debilitating and reduce the quality of life and everyday functioning of older adults. Thus, it is imperative to find rehabilitation techniques to slow the decline of episodic memory in later life.

1.3 The use-it-or-lose-it theory

Popular psychology has accepted the view that regular mental/cognitive stimulation will attenuate cognitive decline in healthy aging and stave off pathological conditions such as Alzheimer’s disease. Since the findings of Bliss & Lomø (1973) psychologists have hypothesised that stimulation of cognitive/neuronal networks will enhance neuronal growth in such networks. Salthouse (1981) predicted that cognitive stimulation would reduce the decline of cognitive functioning which is directly related to advancement of chronological age.

The use-it-or-lose-it theory was thus formed, but the theory rapidly separated to produce two forms of thinking with regards to the protection of cognitive activity. Based on animal research (e.g. Held, 1965) the cognitive reserve hypothesis predicted that cognitive stimulation/environmental enrichment (e.g. Black, Isaacs, Anderson, Alcantara, & Greenough, 1990) at an early age, when neuroplasticity is at its highest, is required for individuals to build up cognitive/neuronal reserve to adapt to cognitive/neurological degeneration associated with healthy and pathological aging (e.g. Nilsson, Perfilieva, Johansson, Orwar, & Eriksson, 1999).

However, the research in both human and animal neurology, for example Calero & Navarro-Gonzalez (2003), indicate that neurogenesis/neuroplasticity is extended into old age. For example, Park & Reuter-Lorenz (2009) and Calero & Navarro-Gonzalez (2003) demonstrated that neurogenesis was still evident in older human adults aged over 80. Taken with evidence from cross-sectional studies (e.g. Christensen & MacKinnon, 1993), which suggest that adults who remained active in middle age and later life showed significantly less cognitive decline and evidence of dementia, it was theorised that activity in later life could also prevent cognitive/neuronal atrophy. This gave rise to the use-dependency theory, which had been hypothesised earlier by Edelman (1987); this theory stated that, due to the existence of neuroplasticity in later life, an increase in cognitive stimulation in later life may attenuate healthy cognitive decline and delay the onset of dementia.

Both theories concur that cognitive stimulation is necessary to enhance neurogenesis, but there is a disagreement about when such cognitive stimulation is needed. There is empirical evidence that a combination of physical and cognitive activity can stimulate the release of proteins such as brain-derived neurotrophic factor (e.g. Stern et al., 2005). However there are still questions as to whether cognitive stimulation/activity, even at a young age, can attenuate or reverse cognitive decline in later life (e.g. Herzog et al., 2009; King & Suzman, 2009).

1.3.1 Support for the cognitive reserve hypothesis

1.3.1.1 Education

One of the largest influences on early development is arguably education (e.g. Bruandet et al., 2008). Therefore, cognitive psychologists have argued that the number of years spent in full time education could represent a measure of cognitive reserve due to the link between education and intelligence (e.g. van Hooren et al., 2007; Mortimer, Snowdon & Markesbery, 2003; Alexander et al., 1997). Mortimer et al. (2003) conducted a large scale cross-sectional investigation into brain size, educational history and presence of dementia in a large cohort of nuns. Their results showed that there was a significant negative relationship between brain size and diagnosis of dementia. There was also a negative relationship between the number of years in education and the presence of dementia. Finally, there was also a direct relationship between brain size and the number of years spent in full time education. As the sample population consisted of nuns it can be argued that socioeconomic factors, which are directly linked to educational status in the general population, can be ruled out of the relationship between education and both brain size and the diagnosis of dementia. As the lifestyle of the whole sample population would be very similar it can be concluded that an increase in the number of years in education can be directly attributed to a decrease in the risk of developing dementia.

Even though the results support the cognitive reserve hypothesis, leisure activities at an earlier age were not considered and the sample population cannot be regarded as representative of the whole population. Furthermore, Schooler & Mulatu (2001) showed that occupational status and leisure activity can also mediate the relationship between cognitive functioning and cognitive decline. As all the sample population in Mortimer et al. (2003) had the same occupation, it can be argued that the cognitive reserve hypothesis is supported, but it is not possible to transfer these findings to the general population, especially since no data was reported regarding previous occupations/cognitive activity before joining the convent, or the age at which the nuns joined the convent.

As reading is one of the cornerstones in western education, Alexander et al. (1997) investigated the relationship between reading ability, dementia severity and neural functioning. The results showed that individuals who displayed a higher reading ability also showed a reduced severity of dementia and higher neural activity in key areas of the brain, even when demographic mediating factors were controlled for. Alexander et al. (1997) argued that these results demonstrate that an increase in activity at an early age (i.e. mainly through education) enables individuals to build up cognitive and neurological reserves in key areas of the brain which are susceptible to dementia and possibly neurological/cognitive decline associated with healthy aging (e.g. van Hooren et al., 2007).

Although Alexander et al. (1997) used premorbid intelligence and reading abilities to represent cognitive reserve, and took into consideration mediating factors such as occupation; it can be argued that critical factors of early adulthood/childhood were ignored. Barnes, Wilson, Mendes de Leon & Bennett (2006) highlighted that both social and environmental factors (e.g. the availability of books and cognitively stimulating resources) can also have a large impact on cognitive development. Wilson et al. (2005) also investigated the relationship between cognitive resources available earlier in life and cognitive functioning later in life. The results showed that the availability of cognitive resources (self-reported retrospectively) was significantly correlated with cognitive functioning. However this relationship was not significant when the researchers controlled for current cognitive activity.

Therefore, it can be argued that the measurement of reading ability and educational history of Alexander et al. (1997) is an insufficient measure of cognitive reserve, even though it is more objective than the measures of Barnes et al. (2006), Wilson et al. (2005) and Kondo, Niino & Shido (1994) who used retrospective self-reports from participants or family members. Furthermore, although occupation was taken into account, there was no direct measurement of socio-economic status in Alexander et al. (1997), which is directly influenced by educational history and occupation; in turn, this can have both a direct and indirect impact on both physical and psychological health status (e.g. Elias & Wagster, 2007; see Section 1.4 for further discussion).

Kondo et al. (1994) conducted controlled case studies of individuals who had developed dementia. A number of factors were investigated using retrospective accounts of family members and documented history. The results showed that the number of years spent in full time education had a significant negative relationship with the age at which participants developed dementia. The results also showed that, at a younger age, those who developed dementia later in life had a higher level of psychosocial interaction as reported by relatives. Taken together Kondo et al. (1994) concluded that high levels of education and psychosocial interaction reduced the risk of developing dementia earlier in life by a significant amount. Overall, the results repeatedly show that the incidence of dementia is significantly lower in adults who have higher educational attainment or a greater number of years in education than those with lower educational attainments or fewer years in education (e.g. van Hooren et al., 2007; Callahan et al., 1996; Evans et al., 1993; Katzman, 1993; Zhang et al., 1990).

1.3.1.2 Life-long cognitive stimulation and measures of cognitive reserve

Gold et al. (1995) used a longitudinal technique with structural equation modelling to investigate the relationship between early adult verbal and non-verbal IQ and the same IQ measured in later life. Taking into account personality, lifestyle, age and health the results indicated that early IQ scores of non-verbal intelligence were the most reliable predictors of non-verbal intelligence in later life. This also appeared to be the case for verbal intelligence, however health and lifestyle also played a part. Although the analysis did not take into account leisure activities, the results show support for the cognitive reserve hypothesis in respect to healthy aging.

However, Hertzog, Hultsch and Dixon (1999) argued that the results of Gold et al. (1995) could have been interpreted differently if more factors were included in the structural equation modelling. Hertzog et al. (1999) demonstrated that the measurement of verbal intelligence was not related to early life activity/occupational status. The critical point is that other factors were not included in Gold et al.'s (1995) research, which may have influenced the relationship between early life experiences and cognitive functioning later in life.

Although the relationship between education and cognitive decline/dementia indicates that an increased number of years in education protects against cognitive decline in later life (by stimulating neuronal growth at an early age) there is an alternate explanation for the results and the cognitive reserve hypothesis. Romainville (1994) has pointed out that success in education requires enhanced metacognition and skills to pass exams. Therefore, one argument is that a greater number of years in education is not protective of cognitive decline but is a demonstration of superior metacognitive abilities. Research has demonstrated that individuals who have a greater number of years in education show later onset of dementia but a faster deterioration (e.g. Bruandet et al., 2008). One possibility is that individuals with superior metacognitive skills (and therefore higher educational attainment) are more able to adjust to the cognitive decline (associated with preclinical dementia) until the severity of the dementia reaches a critical point when metacognition is significantly impaired.

The two explanations of the cognitive reserve hypothesis are not mutually exclusive, it is possible that the neuronal growth, through stimulation, brings about an increase in higher order functioning, particularly associated with the frontal lobes (e.g. Hensch, 2005; Hensch, 2004; Crowe, Andel, Pedersen, Johansson & Gatz, 2003). It is also likely that the two accounts of the cognitive reserve hypothesis mediate one another; that is as neuronal growth occurs individuals develop new cognitive abilities and an increase in a need for cognitively stimulating activities, which in turn stimulates further neuronal growth (e.g. Dellenbach & Zimprich, 2008). Therefore, education is not the only activity which has been implicated as having the ability to produce a cognitive reserve if undertaken regularly early in life.

Friedland et al. (2001) acknowledged that education was not the only factor which may influence the course of cognitive decline across the lifespan. Occupational and leisure activities can also have a bearing on cognitive ability in early and late adulthood. They used a between-subjects technique to investigate retrospective accounts of leisure activities including indexes of time spent undertaking various activities, number of activities undertaken and intensity of partaking in such activities. The results showed that the control group attempted significantly more activities at a greater intensity and for a longer time period in early adulthood than those who were in the case group (i.e. with dementia). However, the results also showed that those in the case group showed significantly less activity in later adulthood compared to participants in the control group.

Friedman et al. (2002) also conducted similar research but did not rely on self-report methods of participants. The researchers sought retrospective accounts of physical and intellectual activity of patients with dementia from friends and family. The results show that both physical and intellectual activity, particularly earlier in life, was significantly associated with a later onset of dementia. Both research groups argued that the increased activity in early adulthood represents support for the cognitive reserve hypothesis while the difference in activity in later adulthood is likely to be due to symptomology of preclinical dementia (see Section 1.4 for further discussion).

Undertaking cognitive activity earlier in life is not the only factor which appears to influence cognitive functioning in later life. Individuals can only undertake cognitive activity if the environment provides the opportunity to do so; therefore Wilson et al. (2005) and Barnes et al. (2006) investigated whether access to cognitively stimulating material at different ages across the lifespan mediated cognitive function in old age. The results show that access to cognitively stimulating materials at childhood has a direct impact on cognitive functioning in old age along with number of years in education. The results also show that cognitive stimulation at an early age influences cognitive activity in early and mid adulthood which also has a significantly positive relationship with cognitive functioning in later life and the decrease in the likelihood of developing dementia. Wilson, Barnes & Bennett (2007) have reviewed the research pertaining to the relationship between cognitive activity and cognitive decline in later life. They concluded that in line with Christensen & MacKinnon (1993) education and early adulthood/childhood cognitive stimulation can enable an individual to build up a cognitive reserve which can counter the cognitive/neuronal atrophy associated with both healthy and pathological aging.

1.3.1.3 Twin studies

As discussed in Section 1.4 Crowe et al. (2003) acknowledged the techniques of retrospective self-report measures can be regarded as unreliable. They also recognized that the development of dementia can have a genetic component which may mediate the relationship between cognitive activities and the onset of dementia (e.g. King & Suzman, 2009; Elias & Wagster, 2007). Considering this confound, Crowe et al. (2003) investigated the relationship between early cognitive activities of twins and the development of dementia later in life. The twins had filled in a questionnaire 20 years before being assessed for dementia. The results indicate that the participants who had only undertaken activities which related to intellectual/cultural leisure pursuits and those who undertook activities which were defined as self-improving or domestic were less likely to develop dementia even after controlling for educational attainment. Although this appears to support the cognitive reserve hypothesis, it was unclear how the researchers constructed the activity categories and the questionnaire was very basic (e.g. when participants were asked about activities undertaken there was no rating scale, just nominal responses (i.e. yes/no)).

1.3.1.4 Animal research

Animal research has demonstrated that mammals which have been raised in enriched environments demonstrate superior cognitive/memory (particularly spatial memory) abilities and show significant differences in neurological autonomy compared to animals which have been raised in sterile environments. For example, Held (1965) raised kittens in an enriched environment from a very young age. In adulthood the cats demonstrated superior spatial memory abilities compared to cats which had been raised without an enrichment program. Furthermore the enriched cats also showed a significantly thicker neocortex than non-enriched cats. Mirmiran, Van Gool, Van Haarren, & Polak, (1986) also demonstrated that rats that were raised in an enriched environment showed a significantly denser and thicker cerebral cortex than rats that were raised in a sterile environment. Ronn, Berezin & Bock (2000) and Nilsson, Perfilieva, Johansson, Orwar & Eriksson (1999) acknowledged that cognitive stimulation at an early age and throughout life can produce an increase in neurogenesis in rodents. However, they also acknowledged that cognitive enrichment programs which have been used in animal studies also promote physical activity, which has also been linked to the release of neurochemicals which promote neurogenesis (e.g. BDNF).

1.3.1.5 Summary

In conclusion, the majority of research has used between-subject techniques to investigate the impact of early life experiences on the process of cognitive decline in both healthy and pathological aging. The results show support for the cognitive reserve hypothesis, in that, older adults who report a higher level of cognitive engagement/activity at an earlier age show significantly less cognitive decline and later onset of dementia. It is possible that this is due to an increase in cognitive resources which delay the effects of aging or that individuals who are more cognitively active earlier in life develop metacognitive abilities which enable them to respond more efficiently to the cognitive demands of aging. It is also likely that the cognitive reserve hypothesis represents a combination of both theories of how early cognitive activity leads to less cognitive decline in later life. Measures of cognitive reserve have been both objective (e.g. number of years in education or measures of intelligence (e.g. Mortimer et al., 2003; Alexander et al; 1997)) and subjective/self-report (e.g. Barnes et al., 2006; Friedman et al., 2002; Kondo et al., 1994). Methodological issues are reviewed in Section 1.4.

1.3.2 Evidence for the use-dependency theory

Research into LTP has shown that cognitive stimulation is critical for neurogenesis and to prevent neuronal atrophy (e.g. Bliss and Lomø, 1973). Furthermore, Baltes & Lindenberger (1997) concluded that 93.1% of age-related decline in cognitive functioning can be accounted for by sensory acuity (i.e. insufficient neurological stimulation). This suggests that stimulation can enhance neurogenesis, and possibly attenuate neurodegeneration associated with healthy and pathological aging. Park & Reuter-Lorenz (2009) have demonstrated that neuroplasticity exists throughout the lifespan and specifically in later life. Therefore, researchers have speculated that cognitive stimulation/activity at a later age (or throughout the entire lifespan) can promote cognitive/neuronal growth and/or reduce cognitive/neuronal atrophy associated with either healthy or pathological aging (e.g. Edelman, 1987).

1.3.2.1 The use-dependency theory and dementia

Early applications of the use-dependency theory targeted persons with dementia in the hope that environmental stimulation would attenuate or reverse the cognitive deficits associated with the disorder. For example, Mirmiran et al. (1992) showed that patients with Alzheimer's disease showed a positive response when light levels were increased. There are two possible conclusions; first, the increase in light stimulated the suprachiasmatic nucleus and increased the production of certain neurotransmitters such as noradrenalin and serotonin. Second, the increase in light raised the sensory input of the patients and provided an increase in cognitive stimulation. This second possibility was supported by Mirmiran, van Someren & Swaab (1996) who showed that Alzheimer patients who were exposed to a more cognitively stimulating environment showed an increase in social and cognitive functioning according to carers.

Although this research suggests that an increase in cognitive stimulation in patients with dementia can promote cognitive functioning, it must be acknowledged that reports of cognitive functioning were from carers and not objective or even self-report measures. In a classic study, Sunderland, Watts, Baddeley & Harris (1986) showed that self-report and carer/spouse reports of cognitive functioning in older adults are unreliable and arguably invalid. Furthermore, it is difficult to remove possible influences from the researchers in Mirmiran et al. (1996), for example, demand characteristics; the trials did not appear to be double blind, therefore it is difficult to draw a causal relationship between the supposed increase in cognitive stimulation and the reported increase in cognitive functioning of the dementia patients.

1.3.2.2 The use-dependency theory in healthy and pathological aging

It was clear from the investigations of Miriman and colleagues that more understanding of the use-dependency theory was needed before direct interventions could be applied. Therefore researchers started to investigate whether the link between cognitive activity and functioning (or the development of cognitive impairments) was evident in longitudinal studies. For example, Bosma et al. (2002) conducted a six year longitudinal study with participants aged over 55, which monitored participants cognitive functioning and self-reported cognitive, physical and social activity. The results indicated that a higher level of all three activities was positively related to superior cognitive functioning. Cognitive activity, alone, was associated with higher executive and episodic memory functioning. However, the researchers also report that a higher level of functioning at baseline was also associated with higher cognitive functioning at the six year follow-up. The authors claim that the results show a symbiotic relationship between activity and cognitive functioning whereby older adults who have and maintain a high level of cognitive, physical and social activity show a reduced level of age-related decline. However, the measures of all three activities were potentially limited as the activities were ill-defined and participants only had to report the undertaking of one specific activity in each category to be regarded as ‘active’.

Wilson et al. (2002) reported that an increase in one cognitive activity per day was associated with a significant reduction in both cognitive decline (without the presence of dementia) and the likelihood of developing dementia. A similar conclusion was found by Verghese et al. (2003), in that one less cognitive activity per day resulted in a significant increase in the probability of developing dementia even when controlling for preclinical dementia. Both Wilson et al. (2002) and Verghese et al. (2003) used a longitudinal technique to investigate the causation of undertaking cognitively stimulating activities and their results on cognitive decline in later life. Both research groups used a more appropriate measure of cognitive activity than Bosma et al. (2002); that is, there was a larger range of cognitive activities assessed and a composite score for overall activities was formulated on a sum from a Likert scale.

This methodology was also used by Hultsch, Hertzog, Small & Dixon (1999), who used structural equation modelling to follow 250 older adults over a six year period, with follow-ups of approximately two years. A relatively large number of cognitive and everyday (self-maintenance/leisure) activities were taken into account and participants were tested on objective measures of cognitive functioning, including episodic memory, working memory, verbal fluency, general knowledge and processing speed.

There was a significant influence of novel information processing activities on a composite measure overall cognitive functioning. Novel information processing activities included interests such as solving crossword puzzles, watching educational television programmes, doing word games and studying foreign languages. This type of information processing was significantly causally related to cognitive functioning, unlike activities such as self-maintenance (e.g. cooking one's own meals or maintaining personal hygiene). Of particular interest was that frontal lobe functioning appeared to have a mediating effect for cognition such as episodic memory and processing speed. Furthermore, novel information processing over the timescale of the study also appeared to have significant and direct impact on executive functioning.

The results indicate that novel information processing has a direct effect on executive functioning which in turn mediates other aspects of cognition which are shown to decline in health aging. The change in novel information processing also shows a significant but critically large effect on current executive functioning. Therefore, Hultsch et al. (1999) conceived that it is impossible to determine whether a decrease in novel information processing causes a reduction in cognitive functioning or whether the natural aging process causes a decrease in overall cognitive functioning, which in turn forces older adults to give up undertaking novel or difficult information processing activities (see Section 1.4 for further discussion). This was supported by Hertzog, Hultsch & Dixon (1999) who analysed the data of Hultsch et al. (1999) in two different ways and found equivocal evidence for the two explanations for the relationship between cognitive activity and cognitive functioning in later life. The results showed that the model which used cognitive functioning as a predictor of cognitive activity was as significant as the model which predicted functioning from cognitive activity. In line with Hertzog & Nesselroade (2003) it was concluded that all between-subjects models/studies of the relationship between cognitive activity and cognitive decline are incomplete because it is impossible to take into account all variables which either effect or mediate cognitive functioning (e.g. Hertzog, 2009).

MacKinnon, Christensen, Hofer, Korten & Jorm (2003) also used a longitudinal technique to investigate the relationship between cognitive and/or physical activity and empirical measures of crystallised and fluid intelligence. The study ran over seven years and took into account mainly physical activities but also a number of cognitive activities such as reading and watching television. The results concluded that over the seven year period both cognitive and physical activities significantly declined with age as did both measures of intelligence but particularly fluid intelligence. There was a significant relationship between the amount of cognitive and physical activity that participants undertook and the decline in intelligence over the study. However, there was one group of participants who showed no decline in cognitive activity but continued to show a decline in intellectual functioning. This raises doubts over whether even physical activity is the sole determinant of cognitive functioning when pathological aging is excluded.

Although MacKinnon et al. (2003) suggests that there is viability for both cognitive and physical intervention techniques to reduce cognitive decline in healthy aging they point out that certain samples of older adults may not benefit from such interventions. It is the case that the sub-sample of older adults who did not show a decrease in activity but showed a decrease in intellectual functioning raises questions over the validity of the use-dependency theory. However, there is an alternate explanation, that is, that the sub-sample already reported a very low activity level, therefore it is possible that the activity levels for these individuals could not significantly decrease over the study period i.e. floor effects.

The results of MacKinnon et al. (2003) and Christensen et al. (1993) support the use-dependency theory in that current cognitive activity is significantly higher in individuals who also perform better on measures of cognitive/intellectual functioning. However, it must be questioned whether the measures of cognitive activities are appropriate and whether other measures of cognitive functioning should have been taken into account. As will be seen in Section 1.2, aging takes a larger toll on certain cognitive systems than others (e.g. episodic memory and metacognition/executive). Arguably, studies which have ignored cognitive functions such as episodic memory, are not focusing on the aspects of cognition which are most affected by age (Salthouse, 2007).

1.3.2.3 Bidirectional theories

The lack of a definitive causal relationship between cognitive activity and function, in later life, led Schooler, Mulatu & Oates (1999) to hypothesise that the relationship between cognitive activity and cognitive decline is bidirectional. In line with Edelman (1987), Schooler et al. (1999) proposed that an increase in cognitive stimulation would bring about an increase in cognitive functioning, which in turn will stimulate another increase in cognitive stimulation, because such adults will feel more able to take on more cognitively demanding tasks (supporting the view of Dellenbach & Zimprich, 2008). However, Schooler et al. (1999) proposed that the opposite is also true; a lack of cognitive stimulation or required cognitive effort will reduce adults' ability and desire to undertake cognitively stimulating activities and hence a cycle of decline will ensue.

Schooler et al. (1999) conducted interviews and took self-report measures of job complexity as well as conducting cognitive neuropsychological tests of abstract thinking and intelligence (e.g. the embedded figure test and hypothesis generation ability). The results showed that cognitive functioning and job complexity appeared to have a bidirectional relationship, which indicated that over the ten year study period, participants who undertook more complex occupations had a higher level of functioning, which in turn encouraged them to attempt more complex jobs at work. This indicated that individuals who were more cognitively able, undertook more cognitively demanding tasks and the relationship between cognitive ability and task requirements reinforced one another. However, Kohn et al. (1997) commented that the relationship between job complexity and intellectual functioning was culturally specific to the USA.

Kohn et al. (e.g. 1997) did not find a similar relationship between job complexity and intellectual functioning for employees in Poland or the Ukraine.

One point which is also questionable is the sampling technique used in Schooler et al. (1999), specifically that individuals who had given up/left work were excluded from the analysis (Salthouse, 2007). One possibility why individuals left work (especially at an older age) could be due to a decrease in cognitive ability/cognitive functioning. Therefore, to remove this subsample from the final analysis may have excluded data that potentially might not have supported the relationship between cognitive functioning and job complexity. That is, Schooler et al. (1999) argued that job complexity had a direct (but reciprocal) relationship with cognitive functions, which indicated a partial causal relationship between job complexity and cognitive functioning. However, it is impossible to conclude a causal relationship when ruling out the factors which influence the unemployment/retirement of the participants who were excluded from the analysis. Although Schooler (2007) argued that the cognitive functioning of those who dropped out of work did not significantly differ from those who were still working (when compared at baseline) it remains questionable whether cognitive change over the period of the study might have impacted on the proposed reciprocal relationship which Schooler et al. (1999) described (e.g. Salthouse, 2007).

Schooler & Mulatu (2001) took this criticism into account and also included a self-reported measurement of leisure activities which have been shown to influence cognitive functioning (e.g. Barnes et al., 2006). The results of Schooler et al. (1999) were confirmed, in that older adults who had a higher degree of job complexity and a higher number of cognitive leisure activities showed significantly better cognitive functioning. The results also held true for individuals who were no longer working, which supports the use-dependency theory, in that older adults who are more cognitively active show and report a higher level of cognitive functioning than those who are less active. It must be acknowledged, however, that Schooler & Mulatu (2001) did not take into account a number of factors which are known to influence current cognitive functioning, such as potential depression or preclinical dementia (e.g. Hertzog, Kramer, Wilson & Lindenberger, 2009; Elias & Wagster, 2007). Furthermore, once again, the dependent variables of Schooler & Mulatu (2001) exclude cognitive functioning, such as episodic memory, which are associated with cognitive decline in healthy aging.

Finally, with regards to Schooler & Mulatu (2001), Salthouse (2007; 2006) also raised the question about the dependent variables used. A number of the dependent variables were extracted from interviews with the participants. Salthouse (2007) indicates that this type of cognitive assessment is potentially unreliable and invalid. Furthermore, the overall cognitive functioning composite was not significantly related to age, which raises further doubt over the measure which Schooler and colleagues used to measure cognitive functioning (see Section 1.4 for further comments).

Dellenbach & Zimprich (2008) also noted a reciprocal relationship between cognitive functioning and cognitive activity when they conducted a cross-sectional study. Participants aged between 65 and 81 reported the level of engagement in typical intellectual activities and were assessed for crystallised and fluid intelligence. Other factors such as number of years in education and sex were also taken into account. The results showed a strong relationship between education and crystallised intelligence. There was also a significant positive relationship between typical intellectual engagement and crystallised, but not fluid intelligence. The association between intellectual engagement and crystallised intelligence was maintained when mediating factors were taken into account (e.g. education). However, the measure of crystallised intelligence was based on reading ability which is closely associated with many of the intellectual activities that Dellenbach & Zimprich (2008) measured. The lack of a relationship between intellectual engagement and fluid intelligence may be due to the use of a cross-sectional design as it is difficult to rule out preclinical dementia.

Furthermore, once again there was no measure of episodic memory or metacognition, which both decline with age. As the relationship between intellectual engagement and cognitive functioning was only investigated in older adults and not younger adults it is difficult to determine whether the correct dependent variables were used. As acknowledged by Salthouse (2007) it is important to ensure that an investigation has sufficient dependent variables to investigate the relationship between cognitive activity and cognitive decline across a wide spectrum of cognitive functions.

The grouping of cognitive activities are discussed in depth in Section 1.4, however different grouping strategies have demonstrated how some cognitive activities may appear to benefit cognitive function in later life differently in different cultures. For example Wang et al. (2006) conducted a longitudinal investigation of the relationship between leisure activities and cognitive functioning in adults aged over 55 across a 5 year period. Playing board games (e.g. Mahjong, chess, poker) was significantly related with a decrease in cognitive decline and the development of cognitive impairments. However, Jopp & Hertzog (2007) found no significant benefit, with regards to cognitive decline across the lifespan, of playing games such as chess or doing crosswords. Although the results of Jopp & Hertzog (2007) showed a positive correlation between playing games (including doing crosswords) and inductive reasoning, as well as verbal fluency, there was no dissociation of this relationship between younger and older participants.

There are two key points from the comparison of Wang et al. (2006) and Jopp & Hertzog (2007); first, the age range and analysis was different in the two studies. It is possible that a combination of different statistical analysis and a different age range produced different results and implicated a positive relationship between leisure activities and cognitive decline in Wang et al (2006), but not in Jopp & Hertzog (2007). Second, the results show how different dependent variables can produce different results. Jopp & Hertzog (2007) used a wide range of clinical neuropsychological assessments to measure cognitive functioning whereas Wang et al. (2006) only used the Chinese version of the mini mental state exam (MMSE). Jopp & Hertzog (2007) also took into account subjective measures of cognitive functioning such as MemSE. Therefore it can be concluded that both studies have their own strengths, for example Jopp & Hertzog (2007) used a cross-sectional design compared to a longitudinal design as used by Wang et al. (2006), but both studies have produced contradictory support for the relationship between leisure activities and cognitive decline in later life. Section 1.4

also raises issues with regards to the cultural bias of the evidence which has supported the use-dependency theory.

Some researchers (e.g. Hertzog et al., 2009) argue that cognitive activity alone is insufficient to counteract healthy and/or pathological cognitive decline throughout the later life span. Other activities, such as physical exercise or social interaction have been linked to a decrease in cognitive decline in later life (e.g. Bosma et al., 2002). For example, Bassuk, Glass & Berkman (1999) conducted a large scale longitudinal study to investigate the relationship between social networking/interaction and cognitive functioning for adults aged over 65. The results, which were supported by Lövdén, Ghisletta & Lindenberger (2005), indicated a significant positive relationship between social activity and cognitive functioning. However the cognitive assessment was very brief (e.g. the MMSE) and it was impossible to rule out preclinical dementia.

The results from Friedman et al. (2002) and Sturman et al. (2005) also showed that cognitive functioning and the development of dementia was negatively associated with self-reported physical and cognitive functioning. Both of these indicate that physical activity may have a larger impact on cognitive functioning later in life due to the neuroimaging and neurochemical evidence that physical activity is associated with an increase in cerebral blood flow and production of BDNF. The link between physical activity and brain structure development in later life is also well established in animal research (e.g. Nilsson et al., 1999).

1.3.2.4 Summary

In conclusion, both animal and human research has shown that enrichment can increase the cognitive functioning of individuals in later life. As explained by Li et al. (2008) skill acquisition in later life is not impossible but takes longer than in early life. Furthermore Maguire, Woollett & Spiers (2006) point out that repeating cognitive activation can lead to long lasting cognitive and neurological changes such as improved spatial memory in London taxi/bus drivers. Cross-sectional and longitudinal research have confirmed a positive link between cognitive activity and cognitive functioning for older adults, however the relationship does not always imply that higher rates of cognitive activity determine increased levels of cognitive functioning or an attenuation in cognitive decline (e.g. Hertzog, 2009; Hultsch et al., 1999). It is possible that individuals who display a higher level of cognitive functioning in earlier life are predisposed to undertake more cognitively stimulating activities (see Section 1.4 for discussion).

1.3.3 Intervention studies

Taking into account the methodological issues with research that has focused on the cognitive reserve hypothesis and the use-dependency theory (see Section 1.4) the weight of evidence suggests that cognitive (and/or physical/social) activity can benefit cognitive functioning throughout the lifespan (e.g. Hertzog et al., 2009). As described in Section 1.2 decline is evident in a number of cognitive domains when observing healthy and pathological aging. Cognitive interventions have generally focused on two specific techniques, either modifying the cognitive processes that are known to decline with age (e.g. using mnemonics to counteract encoding or consolidation difficulties in older adults; e.g. Dunlosky et al., 2007) or increasing overall cognitive and potentially physical/social activity (e.g. Carlson et al., 2008).

1.3.3.1 Strategic training techniques

Rebok & Balcerak (1989) trained younger and older adults in the method of loci mnemonic technique. Both younger and older adults were tested on immediate memory of twelve words and twelve digits. A between-subjects technique was used to compare (younger and older adults) who received/did not receive training to those who also received/did not receive feedback on their performance over the study. The results showed a significant benefit of memory performance in younger and older adults as a result of training, however no dissociation between younger and older participants. The results also did not show a significant benefit of memory performance feedback (for either the mnemonic or control group) in either sample population.

Rebok & Balcerak (1989) also took measures of MemSE before and after the study. Their results indicated that MemSE was not significantly affected by the training of mnemonics compared to the control group. The results also show that participants with a higher MemSE responded better to cognitive training than those with a lower MemSE at baseline. Finally the results show that performance feedback had a significant effect on MemSE, particularly for older adults, which indicates that MemSE may mediate the relationship between cognitive training and cognitive functioning. The authors concluded that an increase in MemSE, through intervention techniques, may enhance mnemonic interventions in older adults.

Research has shown that strategic training techniques can have an immediate impact on recall in children, younger adults and older adults to a similar degree. However the long-term benefits of such training are not evident in older adults who do not receive refresher courses (e.g. Brehmer et al., 2008). Nyberg et al. (2003) used a mnemonic training technique similar to Brehmer et al. (2008). Neuroimaging revealed that younger adults showed a significant increase in activation in the frontal and occipital/parietal lobes when they were using the mnemonic technique. However, when older adults successfully used the training strategy there was only evidence of activation in the occipital/parietal lobe and not in the frontal region. This supports research by Perfect (1997), in that older adults show deficits which are associated with frontal lobe damage (e.g. executive functioning and metacognitive control). Therefore, the evidence indicates that mnemonic strategies, such as those used in Nyberg et al. (2003) can be effective in younger adults, but due to frontal deficits older adults do not implement the strategies which they have learnt (e.g. Brehmer et al. 2008).

Ball et al. (2002) used three different training techniques and compared cognitive functioning of the three training techniques to a no contact control group over a two year period. Cognitive interventions consisted of reasoning training, processing speed training or episodic verbal memory training. For each experimental group there was ten sessions and 60% received a four session booster period of 11 months after the original training period. Compared to the control group, participants in each experimental group showed significant gains in the respective training abilities of the two year period.

Furthermore, the participants who received the booster session also show a significant increase in respective cognitive functioning for the reasoning and processing speed intervention groups but not in episodic memory group. However, there was no significant difference on self-reported independent living abilities between the control group and any of the experimental groups.

Ball et al. (2002) argued that the lack of a significant difference between the control group and any of the experimental group, in terms of independent living capabilities, was due to the relatively short follow-up. Willis et al. (2006) conducted a five-year follow-up of Ball et al. (2002) and offered participants a 35 month booster session. The results confirmed a significant benefit of each intervention on the relevant cognitive training. The 35 month booster showed significant improvement for the processing speed group, but not the other two intervention groups. The results only showed significant benefits for independent living in the reasoning group. Furthermore, booster sessions did not appear to have a significant benefit for self-reported independent living.

The results of Willis et al. (2006) indicate that certain cognitive interventions are not transferred to other cognitive domains (e.g. processing speed and memory training), however, other cognitive interventions which focus on executive functioning or inductive reasoning appear to increase cognitive function and are transferrable to everyday functioning. The relationship between inductive reasoning/executive functioning and metacognition is complicated but there is evidence that all three cognitive functions are interrelated (see Section 1.2). One of the key aspects is that healthy age has a significant detrimental effect on both executive functioning and metacognition (e.g. Souchay & Isingrini, 2004), therefore some interventions have focussed on promoting metacognition to enhance episodic memory functioning. Dunlosky, Kubat-Silman & Hertzog (2003) used a metacognitive intervention which taught older adults to self-test when learning paired-associates. Half of the experimental groups also received method of loci training with or without the self-testing training. The results showed a significant increase in learning paired associates for the experimental group compared to the control group, but only on self-paced trials and not on experimenter-paced trials. Furthermore, there was no significant increase in the learning of single words of the experimental group over the control group.

Dunlosky et al. (2007) repeated the experiment and concluded that there was no significant benefit of combining strategy training with self-testing because the participants who were only trained in either technique showed a similar increase in episodic memory compared to the control group. One possibility for this is that the group who received a combination of training techniques only received one hour tuition on both techniques while participants who were trained in single techniques received two hours tuition. However, Dunlosky et al. (2007) argue that it is most likely that the participants who were trained in the strategic technique learnt to self-test. The results also indicated that the reason why self-testing did not show benefits on experimenter-paced trials was because the participants had insufficient time to self-test.

Metacognitive training has also been shown to be effective in younger adults who have significantly low decision making ability at baseline. For example, Batha & Carroll, (2007) took self-reported metacognition and decision making measures of younger adults. The experimental groups were then given metacognitive training which was aimed at improving problem solving and decision making. Participants who showed poor decision making and metacognitive ability at baseline had a significant improvement in problem solving after training compared to the control group. However, participants who showed high levels of decision making and metacognition at baseline did not benefit from the metacognition training. Not only do the results support the view that there is a relationship between metacognition and decision making/problem solving, but also that individuals who have poor decision making (e.g. older adults; Aristico, Cervone & Pezzuti, 2003) may benefit from metacognitive/inductive reasoning training.

The difference between standard memory training (e.g. method of loci) and the metacognitive training (e.g. strategic training) was also investigated by Cavallini, Pagnin & Vecchi (2003). The results show that both training techniques promoted objective and subjective measures of memory functioning and cognitive awareness in both younger and older adults. This was the case for empirical measures of cognitive functioning and ecological measures of cognitive functioning/awareness. The results also show that strategic training has a significantly greater impact than mnemonic training, suggesting that metacognitive interventions are more transferable than standard mnemonic training techniques.

As MemSE is a critical component of metacognition (e.g. Berry, 1999) some cognitive interventions have combined strategic training with MemSE enhancing. West et al. (2008) showed that a combination of strategy training and MemSE training produced significant gains in both self-reported cognitive awareness and episodic memory ability. However, as discussed in Section 1.4, the relationship between MemSE and metacognition in aging is not unambiguous and it is possible that enhancing MemSE in older adults may lead to an unrealistic opinion of ones memory ability and therefore lead to an over-reliance on external memory aids (e.g. Bäckman, Josephsson, Herlitz, Stigsdotter, & Viitanen, 1991).

The role of executive functioning has also been investigated in cognitive interventions (e.g. Karbach & Kray, 2009). In the study by Karbach & Kray (2009) children, younger adults and older adults were trained in a variety of tasks which involve executive functioning, such as task switching, variable task switching and verbalisation before task switching. A number of dependent variables were used to assess near and far transfer effects of the intervention. There was clear evidence of near transfer effects of the training for all age groups, however, the far transfer effects were relatively small with regards to effect size. The results indicated that executive functioning training can be beneficial for individuals who have high executive functioning at baseline, supporting those of Bissig & Lustig (2007).

Jennings, Webster, Kleykamp & Dagenbach (2005) investigated whether consciously-controlled recollection of information had a significant impact on older adults ability to recognise words compared to a standard recollection group (i.e. when participants had to indicate whether a word had appeared previously) and a no-contact control group. The recollection technique used by Jennings et al. (2005) increased the lag between repetitions of recognised words. The recollection training increased measurements of frontal functioning (e.g. source memory, digit substitutions etc), but did not have a significant effect on episodic or immediate memory functioning. Bissig & Lustig (2007) replicated the findings of Jennings et al. (2005), but showed that the recollection technique was only effective for individuals who had a better encoding strategy at baseline. Therefore, these results suggest that cognitive interventions are only beneficial in older adults who show a relatively high level of cognitive function and not effective for those who can be deemed to be at risk (e.g. Van der Bij, Laurent & Wensing, 2002).

In conclusion, pure cognitive training techniques show significant increases in cognitive functioning of older adults, but mainly for the trained cognitive domain (e.g. Brehmer et al., 2008; Willis et al., 2006; Dunlosky et al., 2003; Ball et al., 2002; Rebok & Balcerak, 1989). Therefore, certain cognitive training has focused on metacognition and/or executive functioning (e.g. Karbach & Kray, 2009; Dunlosky et al., 2007), which have shown greater transfer effects. However, the results of cognitive training techniques do not replicate the findings of investigations into the use-dependency theory. In fact the key findings suggest that cognitive awareness (e.g. metacognition) is a key function which determines cognitive functioning in later life; thus it is possible that metacognition may be a key component in the relationship between cognitive activity and cognitive functioning in later life (i.e. the use-dependency theory).

1.3.3.2 Interventions based on the use-dependency theory

Due to the lack of transferability of cognitive training techniques researchers have tried to produce interventions which mimic the use-dependency theory (e.g. Carlson et al., 2008). Other interventions have incorporated cognitive activity with social and/or physical activity (e.g. Small et al., 2006). These types of studies have provided strong support for the evidence of plasticity in aging and have suggested that a change in lifestyle can attenuate cognitive decline and/or increase cognitive function in later life.

Basak, Boot, Voss & Kramer (2008) investigated an everyday activity over a longitudinal period with regards to its effect on executive functioning. Over an eight week period, the experimental group were required to play a strategy-based computer game and were compared to a waiting list control group. The results showed a significant increase in executive functioning of the experimental group. Although this suggests that everyday activities which require older adults to develop their strategic thinking improve executive functioning, it was unclear as to whether these skills were transferred to other cognitive domains (e.g. metacognition or episodic memory) because of a restricted number of dependent variables.

Carlson et al. (2008) also used an everyday activity of assisting teaching of primary school children as a cognitive intervention for older adults. The experimental group, compared to a waiting list control group, were required to help children with reading and conflict resolution as well as organise the school library. Participants were assessed in memory (short-term and episodic) and executive functioning. Over the whole sample population memory recall decreased over the academic year of the intervention period and there was no significant improvement in executive functioning. However, participants who showed significantly low executive functioning at baseline showed a significant improvement in episodic memory and executive functioning. The authors argue that this was due to a combination of cognitive, social and physical activity of the experimental intervention, which had a significantly larger effect on older adults who can be categorised as being at risk of cognitive decline/developing cognitive impairments (e.g. low executive functioning).

A similar, but arguably more direct, technique was used by Stine-Morrow, Parisi, Marrow, Greene & Park (2007) to use a multi-modal intervention to increase cognitive functioning in adults aged over 55. The experimental group took part in a 20 week programme which was designed to induce problem-solving, using different techniques, while working in groups. The group work was designed to increase social interaction, team work/compromisation and competition. The results showed a significant increase in objective measures of working memory, inductive reasoning, divergent thinking and visuo-spatial ability, compared to a no-contact control group. However, there was no increase in subjective measures of MemSE, mindfulness or cognitive activities, just need for cognition. These results indicate that activities which replicate the use-dependency theory promote objective measures of cognition but not subjective measures (see Section 1.4).

A cognitive intervention technique, based on the use-dependency theory, was used by Tranter & Koutstaal (2008) to investigate the relationship between everyday cognitive activities and crystallised and fluid intelligence. Participants had a number of group discussions and presentations about cognitive decline and metacognition functioning in aging, they also took part in group activities (which involved decision-making, problem-solving etc), creative workshops and did homework (e.g. solving word puzzles, number puzzles etc). Compared to the control group, participants who undertook the activities over the 12 week period showed significant improvement in fluid, but not crystallised, intelligence. These results were still evident after controlling for number of years in education and self-reported cognitive activity. The findings of Tranter & Koutstaal (2008) are contrary to those of Dellenbach & Zimprich (2008) who reported that older adults who took part in more intellectually stimulating activities showed greater crystallised, but not fluid, intelligence.

Small et al. (2006) conducted a two week intervention period which focussed on enhancing cognitive functioning for individuals with mild cognitive impairments. The intervention group took part in cognitively stimulating activities (e.g. brain teasers and word games), cognitive training (e.g. visualisation), cardiovascular exercises and changed their diet, whereas the controls maintained their usual lifestyle for the two week period. Participants were aged between 35 and 69, with a mean age of 53 and were monitored for memory and frontal functioning as well as self-reported MemSE. The results showed a significant increase in episodic memory, verbal fluency and MemSE of the experimental group compared to the matched control group.

An alternative method was used by Park, Gutchess, Meade & Stine-Morrow (2007), which used a novel everyday activity. In line with Noice & Noice (2009; 2006), Park et al. (2007) argue that a cognitive intervention needs to be novel in order to stimulate neurogenesis. This is based on Park et al.’s (2007) review of the neuroimaging evidence and showed that neurogenesis, in older adults, is significantly higher if individuals take part in activities which they have never attempted before rather than a standard cognitive intervention training technique (e.g. speed of processing). The results of Park et al.'s (2007) research is not published to date, however Noice & Noice (2009; 2006) showed that executive functioning and episodic memory was promoted in older adults who learned to act (and had not attempted such an activity before). Although, it is possible that this cognitive enhancement is due to physical activity as well as cognitive, it is likely that the novel cognitive stimulation had a significant impact.

1.3.3.3 Computer-based interventions

With the recent increase in awareness of the aging population and the impact of age on cognition, commercial products have been developed to try and stimulate older adults (in particular) through the use of multi-media (e.g. Nintendo's Brain Training products). In one investigation Owen et al. (2010) tested over 11,000 participants for a six week period to investigate whether attempting activities akin to those used in commercially available products such as Nintendo's Brain Training improved cognitive functioning in participants who were aged between 18 and 60. Participants were assessed on reasoning, verbal short-term memory, spatial short-term memory and paired-associated learning. The control group was required to surf the internet and access a number of BBC resources for an equal amount of time as the two experimental groups who attempted activities which were similar to those involved in brain training. The results showed no significant increase in cognitive functioning of the experimental group over the control group, but all three groups showed a significant increase in the cognitive measures taken. Owen et al. (2010) argue that the results demonstrate that computer-based training techniques are not significantly better at improving cognition than simply surfing the internet, however it must be acknowledged that the age range was insufficient to investigate the use-dependency theory (see Section 1.4 for discussion).

Smith et al. (2009) compared a commercially available computer-based intervention programme to an intervention programme which required participants to watch DVDs about art, history and museums, and then answer questions on the information that they have learned over the eight week period. The results showed that both intervention techniques improve processing speed, episodic memory and frontal/executive functioning. The findings showed that the computer/DVD-based intervention significantly improved short-term verbal learning and MemSE, whereas participants in the activity group showed a decrease in these two measures. Unfortunately, there was no control group which did not take part in any cognitive activity, therefore it is difficult to determine whether the increases in cognitive functioning are due to the intervention techniques or practise effects of repeating the cognitive test (e.g. Ferrer, Salthouse, McArdle, Stewart & Schwartz, 2005).

Rebok et al. (2007) reviewed the evidence pertaining to the use of computer or video/DVD intervention methods in older adults. The conclusion was that such techniques appear to increase subjective measures of cognitive functioning (e.g. MemSE or reducing the belief that one will develop dementia); however there was little or no evidence that these types of interventions promote objective measures of cognitive functioning. Rebok et al. (2007) point out that some older adults have metacognitive/memory strategies, which are as good as strategies that are being taught (through interventions), but other older adults have ineffective strategies which are difficult to modify with training. The authors also state that cognitive interventions should be cost-effective and easily accessible to all older adults; ideally, they should also be based on everyday activities which do not require expert training or instruction.

1.3.3.4 Summary

In conclusion, the results from intervention studies have shown that cognitive training can enhance cognitive functioning and/or attenuate cognitive decline which is associated with mainly healthy aging, but also pathological aging. The results also demonstrate how activities which are based on everyday cognitive activities can be effective at improving cognitive functioning in a number of different cognitive domains. One issue which has been highlighted by researchers (e.g. Salthouse, 2007) is that training programmes which are based on mnemonics or other types of laboratory-based memory training are not transferred to everyday cognitive functioning. However, training techniques that focus on metacognition and executive functioning, and which use everyday activities, appear to be more transferrable across cognitive domains and may have a larger impact on everyday functioning.

1.4 Critique of theories and evidence used to investigate the use-dependency theory and cognitive reserve hypothesis

1.4.1 Identifying the causal relationship between cognitive activity and functioning

Both the use-dependency theory and cognitive reserve hypothesis predict that cognitive activity will have a significant effect on cognitive functioning in later life, thus the unique effect of cognitive activity on functioning needs to be established. It is also important to understand whether the effect of cognitive activity is mediated by other factors which are known to effect cognitive decline. Shadish et al. (2002) described an inus condition whereby investigations must identify all possible factors and mediators which bring about a specific outcome. For example, for a forest fire to occur there must be a number of key factors which have to be present to initiate the event (e.g. oxygen, dry material and a naked flame), but there are also other mediating factors which can also have a significant impact on the resulting condition (e.g. the wind blowing in the right direction, a cigarette being thrown out of a passing car etc). There must also be further extenuating factors which ensures that the final outcome ensues (e.g. in the case of a forest fire; no passersby to intervene, no rainfall, the presence of combustible materials etc). The principle of investigating an inus condition must also be investigated in cognitive neuropsychology with regards to the relationship between cognitive activity and cognitive decline in healthy aging.

No study has reported a direct causal link between cognitive activity and cognitive decline/dementia. Salthouse (2007; 2006) argued that the causal relationship between cognitive activity and cognitive decline in healthy (and/or pathological) aging is uncertain and unproven. The base of Salthouse’s argument is partly based on the premise of Shadish et al. (2002), in that it is necessary to identify an inus condition whereby cognitive activity has a significant impact on cognitive decline/functioning across the lifespan. As acknowledged by Elias & Wagster (2007) and Hertzog (2009) a number of other factors affect or mediate cognitive decline other than cognitive activity. These include factors such as genetic background (e.g. King & Suzman, 2009), diet, stress (and the ability to cope with stress), educational background, socioeconomic status, culture, social support, access to health care etc. These factors may not be independent of one another, but there is evidence that all these factors have either a direct or indirect impact on cognitive functioning throughout life and particularly in older age. Therefore, it is important to identify these mediating factors that have a significant impact on cognitive decline, which is associated with aging (e.g. Hertzog et al., 2009; King & Suzman, 2009; Hertzog, 2009; Elias & Wagster, 2007; Salthouse, 2006; Glisky & Glisky, 1999).

It is clearly impossible to control for every mediating factor/confounding variable (known or unknown) when using a between-subjects technique (e.g. Coolican, 1997). The majority of the support for the use-dependency theory (and cognitive reserve hypothesis) has used a between-subjects technique. However as Hertzog (2009) notes, it is impossible to take into account all confounding variables/factors which will then identify the strength of the relationship between cognitive activity and cognitive decline. Taking into account all known mediating factors or confounding variables will reduce the variance which can be directly associated between cognitive activity and cognitive decline (e.g. Hertzog & Nesselroade, 2003).

The only logical conclusion is to use a within-subjects technique to investigate the relationship between cognitive activity and cognitive decline. There are two ways of doing this, which can be used to investigate either the cognitive reserve hypothesis or use-dependency theory. Poon & Fozard (1978) used a mixed design to investigate the relationship between age and naming latencies for items which were either dated or modern common items (e.g. a telephone from the 1920s compared to a telephone from the 1970s). Pictures of other objects from the 1920s, which were no longer in use in the 1970s, were also shown to the participants, as well as objects which had just been invented for commercial use (e.g. a calculator). Three age groups (i.e. younger adults, middle aged and older adults who were over 65 years old) of participants were required to name the objects as fast as possible. Older adults were significantly faster at naming the dated common objects and the objects which were no longer in use, whereas younger adults were faster at naming the objects which had just become commercially available. This indicates that early life experiences have a significant impact on cognitive functioning later in life because older adults appeared to name the dated objects quicker than the contemporary versions.

Therefore, with regards to the use-dependency theory (and cognitive reserve hypothesis) there is a need to use a within-subjects technique to investigate whether an increase in cognitive activity has a direct effect on cognitive decline which is age-related. With regards to the cognitive reserve hypothesis and use-dependency theory, it is possible to investigate this by studying one cognitive domain which can be separated on the basis of stimulation/activity. This technique was used in Chapter Three when investigating the cognitive reserve hypothesis and Chapter Four with regards to the use-dependency theory. Furthermore, it can be argued that intervention techniques, which have used a between-subjects technique, cannot draw a conclusion that the cognitive intervention has a causal and direct effect on cognitive functioning. This is a critical issue as some research has suggested that older adults who have lower cognitive stimulation and lower cognitive functioning benefit more from cognitive intervention (e.g. Carlson et al., 2008; Glisky & Glisky, 1999) whereas other studies have shown that cognitive interventions have a larger impact on participants with a higher functioning at baseline (e.g. Bissig & Lustig, 2007). The use of a within-subjects technique for an intervention study would allow confirmation of whether the intervention was beneficial for the whole sample population (see Chapter Five). The sample population could then be separated into sub-samples to investigate whether at risk groups showed a different response to the intervention than the whole sample population, as suggested by Elias & Wagster (2007).

When establishing a causal relationship of cognitive activity on age-related functioning it is vital to define the expected outcome. This is discussed further in Section 1.4.3 but, as age takes a significant toll on cognitive functions such as episodic memory, metacognition and executive functioning, the effect of cognitive activity on cognitive functioning must be more apparent in an older sample population than a younger sample population in order to support either the cognitive reserve hypothesis or use-dependency theory. Salthouse (2007; 2006) argued that to support either theory results must show a 2 X 2 interaction between cognitive activity and age on cognitive functioning (in various cognitive domains). This is not in line with Schooler (2007) who argued that an increase in cognitive functioning for adults who are more cognitively active is sufficient to support the use-dependency theory. Schooler (2007) stated that there was no reason why one should expect a large impact of cognitive activity on older adults than younger adults.

However, as supported by Hertzog (2009), Salthouse (2007) pointed out that the premise of the use-dependency theory, in particular, is that cognitive activity can reverse age-related cognitive decline. The key term is “age-related”, because there is clear evidence that older adults can show high levels of cognitive plasticity; that is, older adults are definitely able to learn new behaviours and develop existing abilities (e.g. Park & Reuter-Lorenz, 2009; Li et al., 2008). It is necessary to show that an increase in cognitive activity in later life has a greater impact on age-related decline in cognitive function which impact on everyday functioning, compared to younger adults. Showing that an increase in doing cryptic crosswords, for example, improves episodic memory to the same degree in younger and older adults is insufficient evidence to support the use-dependency theory. The cognitive activity/inactivity at an older age should have a larger effect on age-related functioning than activity/inactivity at a younger age to support the use-dependency theory.

1.4.2 Establishing a measure of cognitive activity

A further issue with research investigating the use-dependency/cognitive reserve hypothesis is the measure of cognitive activity. Measures of cognitive activity have varied over the 40 years of investigating the use-it-or-lose-it theory. For example, Friedman et al. (2002) asked participants to report activities which were closely associated with self-maintenance, but recorded these as a definition of cognitive activity. Conversely, Jopp & Hertzog (2007) used an extremely wide scale of activity measurements, which included taking part in various games (e.g. crosswords, cards), using technology (e.g. surfing the internet), but also experiential activities (e.g. learning new languages). Other studies such as Gold et al. (1995) used measures of intelligence or education as a measure of cognitive reserve.

There is a need to classify and categorise measures of cognitive activity (e.g. Jopp & Hertzog, 2010). Salthouse (2006) has provided evidence that different cognitive activities require a different amount of cognitive effort. Therefore, it is important to devise a classification of cognitive activities which allow researchers to quantify the level of activity being undertaken by participants. Different researchers have not only used different measures of activity, but also calculated total cognitive activity in different ways. For example Hultsch et al. (1999) classified attempting crosswords as a novel information processing activity, whereas Jopp & Hertzog (2007) classified crossword solving under games/leisure activities. Hultsch et al. (1999) demonstrated that their group of cognitive activities, including crossword frequency, was significantly associated with higher cognitive functioning later in life, but Jopp & Hertzog (2007) showed that their "games" measure (including crossword frequency) was not associated with a reduction in cognitive decline or improved cognitive functioning. This raises the question as to which specific cognitive activities are related to attenuation in cognitive decline.

Studies which have used activities such as self-maintenance as a measure of cognitive activity have shown a link between cognitive activity and the development of dementia (e.g. Friedman et al., 2002). However, it is likely that the relationship between self-maintenance (as a measure of cognitive activity) declines with preclinical dementia, which is arguably undetectable (e.g. Wilson et al., 2007). Whereas studies which have investigated the effect of specific cognitive activities on cognitive decline and/or dementia (e.g. Verghese et al., 2003) may be able to identify cognitive activities which are specifically associated with an attenuation in cognitive decline and/or dementia.

Salthouse (2006) argued that it is important to only measure the most cognitively demanding activities when measuring cognitive activity. This is also supportive of Parslow et al. (2006) who developed an alternative measure of cognitive activity which focused on creative/self-improving activities (e.g. studying a foreign language or learning to play a musical instrument etc). However, Parslow et al. (2006) excluded leisure activities such as doing crosswords or word games. The difference between the measures used in Salthouse (2006) and Parslow et al. (2006) demonstrate a problem in the consensus as what constitutes a cognitive activity.

Early research on the use-dependency theory noted that older adults who were more cognitively active in later life showed less cognitive decline and a later onset of dementia (e.g. Schooler, 1997; Edelman, 1987). These studies specifically noted that a higher level of leisure activities was associated with a slower/later cognitive decline. Therefore, arguably the original use-dependency theory implicated leisure activities as a way to attenuate cognitive decline in aging.

The fact that studies such as Parslow et al. (2006) and Jopp & Hertzog (2007) have shown that self-improving activities are related to lower levels of cognitive decline is not surprising. Li et al. (2008) have demonstrated that skill acquisition in later life is possible as well as the development of expertise (e.g. Kimball & Holyoak, 2000; Dorner & Scholkopf, 1991). Researchers have demonstrated how an increase in educational attainment can have a direct and indirect impact on other factors which mediate cognitive functioning in later life (e.g. health awareness, access to healthcare, social economic status, improved diet and lifestyle; e.g. Elias & Wagster, 2007). Therefore, the link between educational activity in later life and a decrease in cognitive decline may not be due to a direct causal relationship between cognitive activity and cognitive functioning; thus not a true representation of the use-dependency theory/cognitive reserve hypothesis.

As the access to activities described in Parslow et al. (2006) and some measures of Jopp & Hertzog (2007) are not accessible/available to the wider older population it is arguably more important to study common leisure activities which have been associated with the use-dependency theory (e.g. Wilson et al., 2007). However, it is still difficult to find a categorization of everyday cognitive activity. For example, certain research has classified watching television as a cognitive activity (e.g. Wilson et al., 2002;

Christensen & Mackinnon, 1993). However, Salthouse (2006) demonstrated that participants rated watching television as the least cognitively demanding leisure activity. This is a problem when researchers construct a factor which represents total cognitive activity; it is possible that a participant who watches television everyday will have a similar cognitive activity rating as someone who attempts cryptic crosswords everyday but never watches television. As expressed by Hultsch (personal communication, 18th February 2010) it is possible to classify television programmes into different categories, but it is still difficult to determine whether participants are engaged in watching the programme and how much effort is required to undertake the activity.

It is necessary to measure activities which are cognitively demanding (Salthouse, 2006), but unlike Wilson et al. (2007) cognitive measures should not ignore activities which are particularly specialised. It is possible to develop expertise in specialised activities such as cryptic crosswords (e.g. Forshaw, unpublished) or advanced problem solving, which can then be transferred to other cognitive domains. Therefore, it is necessary to investigate a wide range of cognitive activities and be cautious when creating a construct which represents total cognitive activity because some activities may have a larger effect on cognition than others.

Furthermore, a number of measures of cognitive activity have included crossword frequency (e.g. Jopp & Hertzog, 2010; Barnes et al., 2006; Verghese et al., 2003), but not distinguished between the specific type of crossword being attempted (i.e. cryptic, quick or general knowledge). Although Salthouse (2006) found that participants rated doing crosswords as the second most effortful activity, it is clear that different types of crosswords require different cognitive abilities. Hambrick, Salthouse & Meinz (1999) acknowledged that different types of crosswords require different cognitive processes.

Forshaw (unpublished) and Nickerson (1977) indicated that a number of different cognitive abilities are required to solve a cryptic crossword compared to a quick or general knowledge crossword. For example, cryptic crosswords tend to have two separate components to a clue, which must both match to find the solution. Forshaw (unpublished) suggested that inductive reasoning is required, specifically in older adults, to solve cryptic crosswords. Conversely, general knowledge and quick crosswords rely on general knowledge or crystallized intelligence (e.g. Hambrick et al., 1999), not necessarily inductive reasoning.

To measure an overall crossword frequency may be masking the effects of one specific crossword because participants will report a frequency rating for whichever crossword they undertake. The self-testing skill required to complete a cryptic crossword is similar to the metacognition training used by Dunlosky et al. (2007). Therefore, it is possible that attempting cryptic crosswords regularly may promote metacognition. However, a frequency rating which does not distinguish between crossword types will produce the same crossword frequency rating for a participant who does quick crosswords everyday (but no cryptic crosswords) and a participant who attempts cryptic crosswords everyday (but no quick crosswords). Hence, it is necessary to investigate whether different types of crosswords have a different effect on cognitive functioning in later life.

The discrimination between types of crosswords being measured also raises a question about the cultural bias of some cognitive activity measures. For example, cryptic crosswords are more common in Britain/Europe compared to the USA. As described by Hambrick et al. (1999) cryptic crosswords are only really available in certain newspapers or online and may not be available daily as in the UK (for example *The New York Times* prints a cryptic crossword on a Sunday, whereas many UK-based newspapers will print cryptic crosswords daily). The crossword puzzle is also an activity which is more commonly associated with western countries. Due to the difference in language, crosswords are not a leisure activity in China. However, Asian countries have developed leisure activities/games which are not widely available in Europe or the USA (e.g. Mahjong). Research has shown that there is still evidence for the use-dependency theory when measuring cognitive activities which are culturally specific, for example, Wang et al. (2006) showed that games which require a high degree of inductive reasoning are associated with a significant reduction in cognitive decline/dementia. Therefore it is necessary to identify the specific type of cognitive leisure activity that is associated with an attenuation of cognitive decline.

Finally, with regards to measures of cognitive activity, there is a question mark over the decisions taken to classify activities in a cognitive activity scale. For example Jopp & Hertzog (2010) and Wilson et al. (2007) argue that cognitive activities (which are measured in investigations of the use-dependency/cognitive reserve theory) must be positively correlated with cognitive functioning. However, this is highly questionable because it is arguably producing findings which are based on a self-fulfilling prophecy. That is, if researchers are only selecting cognitive activities which are positively correlated with cognitive functioning it is inevitable that the relationship between cognitive activity and cognitive functioning will be supported. It is possible that some cognitive activities may reduce certain measures of cognitive functioning in old age, for example undertaking a novel but difficult cognitive activity may reduce MemSE in the short-term. Reducing MemSE in older adults may not be an undesirable outcome because of the relationship between MemSE and metacognition. It is possible that cognitive activities which are not positively associated with specific cognitive functions may be beneficial for other cognitive functions in the long-term. Thus, it is inappropriate to exclude cognitive activities which may be negatively or not significantly associated with cognitive functioning due to the potential to either have mediating effects or long-term benefits for other cognitive functions.

1.4.3 Measuring cognitive functioning and/or decline

The measure of cognitive functioning/decline has also varied when investigating the cognitive reserve hypothesis and/or use-dependency theory. For example, Katzman (1993) and Friedman et al. (2002) investigated the relationship between cognitive activity and the development of dementia, whereas Jopp & Hertzog (2007) and Barnes et al. (2006) investigated the relationship between cognitive activity and cognitive functioning in healthy aging.

Even when research on pathological aging is excluded, there is a large variation in the measures of cognitive functioning in healthy aging. For example, Dellenbach & Zimprich (2008) investigated the impact of cognitive activity on crystallised and fluid intelligence, whereas Wilson et al. (2002) investigated the outcome measures of global cognitive functioning, working memory and processing speed. Intervention studies have also focussed on promoting different cognitive abilities, for example Karbach & Kray (2009) measured executive functioning whereas West et al. (2008) investigated the impact of training on MemSE and episodic memory.

Identifying an outcome measure or various outcome measures/dependent variables is critical for measuring an intervention or investigating the use-dependency theory. First, as mentioned above, it is important to focus on cognitive activities which show age-related decline (e.g. episodic memory, metacognition). Second, without a consensus on dependent variables it is impossible to assess the support for the use-dependency theory. As indicated by Jopp & Hertzog (2007), many cognitive functions mediate one another and therefore a cognitive intervention/activity may not show a direct effect on one cognitive function but may do on a different cognitive function (related or unrelated). The lack of a consensus with regards to outcome measures of studies in this area also highlights a lack of agreement of how cognitive activity influences cognitive functioning.

Some researchers have used subjective measures of cognitive functioning, whereas others have used objective measures of empirically recognised cognitive abilities; further research has used objective measures of everyday cognitive functioning based on a combination of subjective and objective measures (e.g. West et al., 2008; Tranter & Koutstaal, 2008; Cavallini et al., 2003). West et al. (2008) and Berry (1999) argue that cognitive activity enhances objective measures of cognitive functioning (e.g. paired-associated recall) through promoting MemSE and increasing participants' confidence when undertaking cognitive functions. However, other researchers have argued that the resulting increase in MemSE, which is associated with higher levels of cognitive activity, is due to the awareness that cognitive functioning is improving (or not declining) as a result of the cognitive activity having a direct effect on functioning (e.g. Jopp & Hertzog, 2007).

Cognitive activities or interventions that have shown a positive relationship with objective measures of cognitive functioning (e.g. speed of processing; Ball et al., 2002) have not always shown a positive relationship with everyday functioning (self-reported or objectively measured). Not only is it important to identify cognitive activities which are positively associated with everyday functioning, but it is also important to identify whether interventions which enhance certain cognitive abilities also enable an increase in everyday functioning. For example, Cavallini et al. (2003) showed how a metacognition-based intervention appeared to have a greater benefit on both objective and subjective measures of everyday functioning as well as laboratory-based tests of cognitive functioning compared to a mnemonic-based intervention.

Jopp & Hertzog (2007) provided convincing evidence that the relationship between cognitive activity and subjective measures of cognitive functioning (e.g. MemSE) was mediated by actual (objectivity measured) cognitive functioning. An alternate model also showed that there was a link directly between cognitive activity and MemSE, but this association became non-significant when controlling for current cognitive functioning. This is converse to Berry (1999) who believed that the relationship between cognitive activity and MemSE determined the level of cognitive functioning.

It is likely that MemSE has a partially mediating role in the relationship between cognitive activity and cognitive functioning. It is also likely that cognitive function, in old age, has a direct influence on MemSE when taking into account cognitive activity. Hertzog & Hultsch (2000) state that participants are likely to give up attempting certain activities because they lose the ability to undertake the activity, due to a decline in cognitive functioning. This failure of being unable to complete a cognitive activity (that one could complete in the past) will have a direct negative effect on MemSE.

This argument by Hertzog & Hultsch (2000) fits with the classic view of metacognition by Nelson & Narens (1990). Figure 1.1 shows the metacognition model where the meta-level can be regarded as MemSE. The object-level can be regarded as cognitive functioning which both influences and is influenced by the meta-level via the monitoring and control pathways respectively. A drop in cognitive functioning (i.e. object-level performance) will have a direct influence on MemSE (i.e. meta-level) through the monitoring pathway. Dunlosky, Hertzog & Powell-Moman (2005) argue that older adults appear to have a deficit in the control pathway (i.e. the ability for MemSE or the meta-level to affect cognitive functioning/the object-level). As older adults apparently have a deficit in the control pathway it is unlikely that increasing MemSE (the meta-level functioning) will have a significant impact on cognitive functioning in a wide number of cognitive domains, as proposed by West et al. (2008) and Berry (1999).

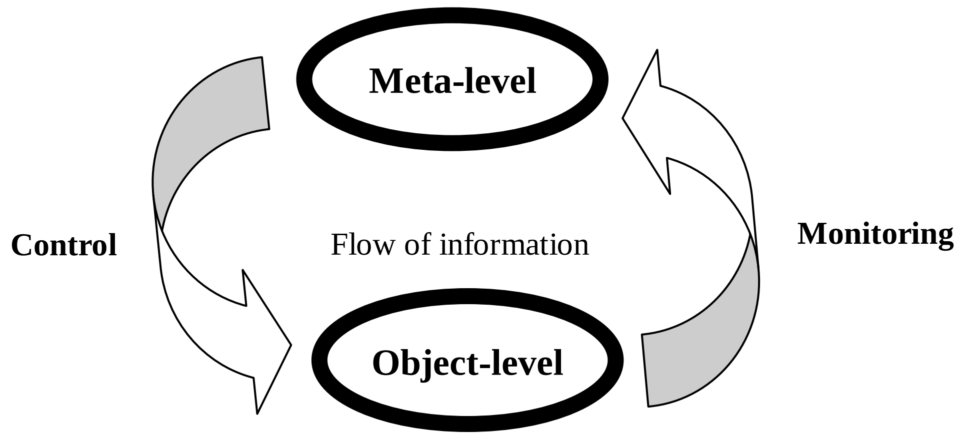

Figure 1.1. The process of metacognition illustrated by Nelson & Narens (1990)

Activities which involve a high level of effort should also increase the amount of monitoring undertaken and thus increase the feedback to MemSE. Cognitive activities which involve self-testing have been shown to improve metacognition and episodic memory functioning in older adults. Therefore it is possible that leisure activities that require similar cognitive abilities (e.g. self-testing) will also enable older adults to become more aware of their cognitive abilities (i.e. metacognition will be increased). This type of scenario supports the view of Hertzog & Hultsch (2000) in that it is possible that older adults who loose their ability to complete activities such as cryptic crosswords will become more aware of their cognitive decline and therefore suffer a decrease in MemSE. This is opposite to the view of Berry (1999) who would argue that a drop in MemSE would have a knock-on effect to produce a drop in cognitive functioning which would then discourage participants from attempting such cognitive activities. The evidence from Jopp & Hertzog (2007) supports the view that the relationship between cognitive functioning and cognitive activity mediates the relationship between cognitive activity and MemSE; not that MemSE mediates the relationship between cognitive activity and objective measures of cognitive functioning.

1.4.4 Subjective versus objective measures of cognitive activity and functioning

Finally, with regards to both measures of cognitive activity and cognitive functioning, there has been a combination of self-report and objective measures used to measure both activity and functioning. Research has shown that computer-based interventions have a significant impact on subjective measures of cognitive ability (e.g. Rebok et al., 2007). That is older adults who undertake these activities show an increase in MemSE and a decrease in the belief that they will develop dementia. However, Rebok et al. (2007) found no evidence that such interventions promote objective measures of cognitive functioning. This was also the conclusion by Rapp, Brenes & Marsh (2002) who found that cognitive interventions appeared to have a significantly larger impact on subjective compared to objective measures of cognitive functioning. However, Floyd & Scogin (1997) conducted a meta-analysis and concluded that cognitive interventions have a significantly larger affect on objective over subjective measures of memory/cognitive ability. Dunlosky et al. (2007) have argued that meta-analyses produce over representative support for particularly objective benefits of cognitive intervention because non-significant findings tend not to be published.

Rabbitt et al. (1995) also commented that self-report measures in older adults tend to be unreliable. This can arguably be the case for both measures of cognitive functioning and activity. There is a high level of comorbidity between preclinical dementia and depression (e.g. Verghese et al., 2003). Furthermore both preclinical dementia and depression have been associated with a reduction in cognitive, social and physical activity (e.g. Wilson et al., 2007; Elias & Wagster, 2007). Therefore research which has shown a relationship between lower levels of cognitive activity and decreased cognitive functioning may have been finding a normal causal relationship; that is, the reduction in activity and functioning may have been due to either preclinical dementia or an alternate psychological illness such as depression. This is also possible because participants with depression have demonstrated a reduced cognitive ability on both subjective and objective measures (e.g. Zelinski & Gilewski, 2004).

Self-reported cognitive activities at the current period in time may be more valid than using retrospective self-reported activity measures of earlier in life that a number of researchers have done (e.g. Barnes et al., 2006; Friedman et al., 2002; Friedland et al., 2001; Kondo et al., 1997; Christensen & Mackinnon, 1993). Memon, Bartlett, Rose & Gray (2003) showed that older adults were significantly poorer at recalling information as the time period between the events and recall increased. Furthermore, some researchers such as Friedman et al. (2002) and Kondo et al. (1997) have used self-reported measures of activity from friends or family of individuals who had developed dementia.

Studies such as Barnes et al. (2006) and Friedland et al. (2001) have shown a significant relationship between early life activities and less cognitive decline or later onset of dementia. However, taking into account the potential fallibility of older adults' memory for retrospective events (e.g. Memon et al., 2003), the influence of preclinical dementia on self-efficacy, the reliance on family/friends for information and the number of other factors which may mediate cognitive activity earlier in life (e.g. parental income or occupation; Salthouse, 2007) it is questionable whether these techniques should be used to investigate the cognitive reserve hypothesis or the use-dependency theory. There is a need to develop an independent measure of cognitive functioning and cognitive activity which is arguably more objective than self-report measures. Furthermore, it can be argued that studies which measure self-reported cognitive activity should also use self-reported measures of cognitive functioning as well as objective measures to investigate whether there is a difference between the two measures.

1.4.5 Targeting the correct sample population at the appropriate age when conducting cognitive interventions.

The most important application of the use-dependency theory (and to a lesser degree the cognitive reserve hypothesis) is to develop cognitive intervention which can attenuate or reverse age-related cognitive decline. Following on from the criticism of studies such as Barnes et al. (2006), there is no agreement as to when (i.e. at what stage in life) an increase in cognitive functioning is required to attenuate cognitive decline or the development of dementia. Studies such as Barnes et al. (2006) and Mackinnon et al. (2003) have argued that cognitive activity is required at an earlier stage in life to develop a cognitive reserve or strategies to counter age-related cognitive decline. However, other studies have measured cognitive activity and cognitive function later in life to investigate the use-dependency theory (e.g. Dellenbach & Zimprich, 2008; Hultsch et al., 1999). Although it is accepted that there is a difference due to the two theories, research which has investigated cognitive activity in later life has not taken into account previous cognitive activity or other factors such as number of years in education which may have a mediating effect on the relationship between cognitive activity and cognitive functioning/decline in later life.

Glisky & Glisky (1999) have suggested that cognitive intervention techniques may be more beneficial for older adults who can be regarded as having a low cognitive reserve or who are relatively cognitively inactive. This was also supported by research by Carlson et al. (2008) which showed that an everyday cognitive intervention activity had a significantly greater effect on participants who could be regarded to be at risk of cognitive decline/developing cognitive impairments. This is converse to the findings of Bissig & Lustig (2007) who demonstrated that cognitive training techniques appear to have a significantly greater benefit on older adults who had higher cognitive functioning measures at baseline. The impact of social demographic/lifestyle factors needs to be investigated in a way whereby specific mediating factors (e.g. lower educational history) can be monitored with regards to the effectiveness of a cognitive intervention or measure of cognitive activity. Supporting the view of Salthouse (2007) there must be clear evidence, to support the use-dependency theory, that an increase in cognitive activity in later life attenuates cognitive decline. It is conceivable that this evidence may only be apparent in specific sample populations (e.g. those with a fewer number of years in education; Christensen & Mackinnon, 1993), therefore countering the view of psychologists such as Schooler (2007) who claimed that cognitive activity in later life can be beneficial for all older adults.

1.4.6 Summary

To recapitulate, an inus condition (e.g. Shadish et al., 2002) describes a causal relationship which takes into account a number of mediating factors. Therefore, when using a between-subjects technique it is important to be cautious when interpreting relationships between cognitive activity and cognitive functioning as causal. This is especially the case when using self-report measures of cognitive activity and/or cognitive functioning, and not taking into account other possible mediating factors (e.g. Bosma et al., 2002). Although it is the case that cross-sectional self-report techniques can be a useful aide in identifying cognitive activities which may have a direct or indirect effect on cognitive functioning, it is important to provide further evidence with objective measures of both cognitive activity and cognitive functioning.

In conclusion, evidence which has supported the use-dependency theory and/or cognitive reserve hypothesis is inconsistent, in terms of designs used, activity measures, cognitive functioning assessed and demographic/mediating factors accounted for. There is a need to use objective measures of cognitive activities and also investigate whether specific cognitive activities have a greater impact on cognitive function than others. It is also necessary to investigate whether self-reported cognitive functioning differs, in terms of its relationship to cognitive activity, when it is measured subjectively and/or objectively. There is also an urgent need to devise a within-subject technique which can be used to investigate the effectiveness of cognitive interventions on the whole sample population, as well as sub-samples, while taking subjective and objective measures of cognitive activity and cognitive functioning. The investigations of sub-samples will allow analysis of mediating factors which may highlight certain groups of individuals who may benefit more from the intervention.

1.5 Aims of the thesis

It is important to identify whether different cognitive activities have a different effect on cognitive functioning. This will indicate whether participation in certain activities is associated with a higher level of functioning in later life. In turn, this will allow a specific cognitive activity to be identified and used as a potential intervention activity. Therefore the first aim of this thesis was to investigate whether self-reported participation in certain activities was associated with less self-reported cognitive decline throughout the lifespan. As discussed in Section 1.4, it is necessary to assess current cognitive activity because self-report techniques of retrospective activity can potentially be unreliable (e.g. Memon et al., 2003).[1]

Due to using self-reported measures of cognitive activity it is arguably necessary to use self-reported measures of cognitive functioning. This is for two reasons; first, if MemSE or other factors such as depression effect self-reported cognitive functioning and activity, then it is important to assess self-reported cognitive functioning compared to objective measures because it is unclear whether mediating factors have a larger impact on objective or self-report measures (e.g. Rebok et al, 2007; Elias & Wagster, 2007). To clarify, because subjective measures are being used to assess cognitive activity, it is prudent to use subjective measures of cognitive functioning.

Second, as described in Section 1.4, it is possible that cognitive activity has a direct effect on metacognition. As older adults appear to have a deficit in the control pathway (e.g. Dunlosky et al., 2005; see Figure 1.1) it is likely that any awareness of the effect of cognitive activity will be apparent in subjective measures of cognitive awareness (e.g. MemSE). Jopp & Hertzog (2007) showed how cognitive activity can affect MemSE. Thus it is important to identify which specific cognitive activities have a significant impact on MemSE, to a greater degree in older than younger participants, because this may indicate specific cognitive activities which have a larger impact on metacognition. The fact that older adults report a greater level of cognitive awareness when undertaking certain cognitive activities may suggest that these activities increase metacognitive functioning, and therefore could be used as intervention activities.

[1] Chapter Two specifically investigated whether different types of crosswords were associated with different self–reported levels of cognitive decline in healthy aging; mainly because different types of crosswords appear to require different cognitive functions, which may have a larger/different impact on age-related cognitive decline.

Importantly, as older adults have benefitted from metacognitive training (e.g. Dunlosky et al., 2007) it is important to identify an everyday activity which could potentially enhance metacognition. This investigation and analysis is covered in Chapter Two.

A further aim of the thesis was to find an objective measure which could indicate cognitive activity but use an alternative technique to self-report measures. Chapters Three and Four investigate the cognitive reserve hypothesis and the use-dependency theory by using objective measures of cognitive activity and cognitive functioning. As discussed in Chapter Three, certain parts of one specific cognitive domain can be activated more frequently, throughout life, than others. For example, in the domain of language, high-frequency and early-acquired words are activated more and earlier than low-frequency and later-acquired words respectively (e.g. Li, 2009; Tan & Ward, 2000).

Both word frequency and age of acquisition (AoA) are known to effect episodic memory; high frequency and early-acquired words are recalled better than either low-frequency or later-acquired words (see Chapter Three for a review of research). As high-frequency and early-acquired words are activated more often, in terms of their cognitive/neuronal representations, it is possible that this area of study could be used as an analogy of the cognitive reserve hypothesis. That is, because high-frequency and early-acquired, compared to low-frequency and later-acquired, words are activated more often throughout life it is logical to assume that cognitive/neuronal atrophy, associated with healthy aging, will take a greater toll on low-frequency and later-acquired words. This has been supported in studies of dementia with regards to word production (e.g. Forbes-McKay et al., 2005).

The cognitive reserve hypothesis states that an increased level of cognitive activity will protect cognitive functioning, especially if this cognitive activity is evident early in life and persists throughout the lifespan. Therefore, a comparison of episodic memory recall of high- compared to low-frequency and early- compared to later-acquired words in younger and older adults will mirror the cognitive reserve hypothesis. Using objective measures of word frequency and AoA as a measure of life-long cognitive activity will negate the criticism of using self-report measures of cognitive activity (especially retrospective measures of childhood activity such as those used in Barnes et al, 2006).

Chapter Four describes a similar technique which investigated the use-dependency theory. To produce an analogy of the use-dependency theory, using a within-subjects design, it is necessary to find a cognitive construct which was matched, in terms of activation/frequency, at one point earlier in life, but was separated later in life on the basis of activation/frequency. To clarify, the use-dependency theory states that a decrease in activity in later life (or an increase in cognitive activity) will result in a decrease (or increase) in cognitive functioning. Therefore, one aspect of a cognitive domain must show a decrease in activation/frequency of use to replicate the use-dependency theory within an individual.

Merry (1995) showed how certain first names decreased in popularity/frequency over a 50-60 year period. As research has shown that older adults show a significant episodic memory deficit for recalling first names (e.g. Semenza, Nichelli & Gamboz, 1996), the ability to recall first names provided an opportunity to test the use-dependency theory using objective measures of cognitive functioning and cognitive activity. Due to the fact that the popularity of certain names reduced over a 40 year period, it is likely that the activation of cognitive/neuronal networks which represent such names also decrease (even though they were activated as frequently as names which were equally as popular earlier in life), therefore in line with the use-dependency theory, names which have remained popular should be easier to recall. According to the requirements for support of the use-dependency theory (i.e. a significant age X activity interaction; Salthouse, 2007), older adults should show a significantly greater ability to recall popular compared to unpopular names than younger adults; specifically as popular names are easier to recall than unpopular names (e.g. James, 2004).

Finally, as in Chapters Three and Four, the use of a within-subjects technique is critical to confirm a direct relationship between cognitive activity and cognitive decline in healthy aging. Section 1.4 describes how demographic mediating factors can affect the relationship between cognitive activity and age-related cognitive decline. As noted by

Hertzog (2009), it is impossible when using a between-subjects design to control for all confounding variables or mediating factors. Furthermore, it is likely that test-retest effects reduce the variance associated with cognitive activity when using longitudinal studies of cognitive decline (e.g. Ferrer et al, 2005). Research has also shown that participants who have withdrawn from intervention studies show lower cognitive functioning as well as decreased interest/frequency in cognitive activities. Therefore, there is a need to develop a technique that can eliminate these confounds and mediating factors.

Chapter Five describes a counterbalanced within-subject technique which is able to measure the direct impact of an everyday cognitive activity intervention on cognitive functioning in older adults. This design enables researchers to first assess the impact of the intervention on the whole sample population, as older sample populations are more heterogeneous than younger ones (e.g. Glisky & Glisky, 1999). Second, the technique allows the entire sample population to be separated into sub-samples based on demographics which are known to influence the impact of cognitive interventions on cognitive functioning (e.g. number of years in education, socialisation; Elias & Wagster, 2007; Christensen & MacKinnon, 1993). This technique also allows for an independent measure of the ability of undertaking the cognitive intervention, which is arguably a more objective measure of cognitive activity (when controlling for time spent attempting the activity) than subjective measures of cognitive activity[2].

In summary, the thesis has three main aims; first, to investigate whether specific cognitive activities (i.e. different types of crosswords) have a greater impact on cognitive functioning in later life and, therefore, could be used as an intervention activity. Second, to use an objective measure of cognitive activity to assess the impact of cognitive activity on cognitive functioning in older adults. Finally, to use a within-subject technique to eliminate, but also investigate factors (e.g. metacognition) which mediate the relationship between cognitive activity and cognitive decline in the cognitive reserve hypothesis, use-dependency theory and intervention techniques.

[2] For example, when using self-report measures of crossword frequency (e.g. Verghese et al., 2003).

CHAPTER TWO
QUESTIONNAIRE INVESTIGATIONS OF THE COGNITIVE RESERVE HYPOTHESIS AND USE-DEPENDENCY THEORY (SUBJECTIVE MEASURES OF COGNITIVE ACTIVITY AND COGNITIVE FUNCTIONING)

2.1 Background

2.1.1 Introduction

As discussed in Chapter One, there is no agreement about the type of cognitive activity required to produce observable changes in cognitive functioning. One aspect of the investigation into the cognitive reserve hypothesis and use-dependency theory is when and what type of activity is required to produce a change in cognitive functioning. Some studies have used self-report techniques of activity attempted earlier in life (e.g. Barnes et al., 2006) while others have focused on current cognitive activities (e.g. Dellenbach & Zimprich, 2008). It is also questionable whether activities which have been included in the self-report measures can all be regarded as cognitive in nature (as indicated by Salthouse, 2006; see Chapter One), for example Wilson et al. (2002) regarded watching television as a cognitive activity and Friedman, Moore, Quinn, Howieson & Kaye (2002) regarded self maintenance as a cognitive activity.

Even studies which have attempted to focus specifically on intellectual activities may not have differentiated between specific types of intellectual activities. For instance, many self-report cognitive activity questionnaires ask about the frequency of attempting crossword puzzles (e.g. Wilson et al., 2005; Verghese et al., 2003; Wilson et al., 2002; Salthouse, Berish & Miles, 2002); however they do not discriminate between different types of crossword puzzle (e.g. cryptic, general knowledge and quick crosswords). The cognitive abilities required to complete each different type of crossword are different (e.g. Hambrick et al., 1999; Nickerson, 1977; Forshaw, unpublished). Therefore, it is necessary to narrow the spectrum of intellectual activities measured and ensure that they are cognitive in nature and require a relatively high demand on cognitive resources (e.g. Salthouse et al., 2002). Salthouse et al. (2002) showed that attempting crosswords was deemed to be the second most cognitively demanding activity out of 22 cognitive activities, however once again the researchers did not discriminate between different types of crossword puzzles.

Furthermore, dependent variables/outcome measures have not been constant throughout the four decades of research into the cognitive reserve/use-dependency theory. Some studies have investigated the effect of cognitive activity on healthy aging (e.g. Wilson et al., 2005) and other research has focused on the mediating factors associated with pathological aging (e.g. Friedman et al., 2002). Different cognitive domains have also been used to measure current cognitive functioning. For example, some studies have taken self-report measures of memory self-efficacy (MemSE) and metacognition (e.g. Cavallini, Pagnin & Vecchi, 2003) while others have used objective measures of cognitive functioning, such as episodic memory tests or fluid intelligence tests (e.g. Tranter & Koulstaal, 2008; Dellenbach & Zimprich, 2008; Hultsch et al., 1999). Bandura (1989) argued that it is more important how older adults feel about their current cognitive abilities, rather than objective measures of cognitive functioning when attempting to use intervention techniques to counter cognitive decline. According to Bandura (1989), an increase in MemSE in later life can help to attenuate cognitive decline in healthy aging. The study also suggests that undertaking cognitively challenging activities can boost MemSE. Therefore, it would be interesting to investigate whether the relationship between self-reported cognitive activity and self-reported cognitive functioning differed across the lifespan. This is important as cognitive intervention studies typically measure objective memory/cognitive performance but do not relate this to subjective/self-reported cognitive functioning (e.g. Willis et al., 2006). However, it would be of interest to investigate whether there was a cognitive activity which had a larger effect on self-reported functioning compared to other activities (e.g. cryptic versus general knowledge or quick crosswords) and whether this information could be used to develop and intervention study (i.e. Study Eight, see Chapter Five).

Thus, there were three aims of this chapter; first, to investigate whether the relationship between self-reported cognitive activity and self-reported cognitive functioning differed across the lifespan. Second, to investigate whether the frequency of attempting different types of crosswords had a different effect on self-reported cognitive functioning at different stages of the lifespan. Finally, to use the theory of Shadish et al. (2002) and to identify an inus condition(s) whereby the relationship between cognitive activity and cognitive decline can be identified and replicated using intervention techniques to eliminate potential mediating effects (see Chapter One for further explanation; Shadish et al., 2002).

2.1.2 Previous self-report measures of cognitive activity

Before the frequency of cognitive activities can be measured it is necessary to define a cognitive activity. Chapter One describes how physical activities can have a direct influence on brain chemistry and cerebral blood flow, therefore it is necessary to exclude cognitive activity that has a significant requirement of physical activity (e.g. Wilson et al., 2007).

According to Wilson et al. (2007) the assessment of cognitive activity frequency should also exclude esoteric cognitive activities such as solving differential equations. However, this exclusion of certain activities may not provide the necessary data to fully understand the cognitive reserve hypothesis or use-dependency theory. This is due to the fact that expertise has been linked to improved metacognitive abilities and the ability to solve problems (e.g. Kimball & Holyoak, 2000; Dorner & Scholkopf, 1991). To exclude some of these activities (e.g. solving cryptic crosswords or being an expert in foreign languages) may not tap into one theory behind the use-dependency theory, that is that metacognitive skills (which decline with age; Vukman, 2005; Souchay & Isingrini, 2004) may enable older adults to adapt to healthy and pathological decline associated with aging (e.g. Rebok & Balcerak, 1989). This is important because it is possible that completing cryptic crosswords may promote abstract thinking and metacognition (e.g. Forshaw, unpublished; Hambrick et al., 1999; Nickerson, 1977). This has a direct implication on previous cognitive activity measurements (e.g. Wilson et al., 2005) because it would be impossible to differentiate between individuals who do cryptic crosswords and individuals who only attempt quick or general knowledge crosswords using previous measures of cognitive activity (e.g. Barnes et al., 2006; Verghese et al., 2003; Wilson et al., 2002).

A more concerning assumption by researchers who have compiled cognitive activity questionnaires is that there should be a direct positive correlation between reported cognitive activity and current cognitive functioning (Wilson et al., 2007). The fundamental problem with this assumption is that the results of any research using such philosophy will result in a self-fulfilling prophecy with regards to the cognitive reserve hypothesis (see Shadish et al., 2002). Although it must be acknowledged that cognitive activity (both reported and observed) decreases in older adults with pre-clinical dementia (e.g. Verghese et al., 2003), it cannot be concluded that cognitive activity must be positively correlated with cognitive functioning throughout the lifespan of healthy individuals. Critically, this means that future research which has not found a positive relationship between self-reported cognitive activity and (self-reported or objected measures of) cognitive functioning must not be discarded as using an invalid measure of cognitive activity (Hertzog et al., 2009). Furthermore, if a cognitive activity is negatively associated with a measure of cognitive functioning, this may provide a different perspective on the relationship between cognitive activity and cognitive functioning.

Questions have been raised about the specific cognitive activities which have been included in questionnaires investigating frequency of cognitive activity (e.g. Salthouse, 2006). Salthouse (2006) pointed out that some activities included in measures may not require as much cognitive effort than other activities. For example, Wilson et al. (2005) included watching television as a cognitive activity. It is debatable how much cognitive effort is required for a person to watch television, that is not only does it depend on whether the person is watching the television programme and concentrating on it but also the type of programme which is being watched (e.g. a documentary or news debate show may require more attention than a soap opera or cartoon[3]). Other studies have also

[3] However, D. Hultsch (personal communication, 18th February, 2010) separated passive television watching and educational television programme watching. Educational television programmes were incorporated into a composite with twenty-six other novel information processing tasks and this construct was found to mediate cognitive functioning directly.

taken self-report measurements of self-maintenance activities as measures of cognitive activities (e.g. Friedman et al., 2002; Hultsch et al., 1999). Such activities may not be appropriate to investigate either the cognitive reserve hypothesis or use-dependency theory (e.g. Salthouse, 2006; Shadish et al., 2002). The cognitive processes required for making a meal, for example, compared to solving a cryptic crossword are likely to be very different (e.g. Hertzog et al., 2009).

Salthouse et al. (2002) attempted to quantify the amount of cognitive effort required in specific cognitive activities. Although the research did not differentiate between specific types of crosswords the results show that out of twenty-two cognitive activities, undertaking crosswords was deemed second most effortful, while watching television was least cognitively demanding. This is also supported by subjective research that has asked participants what cognitive effort is required for attempting crossword puzzles. Hambrick et al. (1999) produced anecdotal evidence that individuals who attempt crosswords believed that abstract thinking is a key cognitive component required to complete crosswords. This was also supported by Nickerson (1977) who reported that individuals who regularly undertake crosswords believe that abstract thinking and cognitive functions which could be encompassed by the term executive functioning/metacognition are required to undertake crosswords, specifically cryptic crosswords.

Apart from the question of whether activities have been appropriately labelled cognitive, there is also a discrepancy in the research about when the frequency of cognitive activity has been measured. For example, a number of studies using cross-sectional or longitudinal methods investigate reported current cognitive activity (e.g. Dellenbach & Zimprich, 2008; Verghese et al., 2003; Wilson et al., 2002), whereas other studies have asked for retrospective accounts of frequencies of cognitive activities earlier in life (e.g. Friedman et al., 2002; Kondo et al., 1994; Christensen & Mackinnon, 1993). Sunderland et al. (1986) provided evidence that current measures produced by self-report techniques are unreliable (specifically by older adults), but there is a large amount of evidence that questions the validity of retrospective memories (e.g. Memon, Bartlett, Rose & Gray, 2003; Loftus, 1984). Rabbitt et al. (1995) have provided some evidence that subjective measures of MemSE are not significantly correlated with objective measures of memory functioning. This is the case when composites of self-report questions are used (which cover a number of different memory domains, such as short-term memory, episodic memory, perspective memory) and when specific questions are compared to objective measures (e.g. older participants report a lower recall for proper names, but this is significantly different to the objective measures). Rabbitt et al. (1995) have also indicated that subjective reports of health status and/or memory functioning can vary over time, suggesting a lack of consistency and/or reliability. Therefore, studies which utilise retrospective levels of cognitive activity can be viewed as unreliable.

Overall, the measures used to date to assess cognitive activity can be viewed as unreliable and potentially an invalid measure of cognitive activity. Taking into account research which has investigated the relationship between cognitive functioning and attempting crossword puzzles it is clear that each type of crossword needs representing in any cognitive activity questionnaire. Finally due to the fact that retrospective memories are dubious at best, investigations into the relationship between cognitive activity and cognitive functioning should focus solely on self-report measures of current cognitive activity.

2.1.3 The impact of crosswords on cognitive functioning

Verghese et al. (2003) provided evidence that attempting crossword puzzles reduced the risk of developing dementia. This supports other research which has included the activity of solving crosswords in a composite of cognitive activity, which have also shown a negative relationship between an increase in cognitive activity (in both cross-sectional and longitudinal techniques) and an attenuation of cognitive decline (e.g. Dellenbach & Zimprich, 2008; Wilson et al., 2002). However, it must be acknowledged that studies did not discriminate between the type of crosswords participants attempted frequently (i.e. cryptic, general knowledge or quick). Although this thesis focused on cognitive decline in healthy aging, the cognitive reserve hypothesis has suggested that an increase in cognitive activity throughout the lifespan can delay the onset of dementia.

Thus, if attempting crosswords can reduce the risk of dementia it is possible that they will also have positive benefits of cognition in healthy aging.

Hambrick et al. (1999) attempted to use objective measures to quantify cognitive functions which promoted crossword solving abilities. Although there was some evidence that abstract reasoning was significantly positively correlated with the ability to solve crosswords, the results were ambiguous. As acknowledged by Hambrick et al. (1999) this is probably due to the fact that the participants attempted crosswords which would be termed quick or general knowledge in nature, not cryptic. Small scale subjective investigations by Hambrick et al. (1999) supported the results from Nickerson (1977) which indicated that individuals felt that abstract reasoning/executive functioning/metacognition was necessary to solve cryptic crosswords. Forshaw (unpublished) investigated which cognitive functions were required for older people to complete cryptic crosswords. Two specific functions were identified which are of relevance to the use-dependency theory. First, the results of Forshaw's (unpublished) study indicated that abstract reasoning was an important component when solving cryptic crosswords. Abstract reasoning has been linked to executive functioning and metacognition, which are both negatively associated with age (e.g. Karbach & Kray, 2009; Tranter & Koulstaal, 2008; Vukman, 2005; Souchay & Isingrini, 2004).

The relationship between cryptic crossword competency and measures of general intelligence was investigated in a sample of adults aged over fifty by Winder (unpublished). The results showed that amongst cryptic crossword experts there was a significant correlation between intelligence tests which focussed on abstract reasoning, as well as crystallised intelligence. However, in the novice crossword solvers group the most significant correlation with regards to the ability to solve cryptic crosswords was age, in that younger adults were more competent than older adults. Most of the cryptic crossword experts had been solving such crosswords for over twenty years, therefore it is possible to suggest that cryptic crosswords promoted both crystallised and fluid intelligence in older adults who attempt them regularly, especially since the sample populations in Winder's (unpublished) research were matched on a number of demographic factors which are known to affect intelligence (e.g. education).

Second, Forshaw (unpublished) and Hambrick et al. (1999) described how solving a crossword clue requires an individual to check the solution on a number of levels; that is, the solution must firstly fit with the clue based on the individual's knowledge. The clue must also fit with any letters from intercepting solutions in crossword grids. Finally, with particular reference to cryptic crossword clue's, it is typical that a clue will have two distinct meanings which need to correspond with one another (e.g. the clue "*antelope, new we hear*" will have the solution "*gnu*", the solver must know that a gnu is a species of antelope and also that the g is silent so that the second part of the clue i.e. new should rhyme with the solution). Checking any solution will result in the crossword solver self-testing effectively. Self-testing has been shown to increase older adult's cognitive abilities, specifically MemSE and episodic memory (e.g. Dunlosky et al., 2007; Dunlosky et al., 2003).

Finally, Bandura (1989) suggested that regularly attempting cognitively challenging activities in later life may enable older adults to maintain a high level of MemSE. Bandura (1989) believed that this was important to promote confidence in an older adult's ability to continue undertaking cognitively stimulating activities. This is similar to the model of metacognition proposed by Nelson & Narens (1990). That is, individuals have an internal representation of their own cognitive ability (termed the meta-level). This representation is influenced by the actual cognitive functioning, which is termed the object-level. Both levels feed into each and it is possible that undertaking cryptic crosswords may promote the monitoring and control pathways in Nelson and Narens' (1990) model (see Figure 1.1).

In summary, there is compelling evidence suggesting that attempting cryptic crosswords on a regular basis may promote cognitive functioning, particularly metacognition. Therefore there was a need to differentiate between the types of crosswords which self-report questionnaires measure. Furthermore, of interest was to examine whether the proportion of crosswords completed by participants had any impact on dependent variables. It is possible that participants who are more adept at solving crosswords may show a higher MemSE than participants who do not solve as much of the crossword they attempt. In turn this may have an impact on metacognitive processes, for example, being unable to solve a number of clues will increase the monitoring feedback and force an individual to reassess their meta-level. This should have a knock-on effect of changing the control that an individual will exert on future tasks (see Figure 1.1).

2.1.4 Measures of cognitive functioning

A number of studies have used objective measures of cognitive functioning to assess the relationship between cognitive activity and cognitive decline in both healthy and pathological aging (see Hertzog et al., 2009 and Chapter One). The approach of using objective measures of cognitive functioning is covered in the following chapters. However it can be argued that is also important to take into account older adults' subjective opinions of their own memory ability (e.g. West et al., 2008; Cavallini et al., 2003; Bandura, 1989).

According to the metacognition model of Nelson & Narens (1990) it is important to take into account individual's opinions of their own cognitive functioning. This is because the meta-level (see Figure 1.1) can be viewed as an individual's MemSE. This means that cognitive functioning perceived at the object-level will have a direct impact on MemSE. If a person feels that their current level of cognitive functioning (object-level) is below the believed level of cognitive functioning i.e. MemSE (or meta-level) then the monitoring pathway will provide positive feedback to increase the meta-level. However, if the functioning at the object-level is below that at the meta-level, the monitoring pathway will readjust the meta-level to allow participants to have a more realistic view of their cognitive abilities and, hence, change the amount of control (i.e. effort) required (see Figure 1.1).

In conclusion, it is important to assess the relationship between self-reported levels of cognitive activity and self-reported cognitive functioning. Previous studies (e.g. Cavallini et al., 2003) have shown a direct positive relationship between increased cognitive activity and improved confidence in one's own memory ability. It is, however, important to investigate whether this is the case when different types of cognitive activities are taken into account and whether it is also the case in the general population, not just in an experimental group as investigated by Cavallini et al. (2003). Furthermore, it was necessary to investigate whether the relationship between cognitive activity and perceived cognitive functioning changes across the lifespan. Previous research such as Wilson et al. (2005) and Christensen & MacKinnon (1989) has indicated that the relationship between cognitive activity and cognitive functioning is significantly stronger in later life. Finally, if the results indicated that certain types of cognitive activities (e.g. cryptic crosswords) have a larger affect on MemSE or metacognition than other cognitive activities; this may allow such activities to be used in therapeutic interventions (see Chapter Five).

2.1.5 Aims and objectives

Overall, the aim of this research was to investigate whether different types of crosswords had a differential effect on self-reported cognitive functioning. Previous research had failed to discriminate between the frequency of undertaking cryptic, general knowledge or quick crosswords (e.g. Wilson et al., 2005; Verghese et al., 2003; Hultsch et al., 1999) and the effect of each crossword on perceived cognitive functioning. Cavallini et al. (2003) and Rebok & Balcerak (1989) indicated that cognitive training can promote MemSE and self-reported metacognition. The research presented in Chapter Two investigated the relationship between self-reported everyday cognitive activities and self-reported cognitive functioning (e.g. MemSE and metacognition). As indicated by Bandura (1989), it is important to consider the subjective/self-reported measures of cognitive functioning when compiling an intervention program. Therefore, Studies One, Two, Three, Four and Four (a) focused on self-report measurements of cognitive ability. Studies One and Two investigated the impact of attempting different types of crosswords on subjective ratings of MemSE and metacognition, whereas Study Three assessed the specific beliefs that participants held about the impact of crossword participation on cognitive functioning. Studies Four and Four (a) took into account participants perceived and actual ability of solving cryptic crosswords in relation to cognitive awareness. Study Eight (see Chapter Five) compared self-reported and objective measures of cognitive activity and cognitive functioning in an intervention style study.

2.2 Study One: The relationship between age, attempting cryptic, general knowledge and quick crosswords and self-reported cognitive functioning.

Study One aimed to investigate whether there was a difference between self-reported frequency of participation in three different types of crosswords and self-reported cognitive functioning. This study also investigated whether the proportion of each type of crossword completed had an effect on self-reported cognitive functioning. Finally, Study One investigated whether any relationship between specific crossword frequency and/or proportion of crosswords completed and reported cognitive functioning was significantly different across the lifespan.

2.2.1 Method

2.2.1.1 Participants

One hundred and five participants were recruited, mainly from the internet. Due to a technical error during data collection anyone aged over 65 was classed as being 66 years old. The mean age of the sample population was 52.3 (SD = 12.8). The sample population has a mean number of years in full time education of 16.96 years (SD = 3.54).

2.2.1.2 Cognitive activity measures

Seven cognitive activities were assessed and participants were required to rate the frequency with which they undertook each activity (scale ranged from 0 – 4). The mean frequency of attempting cryptic crosswords was 2.34 (SD = 1.54), representing a figure between ‘several times a month’ and ‘several times a week’. The mean frequency of participation in quick and general knowledge crosswords was 1.68 (SD = 1.43) and 1.24 (SD = 1.07) respectively. Both values represent a frequency between ‘less than once a month’ and ‘several times a month’. It was also possible to calculate a total crossword activity frequency which had a mean of 5.15 (SD = 2.65) and total cognitive activity score which had a mean of 12.23 (SD = 3.37). It is interesting to note that the maximum total cognitive activity any participant reported was 21 on a scale which could reach 28; therefore there is no evidence of ceiling effects when calculating total cognitive activity.

Participants were also asked to indicate what proportion of each type of crossword which they regularly attempted they normally completed. The means for cryptic, quick and general knowledge crosswords were; 76.37 (SD = 32.78), 86.39 (SD = 24.28) and 72.35 (SD = 27.28) respectively. The scale was 0 – 100% and it is clear that participants completed a higher percentage of quick crosswords than either cryptic or general knowledge crosswords. Participants were also asked whether they attempted each crossword on their own, with a partner or by using another form of help. Unfortunately this information could not be incorporated into the analysis. As expected, the composite of total cognitive activity was significantly correlated with all cognitive activities, supported previous research such as Wilson et al. (2005), however it was not significantly correlated with the number of years in education ($r = 0.034$) as suggested by Wilson et al. (2007). Furthermore, total crossword activity was also higher significantly correlated with the frequency of attempting all three crosswords and total cognitive activity ($r(96) = 0.819$, $p < 0.001$).

2.2.1.3 Measures of self-reported cognitive functioning and health status

Participants were asked to rate their current memory ability, overall health and crossword solving skills to when participants regarded themselves to be in their prime. The scale ranged from -2 (‘much worse’) to 2 (‘much better’) with 0 representing ‘the same’. The second measure of cognitive functioning used an adapted cognitive failures questionnaire (Broadbent, Cooper, FitzGerald & Parkes, 1982). A value representing the total number of cognitive failures was calculated for each participant and the scale ranged from 0 to 48 (see Appendix One for full questionnaire).

2.2.1.4 Design and procedure

The questionnaire was distributed by hand, advertised on websites providing crosswords and on websites recruiting participants for psychological studies. The majority of the respondents completed the questionnaire online. Community groups for older adults were asked to distribute the questionnaire.

The analysis of the questionnaire took three forms; first, correlational analysis was used to identify any relationships between cognitive activity measures and reported cognitive functioning. Second, regression analysis was used to investigate any variables which accounted for a significant proportion of the variance associated with either estimates of participants on memory on total number of cognitive failures reported. Finally, ANOVA was used to compare age and reported crossword frequency on the basis of self-reported memory ability and total number of cognitive failures. To facilitate the third part of the analysis the sample population was reclassified into groups. For the analysis of the effect of age on self-reported cognitive functioning to types of age groups were created. An age split around the median age to produce a young and old group. Groups were created based on the median frequency of each specific type of crossword, total combined crossword frequency and total cognitive activity, to produce high versus low crossword/cognitive activity groups. The influence of percentage of specific crosswords completed was taken into account in various ways which will be described throughout the results section[4].

2.2.2 Results

2.2.2.1 Correlations

Table 2.1 shows the correlations between participants' self-reported health, memory, crossword skills and total number of cognitive failures, and activity variables, age, number of years in education and reported crossword completion rate. The results show the expected negative relationship between self-reported memory functioning and age ($r (105) = -0.27$, $p < 0.01$), but there is no significant negative correlation between age and total number of cognitive failures ($r = -0.050$). The lack of significant correlations

[4] Only key ANOVA results are reported due to the lack of results which differ from correlational and regression analyses.

between age and self-reported cognitive functioning is likely to be due to the technical errors when measuring age.

None of the cryptic activity frequency measures were significantly correlated with either subjective measures of participants own memory or total number of cognitive failures reported. As Table 2.1 shows none of the three crosswords appear to enhance participant's confidence in their own cognitive ability. Furthermore the composite of the three crosswords frequency is also not significantly related to the total number of cognitive failures.

Table 2.1. Correlations between age, number of years in education, self-reported cognitive activity, self-reported crossword completion and self-reported health, memory ability, crossword solving skills and total number of cognitive failures.

	Health	Own memory	Crossword skills	Total cognitive failures
Age	-0.138	-0.276**	0.185	-0.059
Years in education	0.270**	0.177	0.062	-0.127
Quick crossword	-0.064	-0.060	0.041	0.055
Cryptic crossword	-0.129	-0.023	0.494**	0.078
General Knowledge crossword	0.048	0.068	0.095	0.028
Reading	0.061	0.024	-0.126	-0.064
Playing cards	0.037	0.128	0.142	-0.070
Doing quizzes	-0.073	-0.035	0.194*	0.144
Playing board games	0.002	0.148	0.148	0.006
Total crossword activity	-0.095	-0.024	0.366**	0.118
Total cognitive activity	-0.034	0.034	0.387**	0.079
Quick completion rate	-0.223*	-0.074	0.416**	-0.028
Cryptic completion rate	-0.277**	-0.092	0.455**	-0.062
General knowledge completion rate	-0.155	-0.115	0.430**	-0.021

*Significant to $p < 0.05$ (Bonferroni corrected)
**Significant to $p < 0.01$(Bonferroni corrected)

Only cryptic crossword frequency is significantly correlated with self-reported crossword skills. This suggests that participants believe that, compared to quick and general knowledge crosswords, the skills required for completing cryptic crosswords are different. None of the three reported crossword completion rates were significantly related to subjective measures of memory or reported total number of cognitive failures.

However, this is likely to be due to the fact that completion rate of any crossword will rely on the frequency of participating in such crosswords, therefore partial correlations were used to investigate the relationship between crossword completion rate and self-reported memory and cognitive functioning. Only cryptic crossword completion was significantly correlated with subjective opinions of participants own memory functioning after controlling for cryptic crossword frequency.

To investigate the effect of age on the apparent relationship between cryptic crossword frequency/completion rate and self-reported memory/cognitive functioning, the sample population was separated into two groups based on a median age split. Correlational analysis showed no worthy correlations between subjective measures of participants memory and frequency or completion rate of cryptic crosswords (this was also true for quick and general knowledge crosswords). However, the results showed correlations nearing significance between cryptic crossword frequency in older adults and reported total number of cognitive failures ($r\ (52) = 0.0248$, $p = 0.07$). This relationship between cryptic crossword frequency and reported number of cognitive failures was not apparent in younger adults.[5] Unlike the use-dependency theory or cognitive reserve hypothesis predictions, the results indicate that older adults who attempt more cryptic crosswords report a higher number of cognitive failures than those who attempt less cryptic crosswords.

In conclusion, there was a lack of support from correlational analysis to indicate that older adults report more cognitive failures than younger adults as found in previous research (e.g. Broadbent et al., 1982). There was also a lack of support to suggest that either education or reported cognitive activities were associated with a higher self-reported cognitive functioning level. Once again, this is not supportive of previous research which has indicated that increased cognitive activity will result in increased

[5] These results were supported by a 2 X 2 ANOVA using the factors of median age and median cryptic crossword frequency with the dependent variable of total number of cognitive failures. There was a significant two-way interaction between the two factors ($F\ (1,101) = 4.255$, $p < 0.05$, $\eta^2 = 0.040$). The marginal means indicated that younger participants who did not attempt cryptic crosswords as frequently as reported 15.24% more cognitive failures than younger participants who regularly attempted cryptic crosswords. However, older adults who reported attempting cryptic crosswords more frequently had a reported total number of cognitive failures which was 27.68% higher than those who did not attempt cryptic crosswords as frequently.

MemSE and metacognitive functioning (e.g. Cavallini et al., 2003; Bandura, 1989). The use-dependency theory predicts that the relationship between cognitive activity and cognitive functioning is of increased importance in later life compared to earlier in life. Taking into account all of the cognitive activities investigated cryptic crosswords appear to be the only activity which has a direct correlation with reported number of cognitive failures in later life, which was not the case for younger adults. Contrary to the use-dependency theory, the analysis suggested that older adults who attempt cryptic crosswords more frequently report a higher number of cognitive failures than those who attempt cryptic crosswords less frequently.

2.2.2.2 Regression analysis

In line with previous research (e.g. Christensen & Mackinnon, 1993) regression analysis was used to investigate the relationship between cognitive activity and self-reported memory/cognitive functioning in the whole population and in the older adult sample. The results confirmed those provided in the correlational analysis (see Section 2.2.2.1) and did not provide any additional understanding of the relationship between cognitive activity, crossword completion rate and subjective reports of ones own memory or total number of cognitive failures.

2.2.2.3 ANOVA analysis

For completeness, a series of ANOVAs were conducted to investigate the effects of the three specific types of crosswords, total crossword activity, total cognitive activity and age. This was mainly because of the technical error which meant that participants' age was classified as 66 if it exceeded 65. The factor of age had two levels based on a median split (young versus old). The factor of crossword frequency initially used the scale described in Section 2.2.1.2, however no noteworthy results were found. Therefore a factor for each crossword frequency was created based on a median split of specific crossword frequencies. Factors were also created on the median split technique for total crossword frequency and total cognitive frequency (i.e. in all cases the factor represented high versus low frequency for either specific crossword frequency or total crossword/cognitive frequency). Previous research (e.g. Jopp & Herzog, 2007; Christensen & Mackinnon, 1993) has indicated that number of years in education may mediate the relationship between cognitive activity and cognitive functioning, therefore number of years in education was included as a covariate and if any noteworthy results were found between-subjects factor was included (i.e. high versus low education based on a median split). Specific crossword completion rates were also included as covariates and between-subjects factors when applicable. Only noteworthy results are reported below.

2.2.2.3.1 Subjective measures of memory functioning

Primary analysis used a 2 X 2 (specific crossword frequency or total crossword/cognitive frequency X age i.e. young versus old) ANOVA for the dependent variable of self-reported memory functioning. There was no significant main effect of median age on self-reported memory functioning throughout the analysis. There was also no significant main effect of median cryptic, median quick, median general knowledge, total crossword activity or total cognitive activity when these factors were included in separate ANOVAs with median age for this dependent variable. Furthermore, there was no evidence of significant 2 X 2 ANOVAs between median age and any of the other factors on self-reported memory functioning. The results were maintained when number of years in education and specific crossword completion rates were included in the ANOVAs separately. Overall the ANOVA analysis for this dependent variable did not suggest that age or frequent cognitive activity (measured in a variety of ways) had significant independent effects or significantly interacted.

2.2.3 Discussion

The aim of Study One was to investigate the impact of different types of crosswords on self-report measures of memory/cognitive functioning. This study also investigated whether self-reported crossword completion rates had an impact on MemSE. Finally, Study One investigated whether the impact of self-reported cognitive activity and MemSE had the same relationship across the lifespan.

Correlational results did not confirm the negative relationship between age and subjective measures of cognitive functioning (i.e. MemSE as measured by Broadbent et al., 1982), however there was a confirmation of the decrease of subjective ratings of participants own memory evaluations in older adults (e.g. Zelinski & Gilewski, 2004). The results support those of Rabbitt et al. (1995) in that older adults generally remark that their memory is failing due to aging, however do not always report a significantly greater number of cognitive failures than younger adults. One possibility is that older adults forget cognitive failures that they have made and therefore the lack of a significant increase in the report of cognitive failures by older adults may suggest a deficit in cognitive awareness.

There was no evidence that frequency of reported cognitive activity was correlated with reported memory or cognitive functioning. This does not support previous research that has indicated that an increase in cognitive activity is also associated with an increase in confidence in cognitive functioning (e.g. West et al., 2008; Cavallini et al., 2003). Overall correlational analysis did not show that cryptic, quick or general knowledge crosswords affected self-reported cognitive functioning differently. However, partial correlations indicated that the frequency of attempting cryptic crosswords had a larger impact on cognitive awareness in older adults than younger adults. This was supported by the ANOVA analysis which showed that older adults who attempted more cryptic crosswords reported significantly more cognitive failures than younger adults who also attempted cryptic crosswords regularly; however, for participants who did not regularly attempt cryptic crosswords, older adults reported fewer cognitive failures than younger adults.

The direction of the relationship between frequency of undertaking cryptic crosswords and reported cognitive failures, in older adults, suggests that attempting such crosswords may promote increased executive functioning/metacognition. Cryptic crossword solving/participation has been linked to self-testing (Forshaw, unpublished). Dunlosky et al. (2007; 2003) demonstrated that self-testing can increase metacognition and memory functioning in older adults, therefore it can be suggested that attempting cryptic crosswords in later life may also enhance metacognition; particularly the monitoring feedback pathway (see Figure 1.1).

The results did not show that the competency in completing quick or general knowledge crosswords had any direct or indirect effect on self-reported cognitive functioning. However, the results suggest that the perceived ability to complete cryptic crosswords has an indirect effect on cognitive awareness. This relationship could not be investigated, however, because ANOVA analysis did not illuminate how cryptic crossword frequency and reported completion rates interacted. Arguably, this is due to the relatively small sample population.

In conclusion, the results indicate that cryptic crosswords have a significantly larger affect on cognitive awareness than other types of crosswords. The affect of cryptic crosswords on cognitive awareness is more apparent in older than younger participants. The results, however, indicate that older adults who attempt more cryptic crosswords report more cognitive failures than those who attempt fewer such crosswords. There is also an apparent indirect or mediating effect of the ability to complete cryptic crosswords and this was investigated further in Chapter Five. Overall there is a modicum of support for the use-dependency theory, but a lack of support for the cognitive reserve hypothesis. The results suggest that attempting cryptic crosswords frequently may promote the awareness of cognitive decline associated with healthy aging, that is, metacognition may be improved in later life by undertaking cryptic crosswords.

2.3 Study Two: The relationship between age, attempting cryptic, general knowledge and quick crosswords and self-reported metacognition.

Study One possibly indicated that cryptic crosswords have a different effect on self-reported cognitive functioning than quick or general knowledge crosswords, as suggested by Hambrick et al. (1999) and Nickerson (1977). This was particularly the case for older adults; however the results showed that older adults who attempted more cryptic crosswords reported a higher number of cognitive failures than those attempting fewer such crosswords. One possible explanation of this is linked to the fact that solving cryptic crosswords requires self-testing or double checking solutions and clues (Forshaw, unpublished). Dunlosky et al. (2007; 2003) have demonstrated that self-testing can reduce the decline in metacognition which is associated with healthy aging (e.g. Vukman, 2005; Souchay & Isingrini, 2004). Therefore, Study Two investigated the relationship between self-reported participation in a number of cognitive activities (including cryptic, quick and general knowledge crosswords) and self-reported metacognition (e.g. Troyer & Rich, 2002).

2.3.1 Method

2.3.1.1 Participants

After the data was cropped for unfinished responses, the sample population consisted of 2050 participants with an age range of 19 – 92 (mean = 55.35, SD = 14.15). Participants had a mean number of years in education of 16.81 (SD = 3.59). As in Study One, two factors based on age were created to enable ANOVA analysis. First, two groups (young versus old) were created based on a median split. Second, age groups were created based on 20% cumulative frequency of the total age range. Values were group 1 = ages 19 – 44, 2 = 45 – 53, 3 = 54 – 59, 4 = 60 – 67 and 5 = 68 – 92. A factor representing a high and low education group was also created based on the median of total number of years in education.

2.3.1.2 Cognitive activity measures

Two extra cognitive activities were added to the seven which were used in Study One, this was based on Wilson et al. (2005). For cryptic crossword participation the mean frequency was 1.28 representing somewhere between ‘less than once a month’ to ‘several times a month’. Quick and general knowledge crosswords had a mean frequency of 2.55 and 2.73 (respectively) which represents between ‘several times a month’ and ‘several times a week’. As in Study One, a composite of total crossword frequency and total cognitive activity frequency was calculated, the means were 6.57

(SD = 2.78) and 15.10 (SD = 4.45) respectively. Once again, self-reported completion rates were taken for each specific crossword. The means for cryptic crossword completion was 63.22 (SD = 37.87), quick crossword completion was 86.66 (SD = 28.55) and general knowledge completion was 84.77 (SD = 22.94).

To facilitate ANOVA analysis two factors of specific crossword frequency were used, first the reported frequency with five levels and second a high low group based on the median. For total crossword frequency a factor was produced based on a median split (high versus low). For total crossword frequency two factors were created, one based on a median split (high versus low) and one based on 20% groups of total cumulative frequency.

2.3.1.3 Self-reported metacognition

The questionnaire used the self-report technique developed by Troyer & Rich (2002). This questionnaire had three sub-sections; first a measure of MemSE, second a measure of what Troyer & Rich termed cognitive strength (this sub-section focuses on participants confidence in cognitive functioning overall, not just memory functioning) and memory strategies (focusing on the number of strategies used to facilitate memory to complete everyday tasks). Taking into account the results of Study One and those of Rabbitt et al. (1995) it was prudent to consider whether self-report measures which used fewer items and focussed specifically on memory deficits, which have been associated with age, showed a greater sensitivity regarding differences in cognitive activity. The questionnaire also measured subjective memory functioning and crossword skills as Study One, however these results are not reported (see Appendix Two for full questionnaire).

2.3.1.4 Design and procedure

Participants were recruited by posting adverts on two internet sites which produced crossword puzzles, two internet sites recruiting volunteers for psychology studies, the psychology department participant pool and an advert in the university newspaper. Pen and paper copies were also distributed to local community centres and the older adult participant pool, however responses were relatively sparse in comparison to the sample population. The procedure for analysis was identical to that in Study One.

2.3.2 Results

2.3.2.1 Correlational analysis

Table 2.2 shows the correlational relationship between the three dependent variables and the key independent variable. The relationship between cognitive strength and age supports previous research (e.g. Zelinski & Gilewski, 2004) in that older adults are significantly less confident with their own cognitive ability than younger adults. However there is no significant negative relationship between age and MemSE as reported in previous research (e.g. Bandura, 1989). The results also show a significant negative relationship between the number of strategies used to aid memory and age. This indicates that older adults have a deficit in metacognition (e.g. Vukman, 2005).

As expected, number of years in education was significantly positively correlated with all three dependent variables. Unlike Study One taking part in cryptic, quick and general knowledge crosswords was significantly associated with a higher cognitive strength and MemSE, however none of the three crosswords significantly correlated with the use of memory strategies. Self-reported completion rates of all three crosswords were also significantly correlated with the dependent variables of cognitive strength and MemSE, but not the use of memory strategies.

Other activities which were significantly correlated with the dependent variables include doing quizzes, playing a musical instrument and practising a foreign language regularly. Combined crossword activity was also associated with significantly higher cognitive strength and MemSE, but not the use of memory strategies. Total cognitive activity was positively correlated with all three dependent variables, however the correlation with the use of memory strategies is very weak and probably due to the large sample size (Coolican, 1997).

Table 2.2. Correlation coefficients between the three dependent variables and age, number of years in education and the frequency of self-reported cognitive activities.

	Cognitive Strength	Memory Self-efficacy	Memory Strategies
Age	-0.106**	-0.041	-0.088**
Years in education	0.106**	0.077**	0.107**
Quick crossword	0.064**	0.076**	-0.032
Cryptic crossword	0.098**	0.076**	-0.026
General Knowledge crossword	0.119**	0.146**	0.004
Reading	0.036	0.047*	0.027
Playing cards	-0.009	0.025	0.008
Doing quizzes	0.055*	0.046*	0.009
Playing board games	0.032	0.030	0.08**
Playing an instrument	0.043*	0.051*	0.078**
Speaking a foreign language	0.080**	0.083**	0.084**
Total crossword activity	0.147**	0.155**	-0.030
Total cognitive activity	0.144**	0.160**	0.044*
Quick completion rate	0.077**	0.055*	0.043
Cryptic completion rate	0.137**	0.092**	-0.008
GK completion rate	0.129**	0.133**	0.017

*Significant to $p < 0.05$ (Bonferroni corrected)
**Significant to $p < 0.01$ (Bonferroni corrected)

Correlations were conducted for the younger and older group (based on a median split). Unlike Study One, the result indicated that the frequency of attempting cryptic crosswords and the rate of completion of such crosswords was only significantly correlated with MemSE in younger participants and not in older participants. However, both younger and older participants showed significant positive correlations between cryptic crosswords frequency/cryptic completion for cognitive strength. Both younger and older participants showed significant correlations for the frequency and ability to complete quick and general knowledge crosswords with MemSE and cognitive strength but not cognitive strategies used. No noteworthy results were found when partial correlations were used to investigate the relationship between crossword completion rates and the three dependent variables when controlling for specific crossword frequency.

In summary, the results show that older adults report a lower cognitive strength and use less memory strategies, however there was no significant relationship between age and

MemSE. The results support the view that attempting more cognitive activities is associated with higher self-reported memory, cognitive and metacognition functioning. Unlike Study One, there was a significant positive relationship between attempting all three types of crosswords and cognitive/memory confidence. There was no indication that attempting cryptic crosswords promoted self-reported metacognition (i.e. the use of memory strategies) as suggested in Study One. However it is possible that the memory strategy questionnaire does not focus specifically on all aspects of metacognition and only focuses on the control aspects described by Nelson & Narens (e.g. 1990; see Figure 1.1).

2.3.2.2 Regression analysis

2.3.2.2.1 Cognitive strength results

The first linear regression analysis investigated predictors of the variance associated with the cognitive strength dependent variable. Predictors were age which was entered first followed by number of years in education and the frequency of the nine cognitive activities. The regression equation was significant (adjusted $R^2 = 0.045$, $F(11, 2038) = 0.704$, $p < 0.001$). Age accounted for a significant amount of the dependent variable ($\beta = -0.106$, $t = -4.834$, $p < 0.001$) as well as the number of years in education ($\beta = 0.066$, $t = 2.894$, $p < 0.005$), frequency of attempting cryptic ($\beta = 0.093$, $t = 4.226$, $p < 0.001$) and general knowledge crosswords ($\beta = 0.125$, $t = 5.468$, $p < 0.001$). When the sample population was reduced to older people (using a median split) only two predictors accounted for a significant proportion of the cognitive strength variance, which were doing quizzes ($\beta = 0.093$, $t = 2.226$, $p < 0.05$) and the frequency of attempting general knowledge crosswords ($\beta = 0.100$, $t = 2.197$, $p < 0.05$).

2.3.2.2.2 MemSE results

For the dependent variable of MemSE, the procedure was repeated and the regression equation was significant (adjusted $R^2 = 0.036$, $F(11, 2038) = 7.995$, $p < 0.001$). Age did not account for a significant amount of the variance of MemSE ($t = -1.872$). However, number of years in education (β = 0.045, t = 1.953, p = 0.51), cryptic crossword frequency (β = 0.068, t = 3.077, $p < 0.005$), general knowledge crossword frequency (β = 0.141, t = 6.149, $p < 0.001$) and regularly speaking a foreign language (β = 0.048, t = 2.055, $p < 0.05$) accounted for a significant proportion of the variance associated with this dependent variable. When the sample population was restricted to older adults there were no noteworthy changes to report.

2.3.2.2.3 Reported use of memory strategies results

The procedure was repeated for the memory strategies variable and the regression equation was significant (adjusted R^2 = 0.023 F = (11, 2038) = 5.300, $p < 0.001$). The results confirmed the correlational analysis in that age accounted for a significant proportion of the variance for this dependent variable (β = 0.050, t = -2.113, p <0.05) and that the direction of the β value suggests that older people use fewer memory strategies. Number of years in education (β = 0.078, t = 3.397, p = 0.001), playing board games (β = 0.064, t = 2.711, $p < 0.01$) and playing a musical instrument (β = 0.052, t = 2.284, $p < 0.05$) accounted for a significant proportion of the variance associated with this dependent variable. When the sample population was restricted to older adults the only predictor which accounted for a significant amount of the variance associated with memory strategies used was number of years in education (β = 0.087, t = 2.671, $p < 0.01$).

2.3.2.2.4 Regression analysis summary

Overall, the regression analyses confirm that age is associated with a decrease in confidence in overall cognitive ability and a decrease in the use of strategies to aid memory. However the results do not support Zelinski & Gilewski (2004) in that age was not associated with a significant decrease in MemSE. For the whole sample population the regression analysis indicates that cryptic and general knowledge crosswords have a significant impact on confidence in cognitive functioning (i.e. cognitive strength) and MemSE, but not use of memory strategies. The effects of both types of crosswords on the dependent variables appear to be reduced in old age.

Therefore, there is some support for the cognitive reserve hypothesis but not for the use-dependency theory.

2.3.2.3 ANOVA analysis

Jopp & Hertzog (2009) have provided strong evidence that the relationship between cognitive activity and self-reported cognitive functioning can be mediated by a number of factors, including a measure of cognitive reserve. Christensen & Mackinnon (1993) have shown that participants with a differing number of years in education appear to show a different relationship between cognitive activity and cognitive functioning. Wilson et al. (2007) have argued that education is an objective measure of cognitive reserve, therefore it was necessary to use ANOVA analysis to investigate whether the relationship between self-reported cognitive activity and cognitive functioning was significantly different for those who differed on the number of years in education. Winder (unpublished) has also suggested that cryptic crossword completion rate may have a significant impact on the relationship between cryptic crossword frequency and self-reported cognitive functioning. Therefore a series of three-way ANOVAs were used to investigate whether mediating factors affected the relationship between self-reported cognitive activity and self-reported cognitive functioning. ANOVAs were used because regression analysis could not take mediating factors into account while maintaining the variance of effects of single factors. Only the results of three-way ANOVAs are presented here, unless the results of the two-way ANOVAs (activity X age) contradict the partial correlation and regression analysis.

The between-subjects factor of median education groups was included with median cryptic crossword frequency and median age in a 2 X 2 X 2 ANOVA for the dependent variable of MemSE. Of note was the significant three-way interaction between all three factors on MemSE ($F(1, 2042) = 5.826$, $p < 0.05$, $\eta^2 = 0.003$). Figure 2.1 shows that there is very little difference between younger and older participants' MemSE when they do not attempt cryptic crosswords frequently or when they attempt cryptic crosswords frequently and have fewer number of years in education. However for participants who attempt cryptic crosswords frequently and have a higher number of years in education the results show that younger participants have a high MemSE while older participants have a low MemSE.

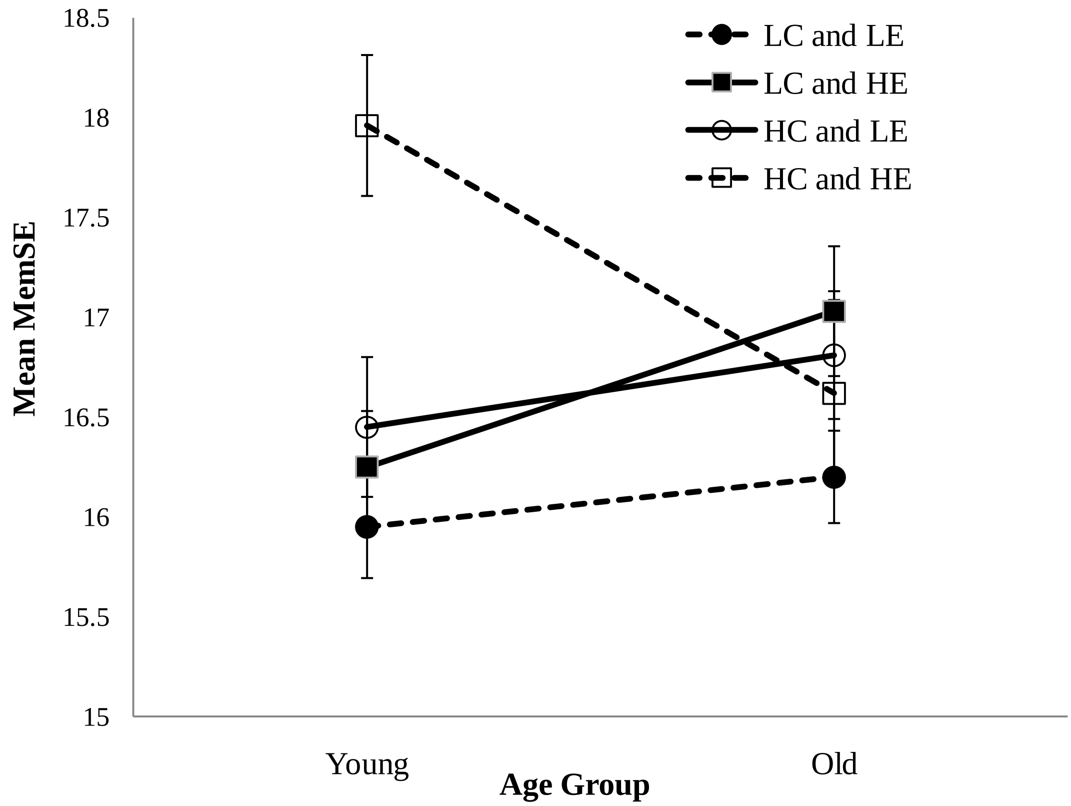

Figure 2.1. Significant three-way interaction between number of years in education, cryptic crossword frequency and age, on memory self-efficacy (MemSE). H = high, L = low, C = cryptic crossword frequency and E = number of years in education.

There was no significant three-way ANOVA involving median cryptic crosswords, median age and median education for the other dependent variable. There were also no significant three-way interactions for any of the dependent variables when median education was substituted for median cryptic crossword completion rate. Furthermore, there was no evidence of significantly fewer interactions with either median education or median crossword completion rate for the factors relating to quick, general knowledge or total crosswords (and total cognitive) activity for any of the dependent variables. In summary, as in Study One the only support for the use-dependency theory came from the analysis of reported cryptic crossword frequency. The results suggested that older adults who attempt more cryptic crosswords and have a higher number of years in education have a more realistic view of their memory ability than older adults who either do not attempt cryptic crosswords as frequently and/or have fewer years in education.

2.3.3 Discussion

Based on the findings of Study One the aim of Study Two was to investigate whether specific crossword frequency had a significant affect on self-reported metacognition and whether this relationship differed when comparing younger and older participants. Study Two also investigated whether total crossword frequency and total cognitive activity frequency affected reported metacognition in the whole (larger) sample population and whether this differed in younger and older participants.

Similar to the result of Study One and Rabbitt et al. (1995) there is no evidence of a negative relationship between age and MemSE. This is not supportive of previous studies such as Zelinski & Gilewski (2004) or Bandura (1989). However, there is clear evidence that confidence in overall cognitive ability (measured by cognitive strength) and metacognition (measured by the reported use of memory strategies) declines with age. This supports research which has indicated that metacognition declines in healthy aging (e.g. Vukman, 2005; Souchay & Isingrini, 2004). The lack of a relationship between cognitive confidence and age in Study One could have been explained by the relatively small sample population; however that cannot be the case in Study Two. It is possible that as the majority of participants were recruited from the internet the sample population was unrepresentative of older adults; that is, older adults who use the internet typically have a higher level of cognitive functioning and a high level of confidence in their memory ability because of the relatively demanding task (Salthouse, 2006; Salthouse et al., 2002).

The results supported the cognitive reserve hypothesis in that the frequency of attempting all three types of crosswords was positively related to self-reported opinions of MemSE and overall cognitive confidence. However, there was no evidence that any crossword promoted the reported use of strategies to aid memory. The results were mirrored for the construct of combined total crossword frequency. Cognitive strength and MemSE were positively associated with a higher reported level of total cognitive activity, as well as the reported use of memory strategies. This indicates that individuals who attempt a large variation of cognitive activities also report using more strategies to promote their own memory, supporting the view of Cavallini et al. (2003). Thus, attempting crosswords appear to promote the monitoring component in the Nelson & Narens' (1990) theory, whereas attempting a larger variety of cognitive activities appears to promote both the monitoring and the control pathways of the model (see Figure 1.1).

Regarding specific crossword frequency, there was a lack of support for the use-dependency theory with regards to quick and general knowledge crosswords. Specifically, there was no evidence that older adults who attempted more quick or general knowledge crosswords reported a higher confidence in their cognitive/memory ability or reported using more memory strategies. However both types of crossword were significantly related to a higher level of cognitive strength and MemSE (across the whole sample population), which supports the cognitive reserve hypothesis.

There was, however, support for the use-dependency theory with regards to the relationship between cryptic crossword frequency and both cognitive strength and MemSE. This was the case only when cryptic crossword completion rates or the number of years in education were taken into account in the analysis. Of particular note was that, when controlling for cryptic crossword completion rate, older adults who attempted no cryptic crosswords had a significantly higher cognitive strength score than younger adults who also did not attempt cryptic crosswords. However, the results were reversed for individuals who attempted cryptic crosswords every day, that is, older adults have a significantly lower cognitive strength than younger adults[6]. This supports the results of Study One in that cryptic crosswords promote self-testing which in turn promotes metacognitive awareness (e.g. Dunlosky et al., 2007; Dunlosky et al., 2003).

[6] However, this result must be taken with a note of caution because it is unclear how participants who do not attempt any cryptic crosswords can report a completion rate of such crosswords. One possibility is that participants are hypothesising/estimating their ability to complete such crosswords, this theory was investigated in Studies Three and Four (see Sections 2.4 and 2.5).

The result of self-reported cryptic crossword frequency also supports Jopp & Hertzog (2007) and Christensen & MacKinnon (1993) with regards to the mediating effects of education on the relationship between cognitive activity and cognitive decline. Figure 2.1 shows that a combination of frequently attempting cryptic crosswords and a greater number of years in education may enable older adults to form a more realistic opinion of their memory ability. Not only does this show support for the use-dependency theory (e.g. Wilson et al., 2002) but also the cognitive reserve hypothesis (e.g. Mortimer et al., 2003) because younger adults who attempt cryptic crosswords frequently reported the highest MemSE of the four sub-samples. A high level of education also appears to bolster MemSE when there is a lower level of cryptic crossword frequency which supports Wilson et al. (2009) and Christensen & Mackinnon's (1993) view that education can act as a protection against cognitive decline associated with healthy aging. It is the case that adults who spend a longer period in education develop skills to aid memory functioning i.e. metacognition (e.g. Romainville, 1994) and this is supported from the results which show a positive relationship between number of years in education and all three dependent variables.

Although the results (from the memory strategies dependent variable) do not indicate that cryptic crosswords promote the control pathway in the metacognition model (e.g. Nelson & Narens, 1990) it is possible that the memory strategies questionnaire was inappropriate to investigate this relationship. For example, the memory strategies questionnaire (Troyer & Rich, 2002) had a large number of questions which focused on strategies for prospective memories and many of these strategies used external aids. According to Hambrick et al. (1999) and Nickerson (1977) cryptic crosswords promote introspection and abstract thinking (e.g. Forshaw, unpublished) which have both been linked to executive functioning and metacognitive ability (e.g. Souchay & Isingrini, 2004; Kimball & Holyoak, 2000; Rebok & Balcerak, 1989). Therefore it is likely that a more direct investigation of the relationship between undertaking cryptic crosswords and the self-perceived impact on metacognition may produce more illuminating results (see Study Three, Section 2.4).

In conclusion, there was support for the cognitive reserve hypothesis, in that, participants who attempted more crosswords and overall cognitive activities reported a higher level of confidence in their cognitive abilities. The results also indicated that taking part in all three types of crosswords promotes the monitoring function/pathway of metacognition. However there was little evidence to support the use-dependency theory other than the relationship between cryptic crossword frequency and confidence in cognitive and MemSE, which differed across the lifespan. In support of Study One, the results showed that when controlling for cryptic crossword completion rates, older adults who never attempted cryptic crosswords had a higher level of confidence in their cognitive abilities than younger participants who also never attempted cryptic crosswords. However, those who attempted cryptic crosswords every day showed a more realistic view in that older adults reported a significantly lower cognitive strength than younger adults who also regularly attempt cryptic crosswords. There was no evidence that undertaking cryptic crosswords promoted the control aspect of metacognition, however this could be due to the questionnaire used. Therefore, Study Three investigated whether participants own opinions of the effect on cognitive abilities of attempting crosswords regularly differed across the lifespan.

2.4 Study Three: The relationship between age, attempting crosswords, MemSE and beliefs about the impact of cryptic and general knowledge crosswords.

Studies One and Two suggested that the frequency of attempting cryptic crosswords had a larger impact on self-reported cognitive functioning than the frequency of attempting quick and general knowledge crosswords. However, Hambrick et al. (1999) also indicated that when using objective measurements of cognitive functioning, general knowledge crosswords appear to have a significant relationship with a number of cognitive abilities including abstract thinking and problem solving[7]. The aim of Study Three was to investigate whether taking part in cryptic or general knowledge crosswords had a relationship with more direct measures of MemSE and to assess

[7] Unfortunately, Hambrick et al. (1999) did not investigate the relationship between cryptic crossword ability and cognitive ability/functioning, but speculated that the relationship between abstract thinking and problem solving would be significantly greater when investigating proficiency of solving cryptic crosswords.

participants' opinions of the impact of cryptic and general knowledge crosswords on cognitive functioning. As with the two previous studies, Study Three also investigated whether there was a difference in the results when comparing younger and older participants.

Although Studies One and Two have used self-report measures which have been shown to be highly reliable at detecting changes in cognition in healthy aging (e.g. Troyer & Rich, 2003), these questionnaires have focused on a number of different cognitive domains (e.g. working memory, episodic memory, perspective memory and semantic memory). Evidence from both subjective (e.g. Bandura, 1989; Berry, West & Dennehy, 1989) and objective (e.g. Dunlosky & Salthouse, 1996; Craik, 1977; Erber, 1974 and Studies Five and Six, see Chapter Three) have suggested that the effect of healthy aging is more apparent on the episodic memory system. Therefore, it is likely that support for the use-dependency or cognitive reserve hypothesis should be more apparent when focusing on episodic memory (see Shadish et al., 2002 and Chapter One for justification).

2.4.1 Method

2.4.1.1 Participants

An increased effort was made to recruit (particularly older) participants from the local community, not just the internet. Therefore, paper copies of the questionnaire were circulated in the local community and using various psychology participant pools for older adults. The sample population was 1,324 with an age range of 18 – 95. The mean age was 49.77 (SD = 17.36) and the mean number of years in education was 18.10 (SD = 3.3, range = 8 – 32). As in Studies One and Two, two age groups were created to facilitate ANOVA analysis. First, two groups were created based on a median split. Second, age groups were created based on 20% cumulative frequency of the total age range. Values were group 1 = ages 18 – 30, 2 = 31 – 47, 3 = 48 – 56, 4 = 57 – 65 and 5 = 66 – 95. A factor representing a high and low education group was also created based on the median of total number of years in education.

2.4.1.2 Cognitive activity measures

The cognitive activity measures were identical to those used in Study Two. For the three specific types of crosswords the means were 0.89 for cryptic (representing roughly less than once a month), 2.77 for general knowledge (representing between several times a month and several times a week) and 2.39 for quick crosswords (representing several times a month to several times a week). The mean for total crossword frequency was 6.05 (SD = 2.81) and the mean for total cognitive activity was 14.76 (SD = 4.61). Due to the length of the questionnaire specific crossword completion rate questions were omitted.

2.4.1.3 Self-reported cognitive functioning measures

The questionnaire took three measures of MemSE. First, a shortened version of Zelinski & Gilewski's (2004) MemSE questionnaire was used. Two other measures focused specifically on episodic memory. The first was termed Episodic Memory (EM) Prime Difference; this was calculated by subtracting participants' current ratings of their EM to ratings when they regarded themselves as being in their prime. The second measure was termed EM Total and was a composite of three questions specifically focusing on episodic memory functioning (based on Berry, West & Dennehy, 1989).

Two other sections of the questionnaire investigated participants' opinions of the cognitive benefits of attempting cryptic or general knowledge crosswords. Varimax rotational factor analysis was used to identify two constructs for each type of crossword. The first factor suggested questions which related to increasing mental awareness through undertaking each type of crossword, therefore these factors were termed Cryptic Awareness and General Knowledge Awareness respectively. A second factor was identified which contained questions relating to the perceived mental benefits of attempting each type of crossword, therefore these were termed Cryptic Mental Benefits and General Knowledge Mental Benefits respectively. The full questionnaire can be found in Appendix Three.

2.4.1.4 Design and Procedure

The design and procedure was identical to that used in Studies One and Two.

2.4.2 Results

The analysis was three-fold; first correlations and partial correlations were used to highlight potential relationship between factors. Second, regression analysis was used in line with previous research. Finally ANOVA analysis was used to take into account possible mediating factors which had been identified in Studies One and Two and by previous research (see Chapter One).

2.4.2.1 Correlational Analysis

Tables 2.3 and 2.4 show the correlational relationship between the factors. The tables have been separated on the basis of the dependent variables. Table 2.3 shows the correlations between the activity variable, age, number of years in education and the three dependent variables associated with memory self-efficacy, while Table 2.4 shows the same independent variables but the dependent variables are those associated with self-reported benefits of attempting cryptic or general knowledge crosswords.

Table 2.3 confirms significant negative correlations with age, MemSE and EM Total, and significant positive correlations between age and EM Prime Difference. All these correlations are supportive of previous research (e.g. Zelinski & Gilewski, 2004) in that participants' opinions of their own memory abilities declined with age. The results showed a small but significant correlation between quick crossword frequency and EM Prime Difference, cryptic crossword frequency and EM Total, and general knowledge crossword frequency and EM Prime Difference (see Table 2.3). There was also a significant correlation between total cognitive activity and both MemSE and EM Total. However, there was no significant correlation between total cognitive activity and EM Prime Difference.

Table 2.3. Correlation coefficients between MemSE, EM Prime Difference and EM Total and age, number of years in education and the frequency of self-reported cognitive activities.

	Memory Self-Efficacy	Episodic Memory Prime Difference	Episodic Memory Total
Age	-0.187**	0.279**	-0.301**
Years in education	0.086**	-0.172**	0.109*
Quick crosswords	-0.005	0.066*	0.021
Cryptic crosswords	0.010	-0.014	0.061*
GK crosswords	-0.016	0.078**	-0.040
Reading	0.080**	0.012	0.005
Playing cards	0.056*	0.004	0.053
Doing quizzes	0.087**	0.004	0.143**
Board games	0.077**	-0.055*	0.161**
Musical instruments	0.082**	-0.137**	0.105**
Foreign language	0.081**	-0.100**	0.127**
Total crossword	-0.006	0.069*	0.021
Total cognitive	0.100**	-0.023	0.148**

*Significant to $p < 0.05$ (Bonferroni corrected)
**Significant to $p < 0.01$ (Bonferroni corrected)

Table 2.4 indicates that cryptic crossword frequency is positively related to the two dependent variables of Cryptic Awareness and Cryptic Mental Benefits. This suggests that participants who attempt more cryptic crosswords believe that cryptic crosswords promote cognitive awareness and cognitive ability (mental benefits). There is a similar relationship between the frequency of undertaking general knowledge crosswords and GK Awareness and GK Mental Benefits. That is, participants who attempt more general knowledge crosswords believe that such crosswords promote cognitive functioning and cognitive awareness. There is also a positive relationship between the frequency of attempting quick crosswords and the two GK dependent variables but not the two Cryptic dependent variables. This is likely to be due to the similarities between general knowledge and quick crosswords. The frequency of median is significantly positively correlated with Cryptic Awareness, GK Awareness and GK Mental Benefit. Cryptic Awareness is also positively correlated with the frequency of playing musical instruments. GK Mental Benefits is positively associated with a number of other cognitive activities which appear to require crystallized intelligence (e.g. Wilson et al., 2005).

Table 2.4. Correlation coefficients between the two Cryptic and GK dependent variables and age, number of years in education and the frequency of self-reported cognitive activities.

	Cryptic Awareness	Cryptic Mental Benefits	GK Awareness	GK Mental Benefits
Age	-0.022	0.025	0.069*	0.104**
Years in education	0.035	-0.014	0.056*	-0.138**
Quick crosswords	0.028	0.043	0.085**	0.257**
Cryptic crosswords	0.458**	0.172**	-0.025	-0.015
GK crosswords	-0.047	0.018	0.224**	0.417**
Reading	0.079*	0.050	0.094**	0.125**
Playing cards	0.011	0.039	-0.044	0.126**
Doing quizzes	-0.018	0.002	0.008	0.171**
Board games	0.031	0.007	0.002	0.061*
Musical instruments	0.103**	0.013	0.047	0.033
Foreign language	0.059	0.052	0.009	0.022
Total crossword	0.217**	0.114**	0.141**	0.335**
Total cognitive	0.194**	0.108**	0.107**	0.325**

*Significant to p < 0.05 (Bonferroni corrected)
**Significant to p < 0.01 (Bonferroni corrected)

Repeating the analysis of Studies One and Two, the sample was split on the basis of median age and the correlations were repeated. Supporting Studies One and Two, older participants showed a significant positive correlation between cryptic crossword frequency and EM Total ($r (653) = 0.091, p < 0.05$), which was not the case in younger participants ($r = 0.057$). This suggests that older adults who attempt more cryptic crosswords report a higher episodic memory self-efficacy. The results also showed a significant correlation between the number of years in education and both EM Prime Difference ($r (653) = -0.222, p < 0.001$) and EM Total ($r (653) = 0.162, p < 0.001$) for older participants which was also not evident in the younger sub-sample ($r = -0.064$ and $r = 0.002$, respectively). Both correlations indicate that older adults who have a higher number of years in education report a higher confidence in their episodic memory ability. The results did not show any other noteworthy findings when the sample population was separated into median age groups compared to correlations reported in Tables 2.4 and 2.5.

Overall, the correlational analysis confirms the results of Study Two in that the frequency of attempting cryptic crosswords is significantly positively associated with confidence in individuals' memory abilities, specifically episodic memory ability. The result also showed that this relationship is only significant in the older adult sample population and not for younger participants. The results confirmed that individuals who attempt more cryptic crosswords believe that such crosswords have a positive benefit for cognitive awareness and cognitive functioning. A similar relationship is also found for general knowledge crossword frequency and the two general knowledge dependent variables. However, the correlational analysis does not indicate that the beliefs that attempting cryptic or general knowledge crosswords promote cognitive awareness/functioning are different between younger and older adults. Finally, in support of both previous studies, total cognitive activity is significantly positively correlated with MemSE and own measure of episodic memory self-efficacy (i.e. EM Total).

2.4.2.2 Regression analysis

As is Studies One and Two, regression analysis was used to extend the correlational analysis. Once again, for each dependent variable only key results are reported.

2.4.2.2.1 MemSE results

The regression equation was significant for MemSE (adjusted $R^2 = 0.032$, $F (11, 1312) = 5.009$, $p < 0.001$). Age accounts for a significant amount of the variance associated with MemSE ($\beta = -0.187$, $t = -6.911$, $p< 0.01$). Other predictors of MemSE included number of years in education ($\beta = 0.074$, $t = 2.646$, $p < 0.01$), reading ($\beta = 0.066$, $t = 2.382$, $p < 0.05$), doing quizzes ($\beta = 0.066$, $t = 2.251$, $p < 0.05$) and playing a musical instrument ($\beta = 0.057$, $t = 2.041$, $p < 0.05$). When age was excluded from the regression analysis, doing quizzes ($t = 1.757$) and playing a musical instrument ($t = 1.742$) did not account for a significant proportion of the variance associated with MemSE. Confirming the correlational results the regression analysis did not show that the frequency of attempting any of the three types of crosswords accounted for a significant proportion of MemSE. The results indicate that the predictors of age, doing quizzes and playing a musical instrument share a significant amount of the variance associated with MemSE.

The sample population was separated on the basis of median age and the regression analysis was repeated. For older adults, the predictors of number of years in education ($t = 1.896$), doing quizzes ($t = 0.246$) and playing a musical instrument ($t = 1.693$) became non-significant. This was not the case for the younger adult sample population. Once again, none of the three specific crossword frequencies were significant predictors of the variance associated with MemSE for younger or older participants.

2.4.2.2.2 EM Prime Difference results

The regression equation accounted for a significant proportion of the variance associated with EM Prime Difference (adjusted $R^2 = 0.100$, $F (11, 1312) = 14.427$, $p < 0.001$). Age ($\beta = 0.255$, $t = 8.754$, $p < 0.001$), number of years in education ($\beta = -0.151$, $t = -5.492$, $p < 0.001$) and playing a musical instrument ($\beta = -0.112$, $t = -4.024$, $p < 0.001$) were significant predictors of EM Prime Difference variance. Cryptic crossword frequency also accounted for a borderline significant proportion of the variance associated with EM Prime Difference ($\beta = -0.050$, $t = -1.849$, $p = 0.065$). When age was not included in the regression analysis, cryptic crossword frequency did not account for a significant proportion of EM Prime Difference ($t = -1.523$). When age was excluded from the regression analysis, speaking a foreign language ($\beta = -0.084$, $t = -2.494$, $p < 0.05$) and playing board games ($\beta = -0.065$, $t = -1.985$, $p < 0.05$) also accounted for a significant proportion of EM Prime Difference. The results were identical, in terms of significance, when the regression analysis was repeated for younger and older participants.

2.4.2.2.3 EM Total results

Once again, the regression equation for EM Total was significant (adjusted $R^2 = 0.123$, $F (11, 1312) = 17.860$, $p < 0.001$). Age ($\beta = -0.282$, $t = -9.815$, $p < 0.001$), number of years in education ($\beta = 0.100$, $t = 3.645$, $p < 0.001$), doing quizzes ($\beta = 0.109$, $t = 3.817$,

$p < 0.001$), playing a musical instrument ($\beta = 0.061$, $t = 2.202$, $p < 0.05$), speaking a foreign language ($\beta = 0.081$, $t = 2.935$, $p < 0.01$) and cryptic crossword frequency ($\beta = 0.075$, $t = 2.820$, $p = 0.005$) all accounted for a significant proportion of the variance associated with EM Total. Supporting the view that age and the frequency of attempting cryptic crosswords share variance associated with EM Total, the predictor of cryptic crossword frequency ($t = 0.868$) was not significant when age was excluded from the regression analysis. The predictor of playing a musical instrument also because non-significant ($t = 1.479$) when age was excluded.

When repeating the regression analysis on older participants, cryptic crossword frequency remained a significant predictor ($\beta = 0.085$, $t = 2.153$, $p < 0.05$), which was not the case in the younger sample population ($t = 0.430$). This supports Studies One and Two, and the correlational analysis, in that older adults appear to believe that undertaking cryptic crosswords frequently enhances the awareness or functioning of episodic memory. The results also show that for older adults, playing board games was a significant predictor of the variance associated with EM Total ($\beta = 0.091$, $t = 2.234$, $p < 0.05$), but playing a musical instrument ($t = 0.547$) and practising a foreign language ($t = 1.043$) did not significantly predict the variance associated with this dependent variable.

2.4.2.2.4 Cryptic Awareness results

The regression equation for Cryptic Awareness was significant (adjusted $R^2 = 0.217$, $F (11, 693) = 18.780$, $p < 0.001$). Age did not account for a significant amount of the variance associated with this dependent variable ($t = 1.665$). As expected, cryptic crossword frequency was a significant predictor of Cryptic Awareness ($\beta = 0.463$, $t = 13.558$, $p < 0.001$). The only other cognitive activity which was associated with a significant amount of the variance of Cryptic Awareness was playing a musical instrument ($\beta = 0.077$, $t = 2.212$, $p < 0.05$), however when age was excluded from the regression analysis this predictor was not significant ($t = 1.722$).

For older adults, number of years in education was still a significant predictor of the variance associated with Cryptic Awareness ($\beta = 0.126$, $t = 2.578$, $p = 0.01$), however this was not the case for the younger sample population ($t = -1.116$). This indicates that older adults who have a higher number of years in education feel that cryptic crossword frequency is positively associated with the belief that cryptic crosswords promote cognitive awareness, but the relationship is reversed in younger adults, that is, younger adults with fewer years in education feel that cryptic crosswords promote cognitive awareness. For younger adults, playing a musical instrument was not a significant predictor of this dependent variable ($t = 0.172$).

2.4.2.2.5 Cryptic Mental Benefit results

The regression equation for Cryptic Mental Benefits was significant (adjusted $R^2 = 0.022$, $F(11, 760) = 2.559$, $p < 0.005$). Age did not account for a significant amount of the variance associated with Cryptic Mental Benefits. The only predictor to account for a significant proportion of the variance associated with Cryptic Mental Benefits was cryptic crossword frequency ($\beta = 0.463$, $t = 13.558$, $p < 0.001$). The regression equation did not change in terms of overall significance or significance of predictors when age was excluded. The results were identical when the sample population was restricted to older adults.

2.4.2.2.6 GK Awareness results

The regression equation for GK Awareness was significant (adjusted $R^2 = 0.022$, $F(11, 760) = 7.959$). Age did not account for a significant proportion of the variance associated with GK Awareness ($t = 0.368$)[8]. Significant predictors were general knowledge crossword frequency ($\beta = 0.219$, $t = 7.451$, $p < 0.001$), number of years in education ($\beta = 0.058$, $t = 2.054$, $p < 0.05$), reading ($\beta = 0.063$, $t = 2.243$, $p < 0.05$) and playing cards ($\beta = -0.076$, $t = -2.569$, $p = 0.01$). When age was excluded from the

[8] When the predictor of age was entered in the regression analysis alone it accounted for a significant amount of the variance associated with GK Awareness ($\beta = 0.069$, $t = 2.411$, $p < 0.05$). This indicates that the predictors of age, general knowledge crossword frequency, reading, playing cards and the number of years in education share a proportion of the variance associated with GK Awareness.

analysis, reading did not account for a significant proportion of the variance for this dependent variable ($t = 1.425$). When the sample population was split on the basis of median age and the regression analysis was repeated, the only predictor which had a drop in significance for older adults was playing cards ($t = 1.160$). The significance levels for all other predictors were maintained.

2.4.2.2.7 GK Mental Benefits results

For the GK Mental Benefits dependent variable the regression equation was significant (adjusted $R^2 = 0.220$, $F (11, 1235) = 32.897$, $p < 0.001$). When age was entered before the other predictors it accounted for a significant proportion of the variance associated with GK Mental Benefits ($\beta = 0.104$, $t = 3.706$, $p < 0.001$), however it was not a significant predictor when number of years in education and the other cognitive activities were included in the regression model ($t = 0.923$). This indicates that age and number of years in education and/or cognitive activities share a significant amount of the variance associated with GK Mental Benefits. Significant predictors of variance were number of years in education ($\beta = -0.104$, $t = -4.159$, $p < 0.01$), quick crossword frequency ($\beta = 0.122$, $t = 4.517$, $p < 0.01$), general knowledge crossword frequency ($\beta = 0.356$, $t = 13.255$, $p < 0.001$), reading ($\beta = 0.053$, $t = 2.078$, $p < 0.05$), doing quizzes ($\beta = 0.091$, $t = 3.393$, $p < 0.05$) and cryptic crossword frequency ($\beta = -0.050$, $t = -1.952$, $p = 0.05$). Individuals who attempt more cryptic crosswords and have a higher number of years in education appear not to believe that taking part in general knowledge crosswords promotes cognitive functioning. When age was excluded from the analysis there was no difference in the significance of predictors. When restricting the sample population to older adults the predictor of cryptic crossword frequency was not significant ($t = -1.406$), all other predictors had the same significance level.

2.4.2.2.8 Regression analysis summary

The regression results supported the correlational results in that older adults apparently reported a lower MemSE than younger adults. Unlike Studies One and Two, there was no evidence that cryptic, quick or general knowledge crossword frequency accounted for a significant proportion of the variance associated with MemSE, which supports the correlational results. As expected, age accounted for a large proportion of the variance associated with EM Prime Difference. Cryptic crossword frequency also had a significant negative β value which indicates that individuals who attempt more cryptic crosswords believe that attempting such crosswords reduces the effects of age on episodic memory, however this was not the case when the sample population was restricted to only older participants. There was also no suggestion that participants felt that attempting general knowledge crosswords frequently reduced the episodic memory difference from their current age compared to when they were in their prime.

Regarding EM Total, age significantly accounted for a proportion of the variance associated with the dependent variable. This was also the case for a number of other cognitive activities including cryptic crossword frequency, but not general knowledge or quick crossword frequency. The direction of the β value for cryptic crossword frequency suggested that cryptic crossword frequency was positively associated with EM Total, supporting a correlational result and the results of Study Two. Interestingly, cryptic crossword frequency accounted for a significant amount of the variance associated with EM Total when the sample was restricted to older adults but this was not the case in the younger sample population. Once again, this supports previous results in that older adults appear to believe that cryptic crossword frequency has a larger impact on episodic memory functioning than younger adults.

As shown in the correlational analysis, cryptic crossword frequency and general knowledge crossword frequency were significant predictors of the two cryptic crossword dependent variables and the two GK dependent variables respectively. Older adults, compared to younger adults, appeared to have a higher association between cryptic crossword frequency and the belief that cryptic crosswords promote mental awareness. There was no difference for the Cryptic Mental Benefits measure. The results support Studies One and Two, and the correlational analysis of the current Study, in that older adults, who attempt more cryptic crosswords, believe that attempting cryptic crosswords promotes cognitive awareness. This is not the case for the two general knowledge crossword dependent variables (i.e. GK Awareness and GK Mental Benefits).

2.4.2.3 ANOVA analysis

The two-way (activity X age) ANOVA analysis supported the findings of both the correlational and regression analysis, particularly regarding the effects of cryptic crosswords on episodic memory. The factor of median education was included in the analysis for each dependent variable and each cognitive activity factor. There was only one significant three-way ANOVA which was between median total cognitive activity, median age and median education on MemSE ($F(1, 1314) = 8.997$, $p < 0.005$, $\eta^2 = 0.007$).

Figure 2.2 illustrates the three-way interaction between median education, median age and median total cognitive activity. Individuals with a low level of total cognitive activity and fewer years in education demonstrate the lowest MemSE score, regardless of age. The figure also demonstrates that older adults who have a greater number of years in education and a high level of total cognitive activity actually have a higher MemSE than younger adults with the same education background and level of cognitive activity. For younger adults, there does not appear to be a large difference in MemSE between those with high total cognitive activity and low educational background, or those with low total cognitive activity and a greater number of years in education. However, the results suggest that higher levels of total cognitive activity can bolster MemSE for older adults who have fewer years in education. For older adults, there is good support for the use-dependency theory but a lack of support for the cognitive reserve hypothesis. That is, individuals with a greater number of years in education and a low total cognitive activity demonstrate a low MemSE which is almost identical to older adults with fewer years in education and low total cognitive activity.

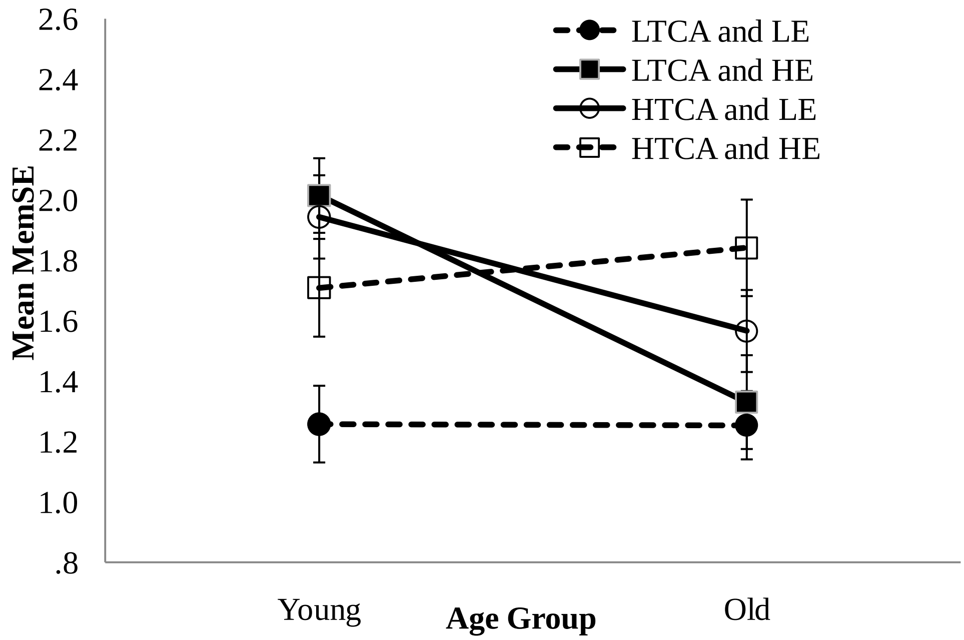

Figure 2.2. Significant three-way interaction between number of years in education, total cognitive activity and age, on memory self-efficacy (MemSE). H = high, L = low, TCA = total cognitive activity and E = number of years in education.

2.4.3 Discussion

One aim was to recruit a sample population which was more representative of the general population. The results support previous research (e.g. West et al., 2008; Zelinski & Gilewski, 2004; Cavallini et al., 2003; Bandura, 1989) with regards to the fact that older adults reported significantly lower MemSE and EM Total scores, and significantly higher EM Prime Difference scores. It is probable that this is due to the increase in sampling of older adults using the pen and paper method of testing; and not relying on internet sampling. This is critical because older adults, compared to younger adults, tend to require a greater degree of confidence in their cognitive abilities to use the internet and that using the internet may also have a reciprocal effect on MemSE as older adults regarded as very cognitively demanding (e.g. Salthouse, 2006).

The second aim of Study Three was to investigate the relationship between age and crossword frequency on more direct measures of self-reported cognitive functioning. Studies One and Two used reliable questionnaires which assessed self-reported cognitive and metacognitive functioning across a number of cognitive domains (e.g. working memory, episodic memory and perspective memory). Empirical research has shown that older adults report an increase in deficits in episodic memory (e.g. West et al., 2008; Zelinski & Gilewski, 2004; Berry et al., 1989), which is supported by objective measures (e.g. Dunlosky & Salthouse, 1996; see Chapter Three). Therefore, as discussed in Chapter One, evidence for the use-dependency theory and cognitive reserve hypothesis should be more apparent in cognitive domains that show both subjective and objective declines in healthy aging, specifically episodic memory.

With regard to this aim, there was support from the correlational, regression and ANOVA analysis for the cognitive reserve hypothesis. The results showed that individuals who attempted more cognitive activities (in particular cryptic and general knowledge crosswords) reported significantly higher levels of cognitive functioning. The composite of total cognitive activity indicated that over the whole sample population, those who attempted more cognitive activities also reported a higher level of confidence in their cognitive abilities. However, the ANOVA analysis indicated that cryptic crosswords were reliably associated with a higher rating of cognitive abilities, which was not the case for general knowledge, quick or total crossword frequency. This supports the results of Studies One and Two, in that cryptic crossword frequency has a larger impact on cognitive awareness than general knowledge or quick crossword frequency, as suggested by Hambrick et al. (1999) and Nickerson (1977).

There was also a significant amount of support for the use-dependency theory, particularly with regards to cryptic crosswords and total cognitive activity. The results show that older participants who attempt more cryptic crosswords had a higher EM Total score than those who attempt fewer cryptic crosswords. This relationship was not evident in the younger sample population. The ANOVA results show that older adults who have fewer number of years in education but attempt more cognitive activities have a higher MemSE than older adults who either have fewer years in education and attempt fewer cognitive activities or have an equal number of years in education and attempt less cognitive activities. These results support those of Christensen & Mackinnon (1989) and those of Study Eight, whereby cognitive activity appears to mediate cognitive decline/functioning for older adults with fewer years in education. To clarify, previous research such as Wilson et al. (2009) has indicated that a greater number of years in education can attenuate cognitive decline in later life. However, an increase in cognitive activity in mid to later life for those individuals with fewer years in education can also counteract the healthy aging process (e.g. Christensen & Mackinnon, 1993; Study Eight).

The final aim of Study Three was to investigate the subjective beliefs that attempting cryptic or general knowledge crosswords promoted cognitive awareness and cognitive functioning. As expected, individuals who attempted more cryptic or general knowledge crosswords believed that such crosswords promoted cognitive awareness and cognitive functioning. However, there was only evidence of a dissociation between younger and older adults for the belief that cryptic crosswords promoted cognitive awareness. There is evidence that adults aged between 48 and 56 show the highest belief that both cryptic and general knowledge crosswords promote cognitive awareness, but not cognitive functioning. However, the beliefs that cryptic crosswords promote cognitive awareness within the older sample population is apparent in the correlational, regression and ANOVA analysis, but this is not the case with general knowledge crosswords. Therefore, the results of Studies One and Two are supported, in that, the results show that older adults, to a greater degree than younger adults, who attempt more cryptic crosswords believe that such crosswords promote cognitive awareness.

The result of the correlational and regression analysis supports the findings of Study Two, in that attempting cryptic crosswords frequently appears to promote the monitoring pathway in Nelson & Narens' (1990) model of metacognition. Not only is there a direct reliable relationship between cryptic crossword frequency and the cryptic awareness dependent variable, but also that this relationship is more apparent in older adults. This adds support to the findings of Studies One and Two. In line with Dunlosky et al. (2007; 2003), the process of self-testing (required when solving cryptic crosswords; Forshaw, unpublished) seems to promote the awareness of cognitive functioning to a greater degree in older adults than younger adults.

Although there was evidence that cryptic crosswords promoted the control pathway in the metacognition model of Nelson & Narens (1990), there was no dissociation between this belief in younger and older adults. Specifically, participants who attempted more cryptic crosswords believed that such crosswords promoted cognitive functioning (measured by the Cryptic Mental Benefits dependent variable, which can be assumed to be a representation of the control pathway with regards to metacognition). However, there was no evidence of an increase in this belief for older adults compared to younger adults. Therefore, overall the results suggest that, although cryptic crosswords increase the awareness of cognitive functioning in older adults, there is no evidence that these individuals use the increasing awareness/monitoring to promote their cognitive functioning/control pathway. However, once again, it must be acknowledged that these are self-reported beliefs of participants and may not be representative of actual cognitive functioning (e.g. Rabbitt et al., 1995); this was investigated in Study Eight.

Even though the relationship between cryptic crossword frequency and self-reported metacognition is evident in older more than younger adults, this is not the case for the relationship between general knowledge crossword frequency and self-reported metacognition. The results show that over the entire sample population, those who attempt more general knowledge crosswords believe that such crosswords promote cognitive awareness and cognitive functioning. However, this belief is not significantly greater in the older compared to the younger sample population. Therefore, the results support the original hypothesis and the research by Forshaw (unpublished), Hambrick et al. (1999) and Nickerson (1977), which suggests that cryptic crosswords provide an opportunity for older adults to increase their metacognitive abilities. This is not the case with regards to general knowledge crosswords, suggesting that cryptic crosswords are unique and may provide a cognitive activity which could be used as an intervention to counteract healthy aging (see Chapter Five).

In conclusion, the results show that older adults report a significantly lower self-reported MemSE and evaluation of their own episodic memory functioning. The results also suggest that individuals who attempt more cryptic and general knowledge crosswords believe that such crosswords promote cognitive awareness and cognitive functioning. There is support for the use-dependency theory and for the results in Studies One and Two that suggest older adults who attempt cryptic crosswords show an increased belief that such crosswords promote the monitoring pathway of the metacognition model of Nelson & Narens (1990). This relationship is not significant in younger adults or in the relationship between general knowledge crossword frequency and the belief that general knowledge crosswords promote cognitive awareness more in older compared to younger adults. There is also evidence that older adults, but not younger adults, who attempt more cryptic crosswords have a higher confidence in their episodic memory ability than those who do not attempt cryptic crosswords frequently.

To follow on from Study Three, it was necessary to investigate whether individuals who attempted cryptic crosswords frequently also felt that cryptic crossword clues were easier to solve than those who do not attempt cryptic crosswords frequently. Also, whether the relationship between perceived cryptic clue solving and/or actual cryptic clue solving is different in younger and older adults. Furthermore, the relationship between the perceived ability (and the actual ability) of solving cryptic crossword clues and self-reported evaluations of participants own memory needed investigating. It is likely with the results of Studies One, Two and Three that older adults, in particular, who felt that cryptic crossword clues were relatively easy to solve may have a different MemSE (or episodic MemSE) evaluation to individuals who felt that such clues were more difficult to solve. Finally, it is possible that individuals who gave up attempting cryptic crosswords may have done so due to a decrease in perceived cognitive functioning. Therefore, Study Four and Study Four (a) investigated these relationships.

2.5 Study Four: The relationship between age, attempting cryptic crosswords, MemSE and the beliefs of solving cryptic crossword clues.

Study Three indicated that individuals who attempted more cryptic crosswords believed that such crosswords promoted cognitive awareness and cognitive functioning. Furthermore, the belief that cryptic crosswords promoted cognitive awareness was more evident in older adults than younger adults. However, it is necessary to investigate whether individuals who believe that cryptic clues are easier to solve also demonstrate a higher MemSE and episodic MemSE. According to Studies Two and Three, individuals who attempt more cryptic crosswords appear to have more confidence in their memory ability, however it is not clear whether these individuals actually believe that cryptic crosswords are easier to solve than individuals who do not attempt such crosswords. Furthermore, Studies One, Two and Three have indicated that the frequency of attempting cryptic crosswords has a larger impact on older adults than younger adults; therefore it was of interest to investigate whether the relationship between perceived cryptic clue difficulty and MemSE/episodic MemSE was different between younger and older participants. Previous studies had indicated that cryptic completion rate was a mediating factor, therefore Study Four considered this in the relationship between MemSE, cryptic crossword frequency and perceived cryptic crossword clue difficulty.

One possibility for the relationship found in Studies Two and Three in particular (that is, that older adults who attempt more cryptic crosswords appear to have a higher confidence in their memory ability or apparent improved cognitive awareness) is because older adults who feel that their cognitive abilities are declining gave up attempting cryptic crosswords. Therefore, Study Four investigated whether there was a difference in perceived cryptic clue difficulty between individuals who regularly attempt cryptic crosswords, never attempt cryptic crosswords or who have given up attempting such crosswords. The Study also investigated reasons why individuals gave up attempting crosswords.

2.5.1 Method

2.5.1.1 Participants

Study Four recruited 366 participants with a mean age of 38.40 (SD = 23.44). The entire sample population had a mean number of year in education of 15.09 (SD = 2.66). The majority of participants aged under 25 were recruited from the internet, mainly the student participant pool, however the over 80% of participants aged over 45 were recruited using pen and paper sampling techniques.

2.5.1.2 Cognitive activity measures

As in the previous three studies the frequency of participating in each type of crossword was measured on a five point Likert scale. Participants were also asked on a three point Likert scale whether they had given up a specific crossword, never attempted a specific crossword on a regular basis or still attempted the specific crossword. A four point Likert scale was used to measure what percentage of the participants' life had been spent attempting specific crosswords on a regular basis, there was also an option for those who never attempted such crosswords. These were 0 – 25%, 26 – 50%, 51 – 75%, 76 – 100% and not applicable/never attempted. Participants were also asked to report reasons why they may have given up attempting each type of crossword. The list of reasons can be found with the whole questionnaire in Appendix Four.

2.5.1.3 Self-reported cognitive functioning and cryptic crosswords clues difficulty measures

The cognitive functioning measures were identical to those used in Study Three (see Section 2.4.1.3); these included Episodic Memory Prime Difference (EM Prime Difference), Episodic Memory Total (EM Total) and overall Memory Self-efficacy (MemSE). A second measure asked participants to rate the difficulty of ten cryptic crossword clues which varied in difficulty according to the compiler. This used a five point Likert scale ranging from Very Difficult, Fairly Difficult, Moderate, Fairly Easy and Very Easy.

2.5.1.4 Design and procedure

The design and procedure was identical to that of the previous three studies with the exception of omitting regression analysis. However, the sample was heavily skewed in terms of age therefore it was not possible to produce median age groups. Thus, artificial age groups were created based on previous research (e.g. Wilson et al., 2005); these were 18 – 38 (mean age = 20.26, SD = 3.92, mean number of years in education = 14.96, SD = 2.05), 39 – 59 (mean age = 51.98, SD = 5.52, mean number of years in education = 16.24, SD = 2.95) and 60 – 90 (mean age = 70.83, SD = 7.43, mean number of years in education = 14.89, SD = 3.46).

A total of the perceived difficulty in solving each cryptic crosswords clue was calculated. This factor was used as both a dependent variable and a covariate throughout correlational and ANOVA analysis. Perceived cryptic crossword solving difficulty was also used as a dependent variable to investigate whether there was any interaction between age and cryptic crossword frequency on the perceived difficulty of cryptic crossword clues. As the results of the previous three studies indicated that cryptic crosswords have a larger effect on self-reported cognitive functioning, only the results of cryptic crosswords frequency, percentage attempted and stated of attempting/given up are reported.

2.5.2 Results

2.5.2.1 Correlational analysis

Table 2.5 shows the overall correlation matrix with the demographic factors and the four dependent variables. Supporting previous research (e.g. Zelinski & Gilewski, 2004; Berry et al., 1989; Studies Two and Three) there is a significant negative relationship between age and EM Total and MemSE, there is also a positive significant correlation between age and EM Prime Difference. The results also show that older adults who have attempted cryptic crosswords for a longer period of their lives believe that the cryptic crossword clues were easier to solve (see Table 2.5). This could have been due to the significantly positive correlation between age and cryptic crossword frequency ($r(363) = 0.458$, $p < 0.001$).

As expected, Cryptic Solve Total was significantly positively correlated with cryptic crossword frequency and the proportion of participants' life spent attempting cryptic crosswords (cryptic proportion; see Table 2.5). The results also showed that Cryptic Solve Total was not significantly correlated with either MemSE, EM Prime Difference or EM total. This indicates that participants who believed that the sample of cryptic crossword clues were easier to solve did not show significantly higher self-reported memory evaluations.

Table 2.5. Correlations between age, age group, number of years in education, cryptic crossword frequency, percentage of life spent attempting cryptic crosswords (cryptic proportion) and the four dependent variables.

	Memory Self-efficacy	EM Prime Difference	EM Total	Cryptic Solve Total
Age	-0.178**	0.419**	-0.438**	0.347**
Age group	-0.179**	0.394**	-0.432**	0.231*
Number of years in education	0.060	-0.115*	0.024	0.234**
Cryptic crossword frequency	-0.027	0.173**	-0.095	0.760**
Cryptic proportion	-0.029	0.138	-0.022	0.719**

* Significant to $p < 0.05$ (Bonferroni corrected)
** Significant to $p < 0.01$ (Bonferroni corrected)

The sample population was separated on the basis of age groups and the correlational analysis was repeated. The total number of reasons participants gave for giving up cryptic crosswords was also included in the analysis (termed Cryptic Reasons Total). In the overall sample population, there was no significant correlation between Cryptic Reasons Total and EM Prime Difference ($r = 0.045$), EM Total ($r = -0.014$) or MemSE ($r = -0.088$). In the youngest sample population these correlations were repeated, that is, none were significant, however in the 39 – 59 age group there was a significant correlation between Cryptic Reasons Total and EM Prime Difference ($r\ (35) = 0.406$, $p < 0.01$)[9]. In the oldest age group, there were no significant correlations between Cryptic Reasons Total and any of the self-reported memory functioning variables.

For the youngest age group there was also a positive correlation between age and Cryptic Solve Total ($r\ (172) = 0.272$, $p < 0.001$), which indicates that older adults within the youngest age group feel that cryptic crosswords are easier to solve. For the middle-aged group, the correlation between age and all four dependent variables were not significant. However, for the oldest age group the results confirmed a significant correlation between age and EM Prime Difference ($r\ (75) = 0.325$, $p = 0.001$), EM Total

[9] However, it is likely that this result is a statistical anomaly as only two people in the middle-aged group gave up attempting cryptic crosswords.

(r (75) = -0.211, $p < 0.05$) and MemSE (r (75) = -0.209, $p < 0.05$), however there was no significant correlation between Cryptic Solve Total and age (r = 0.025). The results confirmed those of Glisky & Glisky (1999) in that there is a larger variation of perceived memory functioning in older adults, which also supports Rabbitt et al. (1995).

The data was also separated on the basis of whether participants had given up cryptic crosswords, not given up cryptic crosswords or never attempted such crosswords. The results provide good support for the use-dependency theory in that for individuals who had given up cryptic crosswords the correlation between age and EM Prime Difference (r (22) = 0.639, p = 0.001), and the correlation between age and EM Total (r (22) = -0.664, p = 0.001) was larger than the correlations between age and EM Prime Difference (r (60) = 0.408, p = 0.01) and age and EM Total (r (60) = -0.456, $p < 0.01$) for individuals who were still attempting such crosswords. The correlation between age and EM Prime Difference and EM Total for those still attempting cryptic crosswords were also larger than for individuals who had never attempted such crosswords (r (200) = 0.293, $p < 0.01$ and r (200) = -0.418, $p < 0.01$, respectively). This relationship is more apparent when comparing the correlations between age group and EM Prime Difference which show a highly significant correlation for those who have given up cryptic crosswords (r (22) = 0.629, p = 0.002) compared to those who still attempt cryptic crosswords (r = 0.247, n.s.). Finally, those who had given up cryptic crosswords had a borderline significantly negative correlation between cryptic crossword frequency and EM Total (r (22) = -0.399, p = 0.066) which was not apparent in the sample who still attempted cryptic crosswords (r = 0.155, n.s).

Overall, the correlational results support the use-dependency theory in that participants who have given up attempting cryptic crosswords show larger correlation coefficients between age and both EM Prime Difference and EM Total than participants who either never attempt such crosswords or still attempt cryptic crosswords, this is more apparent when comparing the age group means. However, there is a lack of support for the cognitive reserve hypothesis in that cryptic crossword frequency and the proportion of participants' life spent attempting cryptic crosswords were not significantly correlated with either EM Prime Difference or EM Total. However they were significantly correlated with MemSE (see Table 2.5). Finally, the results support those of Studies Two and Three (e.g. Sunderland et al., 1986) in that older adults show a larger variation in self-reported cognitive functioning measures than younger adults.

2.5.2.2 ANOVA analysis

As in Studies One, Two and Three, ANOVA analysis was used to investigate the impact and interactions of age and cryptic crossword frequency on the four dependent variables. ANOVA analysis was also used to investigate the main effects and interactions of age and cryptic status (i.e. whether participants had given up attempting cryptic crosswords, never attempted cryptic crosswords or still attempted cryptic crosswords). The median age factor used previously could not be used due to the skew of age in the sample population; therefore the factor of age group (described in Section 2.5.1.4) replaced median age.

2.5.2.2.1 Cryptic crossword frequency results

A two-way ANOVA investigated the relationship between age group and median cryptic crossword frequency (3 X 2) on EM Prime Difference. There was the expected significant main effect of age group on EM Prime Difference supporting the correlational analysis ($F(2, 359) = 10.000$, $p < 0.001$, $\eta^2 = 0.053$). Older participants showed a 221.71% higher EM Prime Difference than younger adults. There was no significant main effect of median cryptic crossword frequency on this dependent variable ($F = 1.419$). However, there was a significant interaction between the two factors on EM Prime Difference ($F(2, 359) = 3.650$, $p < 0.05$, $\eta^2 = 0.020$).

Figure 2.3 illustrates the significant two-way interaction between age group and median cryptic frequency on EM Prime Difference. The figure shows that for the youngest and oldest age group, there is relatively no difference between those who attempt cryptic crosswords regularly or infrequently. However, for the middle aged group, the results show that those who attempt fewer cryptic crosswords show a larger EM Prime Difference than those who regularly attempt cryptic crosswords. These results support those in Study Three that suggest that the frequency of attempting cryptic crosswords may have a larger impact on individuals who can be classed as middle aged, compared to younger or older adults.

Controlling for the number of years in education did not change the significance levels of the original ANOVA. However, controlling for cryptic proportion produced a significant main effect of median cryptic crossword frequency on EM Prime Difference ($F\ (1, 77) = 4.656$, $p < 0.05$, $\eta^2 = 0.057$). The marginal means confirm that participants who attempted more cryptic crosswords had a 206.46% lower EM Prime Difference compared to those who attempted fewer cryptic crosswords. The results confirmed the original findings with regards to age group but the interaction between the two factors on EM Prime Difference was not significant ($F = 1.481$). The covariate of Cryptic Solve Total was included in the original ANOVA; the results were identical to those reported above.

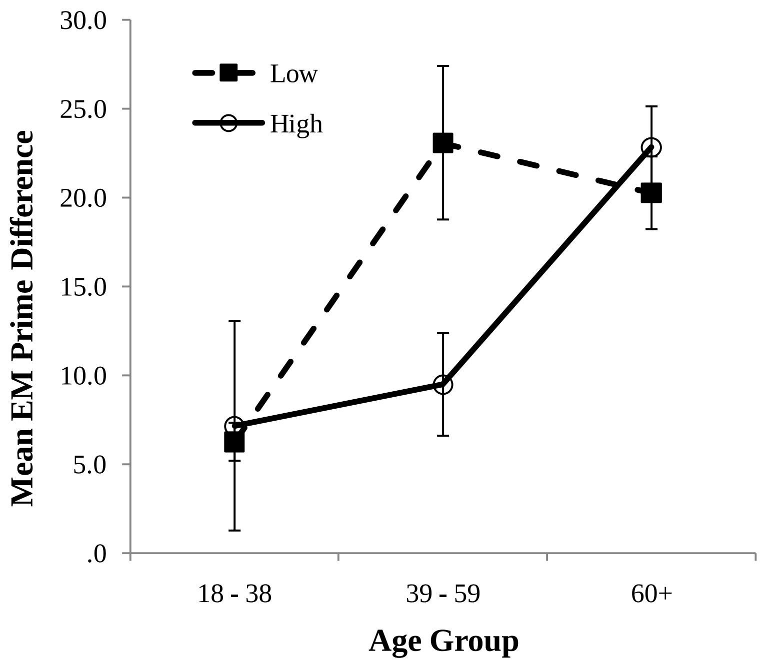

Figure 2.3. Significant two-way interaction between age group and median cryptic crossword frequency on Episodic Memory Prime Difference (EM Prime Difference).

The original ANOVA was repeated for the dependent variable of EM Total. The results confirmed a significant main effect of age group on EM Total ($F(2, 359) = 16.397$, $p < 0.001$, $\eta^2 = 0.084$). The marginal means showed that the youngest age group had a 28.61% higher EM Total than oldest age group. There was no significant main effect of median cryptic crossword frequency on EM Total ($F = 0.487$) and there was also no significant two-way interaction between both factors ($F = 0.166$). Controlling for number of years in education and Cryptic Solve Total (in separate ANCOVAs) did not produce different results from the original ANOVA. However, controlling for cryptic proportion reduced the significance of the main effect of age group on EM Total to a non-significant level ($F = 2.656$). No other noteworthy results were found.

Age group and median cryptic crossword frequency were entered into a 3 X 2 ANOVA with the dependent variable of MemSE. There was no significant main effect of age group ($F = 1.982$) or median cryptic crossword frequency ($F = 1.515$) on MemSE. There was also no significant two-way interaction for this dependent variable ($F = 0.175$). Controlling for the number of years in full time education or Cryptic Solve Total, did not influence the results of the original ANOVA.

However, when controlling for cryptic proportion, the results showed a significant two-way interaction between median cryptic crossword frequency and age group ($F(2, 76) = 6.323$, $p < 0.005$, $\eta^2 = 0.143$). Similar to the EM Prime Difference results, Figure 2.4 shows that participants who regularly attempt cryptic crosswords between the ages of 39 – 59 show a significantly higher MemSE that those who do not attempt such crosswords. There is no apparent difference for the other two age groups with regards to MemSE for those who regularly attempt or do not attempt cryptic crosswords. The covariate did not change the significance of the main effects of either factor.

A further 3 X 2 ANOVA investigated the influence of age group and median cryptic crossword frequency on the dependent variable of Cryptic Solve Total. The results showed a significant main effect of age group ($F(2, 388) = 3.700$, $p < 0.05$, $\eta^2 = 0.021$). The marginal means indicated that the reported belief of the cryptic crossword clues difficulty was 14.37% lower in younger adults than older adults. However, for the middle age group, the Cryptic Solve Total was 12.05% higher than the younger group and 27.99% higher than the older group. The results also confirmed a significant main effect of median cryptic crossword frequency on Cryptic Solve Total ($F (1, 338) = 220.733$, $p < 0.001$, $\eta^2 = 0.395$). The marginal means confirmed that participants who attempted more cryptic crosswords had a Cryptic Solve Total which was 334.76% higher than those who attempted fewer cryptic crosswords. There was no significant interaction between the two factors for this dependent variable ($F = 1.421$).

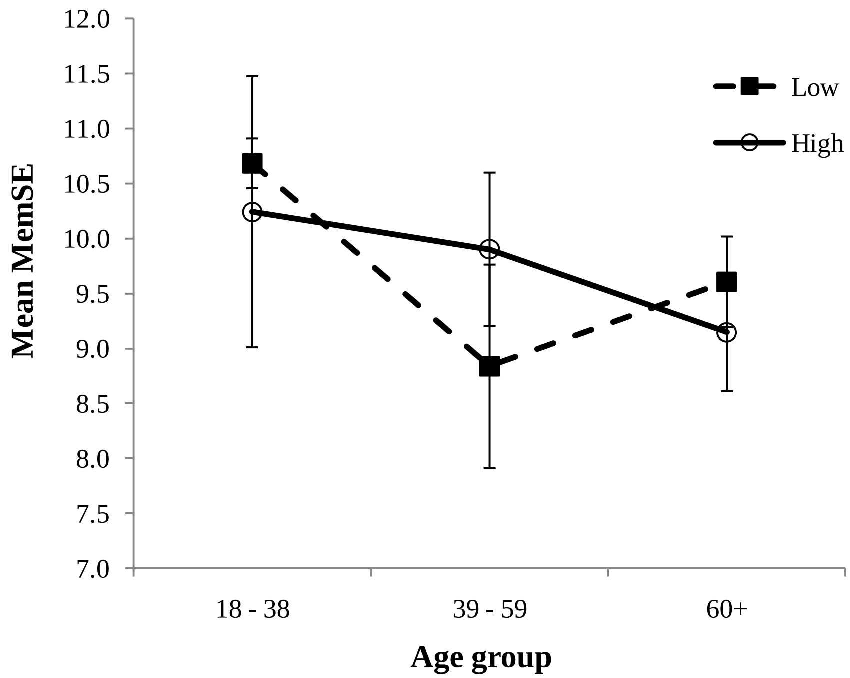

Figure 2.4. Significant two-way interaction between age group and median cryptic crossword frequency on Memory Self-Efficacy (MemSE).

In summary, the results confirm the findings in Studies One, Two and Three, in that older adults report a significantly lower self-efficacy in both overall memory ability and specifically episodic memory. The results also show that when taking into account the percentage of ones lifespan spent attempting cryptic crosswords, there is evidence of a two-way interaction between age group and cryptic crossword frequency for both EM Prime Difference and overall MemSE. The results support the findings from Study Three and indicate that cryptic crossword frequency has a larger impact on episodic/memory self-efficacy of middle-aged individuals than younger and older adults. The results show that participants in the age group of 39 – 59 report a higher confidence in their memory abilities than those who do not attempt as many cryptic crosswords. However, this finding was not repeated when covariates were excluded from the analysis. This indicates that the proportion of time (over ones life) spent attempting cryptic crosswords, mediates the relationship between cryptic crossword frequency and memory self-efficacy at specific ages across the lifespan.

2.5.2.2.2 Cryptic status results

A number of different ANOVAs were used to investigate the relationship between cryptic status (i.e. whether participants had given up attempting cryptic crosswords, never attempted cryptic crosswords or were still attempting cryptic crosswords) and age (i.e. age groups) on the four dependent variables. The first group of ANOVAs used a 3 (age group) X 3 (cryptic status) design, then a combination of 3 X 2 ANOVAs (age group X still attempting versus never attempted, or youngest age group versus oldest age group X cryptic status) were used. Finally, 2 X 2 ANOVAs (youngest versus oldest age group X given up attempting cryptic crosswords versus still attempting cryptic crosswords) were used for each dependent variable. The covariates of number of years in education and cryptic proportion were included for each dependent variable separately. Furthermore, the covariate of cryptic solve total was also included for the first three dependent variables (i.e. EM Prime Difference, EM Total and MemSE) but obviously not when Cryptic Solve Total was a dependent variable. Only key results are reported.

Regarding the dependent variable of EM Prime Difference, a 3 X 3 ANOVA confirmed the significant main effect of age group ($F\ (2, 273) = 12.007$, $p < 0.001$, $\eta^2 = 0.081$); the results support those in Section 2.5.2.2.1. There was also a significant main effect of cryptic status on EM Prime Difference ($F\ (2, 273) = 3.305$, $p < 0.05$, $\eta^2 = 0.024$). The marginal means showed that those who had given up attempting cryptic crosswords had a 79.85% higher EM Prime Difference than those who still attempted cryptic crosswords. Furthermore, those who had given up such crosswords had a 93.75% higher EM Prime Difference compared to those who never attempted such crosswords, however the difference in EM Prime Difference of those who never attempted cryptic crosswords and who still attempted cryptic crosswords was only 7.17%.

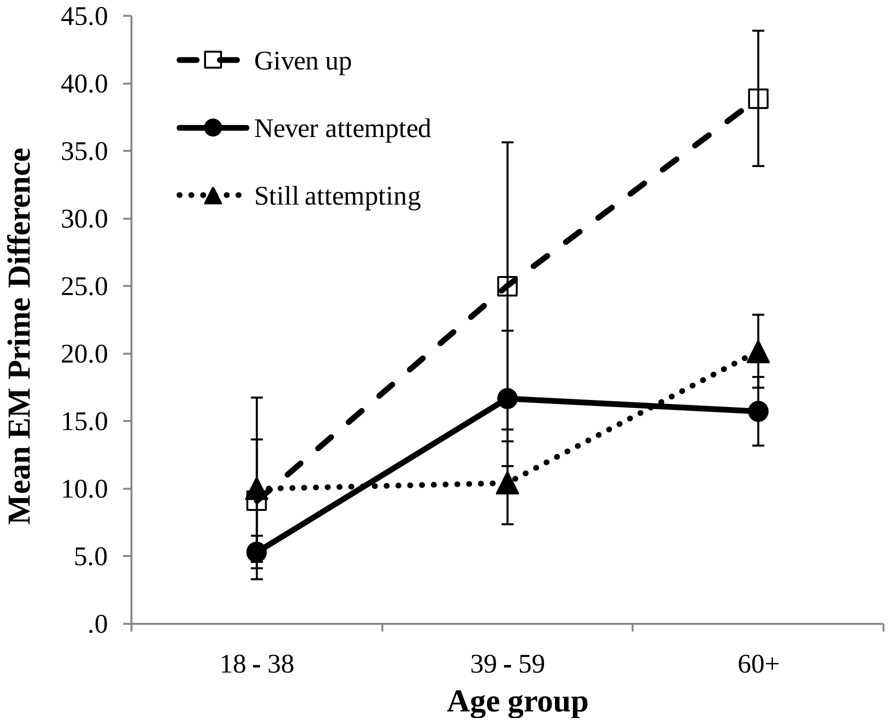

Figure 2.5. Significant two-way interaction between age group and cryptic status on mean episodic memory (EM) Prime Difference.

There was also a borderline two-way interaction between the two factors ($F (4, 273) = 2.254$, $p = 0.06$, $\eta^2 = 0.032$). Figure 2.5 illustrates that there is little difference between the EM Prime Difference of participants who either still attempt cryptic crosswords or who had never attempted cryptic crosswords; for these two groups of participants, there is only a slight increase in EM Prime Difference when comparing the youngest to oldest group. However, for participants who had reported giving up attempting cryptic crosswords, the figure shows that EM Prime Difference is much higher for the middle-aged and especially the oldest age group compared to either the youngest group who have given up cryptic crosswords or the other two older subsamples. This supports the correlational analysis and indicates that older participants may give up attempting cryptic crosswords due to a drop in the confidence of their cognitive abilities. Of note, is that when controlling for Cryptic Solve Total, the interaction increased in significance ($F (4, 254) = 3.204$, $p < 0.05$, $\eta^2 = 0.048$). This indicates that participants' beliefs of the difficulty of the cryptic crossword clues presented in the questionnaire mediated their reported episodic memory functioning.

For the same dependent variable of EM Prime Difference, a 2 X 2 (age group X cryptic status) ANOVA compared participants who were in the youngest and oldest age groups and who still attempted or had given up attempting cryptic crosswords. Once again, when controlling for cryptic solve total the results of the ANOVAs showed a significant two-way interaction ($F(1, 46) = 3.791$, $p = 0.058$, $\eta^2 = 0.076$). The difference in EM Prime Difference between younger and older adults who still attempt cryptic crosswords was 84.41%; however for individuals who had given up attempting cryptic crosswords, the difference between younger and older adults was 1074.93%. This adds further support to the view that older adults who have given up cryptic crosswords have done so due to the fact that attempting such crosswords reduces their memory self-efficacy and potentially makes them more aware of their current cognitive abilities (i.e. cognitive decline). An alternate explanation would be that older adults gave up attempting such crosswords due to losing the cognitive ability to do so, but as the interaction is only evident when controlling for Cryptic Solve Total the results suggest that attempting cryptic crosswords promotes awareness, which supports the results of Studies Two and Three.[10] Unfortunately it was not possible to investigate the relationship between median Cryptic Solve Total, age group (young versus old) and cryptic status (still attempting versus given up) due to the relatively small sample population.

A 3 X 3 (cryptic status X age group) ANOVA showed no significant main effect of cryptic status on EM Total ($F = 2.446$). The results confirmed the significant main effect of age group on EM Total ($F(2, 272) = 21.232$, $p < 0.001$, $\eta^2 = 0.135$); as reported previously, younger participants reported a higher EM Total than older participants. There was no significant two-way interaction between the two factors on EM Total ($F = 0.833$). This result was maintained when all covariates were included in the ANOVAs separately.

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[10] The main effect of age group on EM Prime Difference was maintained ($F(1, 46) = 12.007$, $p = 0.001$, $\eta^2 = 0.207$) in this analysis, however there was no significant main effect of cryptic status ($F = 0.291$).

Of note was the result of a 2 X 2 (cryptic status; still attempting versus given up X age group; youngest versus oldest) ANOVA on EM Total when cryptic proportion was included as a covariate. There was no significant main effect of either cryptic status ($F = 0.907$) or age group ($F = 2.609$), but there was a significant two-way interaction between the two factors on EM Total ($F (1, 26) = 5.970$, $p < 0.05$, $\eta^2 = 0.184$). The marginal means showed that compared to older adults, younger adults who had given up attempting cryptic crosswords had an EM Total which was 77.06% higher, however older adults compared to younger adults who still attempted cryptic crosswords had an EM Total which was 9.03% higher. Not only does this indicate that attempting cryptic crosswords regularly in old age can boost episodic memory self-efficacy, but the result also supports the view that older adults who find cryptic crosswords difficult give up attempting such crosswords potentially due to a drop in memory self-efficacy. Once again, this relationship was only evident when controlling for perceived difficulty of the cryptic clues percentage in the questionnaire, which may have encouraged older adults to re-evaluate their current cognitive functioning. No other noteworthy results were found for this dependent variable when including the other covariates in the analysis.

The original 3 X 3 (age group X cryptic status) ANOVA was repeated for the dependent variable of MemSE. There was no significant main effect of either age group ($F = 1.882$) or cryptic status ($F = 2.623$) on MemSE. Furthermore, there was no significant two-way interaction between the two factors for this dependent variable ($F = 0.280$). Controlling for number of years in education and cryptic solve total did not influence the results of the original ANOVA. However, the covariate of cryptic proportion produced a significant two-way interaction between age group and cryptic status on MemSE ($F (4, 64) = 2.710$, $p < 0.05$, $\eta^2 = 0.145$).

Figure 2.6 illustrates the relationship between the two factors; younger adults who still attempt cryptic crosswords show the lowest MemSE of all subgroups, however younger adults who have never attempted cryptic crosswords show the highest MemSE. For individuals who have either never attempted cryptic crosswords or have given up cryptic crosswords, there is little difference for the youngest group and middle-aged group. The middle-aged subsample who still attempt cryptic crosswords showed a markedly higher MemSE compared to the other two middle-aged groups. Also, regarding the oldest group, the results support those shown in the EM Prime Difference analysis, that is that those who have given up cryptic crosswords show the lowest MemSE for that age group followed by those who have never attempted such crosswords and the highest MemSE for older adults is reported by those who still attempt cryptic crosswords. Once again, the results indicate that older adults who have given up cryptic crosswords, may have done so due to a lack of confidence in their cognitive abilities, especially since the cryptic crossword clues were presented before the MemSE questions which may have encouraged older adults to re-evaluate their current cognitive functions.[11]

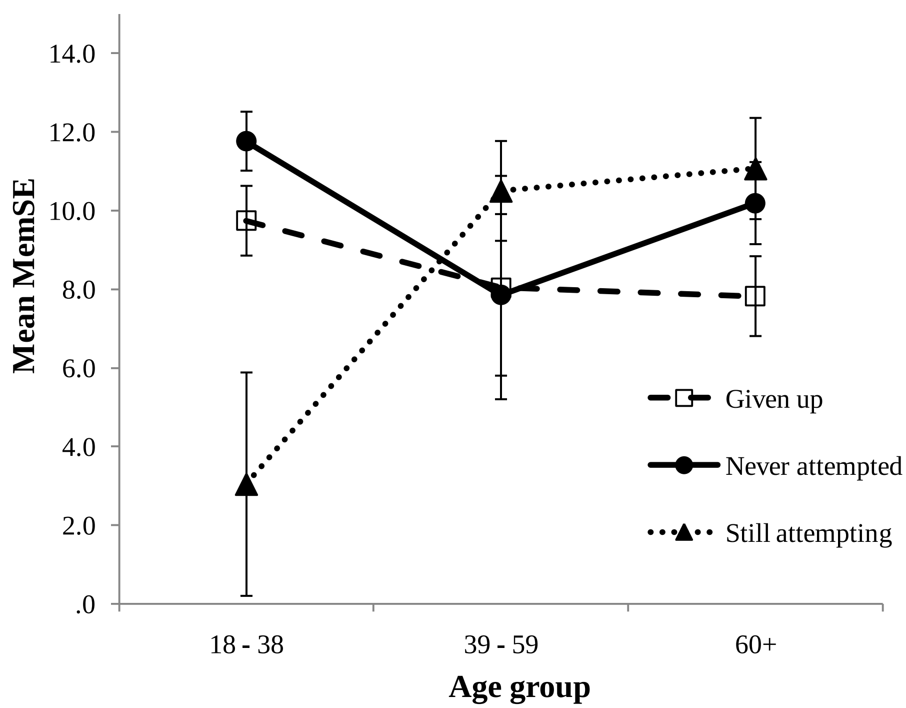

Figure 2.6. Significant two-way interaction between age group and cryptic status on mean memory self-efficacy (MemSE) when controlling for cryptic percentage.

A 2 X 2 (age group; youngest versus oldest X cryptic status; still attempting versus give up) ANOVA showed no significant main effect of either age group (F = 1.844) or

[11] These results were supported in a 2 X 3 ANOVA where the middle-aged group was omitted (F (2, 56) = 5.124, $p < 0.01$, $\eta^2 = 0.155$), however, once again this was only significant when cryptic percentage was included as a covariate.

cryptic status ($F = 2.063$) on MemSE. There was also no significant interaction between the two factors on MemSE ($F = 0.013$). However, when cryptic proportion was entered as a covariate, the results showed a highly significant two-way interaction on MemSE ($F (1, 27) = 10.025$, $p < 0.005$, $\eta^2 = 0.271$), but the main effect of age group ($F = 3.982$) and cryptic status ($F = 0.498$) remained non-significant. The interaction showed that the mean MemSE for younger adults who had given up cryptic crosswords was 24.96% higher than older adults who had also given up cryptic crosswords. However, the pattern was reversed for individuals who still attempted cryptic crosswords; older adults had a 296.22% higher MemSE than younger adults who also still attempted cryptic crosswords. As with the results from EM Prime Difference, this indicates that completing cryptic crosswords influences participants opinions of their own memory ability and may be a mediating factor for why certain people give up attempting such crosswords. No other results of note were found for this dependent variable.

The final set of ANOVAs used Cryptic Solve Total (i.e. the perceived ease of solving ten cryptic crossword clues) as a dependent variable. A 3 X 3 (age group X cryptic status) ANOVA showed a significant main effect of cryptic status on Cryptic Solve Total ($F (2, 255) = 86.337$, $p < 0.001$, $\eta^2 = 0.404$). As expected, those who had never attempted cryptic crosswords perceived the clues as 325.37% more difficult than those who still attempt cryptic crosswords. Participants who had given up such crosswords perceived the clues to be 132.30% more difficult than those who still attempt cryptic crosswords and 83.11% easier than those who have never attempted cryptic crosswords. There was no significant main effect of age group ($F = 1.688$) and no significant two-way interaction ($F = 1.254$) for this dependent variable. The only covariate which influenced the significance was cryptic proportion. The results of the 3 X 3 ANOVA showed a significant main effect of age group on Cryptic Solve Total ($F (2, 59) = 9.321$, $p < 0.001$, $\eta^2 = 0.240$). The marginal means are reported in Section 2.5.2.2.1. The significant main effect of cryptic status was maintained. There was also a significant two-way interaction on this dependent variable ($F (4, 59) = 3.161$, $p < 0.05$, $\eta^2 = 0.175$). The marginal means are not particularly interesting; the interaction appears to have been produced as there is relatively no difference between cryptic status for the middle-aged group on Cryptic Solve Total. When the middle-aged group is excluded from the analysis, no significant results are found, even when covariates were included.

In conclusion, the results confirm that older adults, compared to younger adults, who have given up cryptic crosswords tend to have a significantly lower confidence level in their episodic memory than those who still attempt cryptic crosswords. These results support the view that older adults who have given up cryptic crosswords have done so due to a drop in their current memory self-efficacy. These results support the correlational analysis in the current study and the views/results of Studies One, Two and Three. The interactions between cryptic status and age group become more apparent when controlling for reported ability to solve cryptic crosswords in the past (i.e. cryptic proportion). This was also the case for the dependent variable of overall MemSE, that is older adults reported a higher MemSE when still attempting cryptic crosswords than those who had given up attempting such crosswords, however this relationship was reversed for the younger sample population. Taken together, these results indicate that the perceived ability of solving cryptic crosswords (either across the lifespan as measured by cryptic proportion or during the questionnaire, as measured by Cryptic Solve Total) mediates the relationship between age and perceived memory ability.

2.5.2.3 Reasons for giving up cryptic crosswords results

As stated in Section 2.5.1.2, participants were asked to indicate reasons why they had given up undertaking cryptic crosswords. Two constructs were produced, one representing the total number of reasons given (total reasons) and one representing the reason relating to cognitive abilities associated with attempting cryptic crosswords (mental reasons). The overall correlational analysis appeared to support the construct validity of both variables. That is, total reasons was significantly negatively correlated with cryptic crossword frequency ($r(363) = -0.101$, $p = 0.05$) and cryptic proportion ($r(84) = -0.423$, $p < 0.001$). Mental reasons were also significantly correlated with cryptic crossword frequency ($r(363) = -0.104$, $p < 0.05$) and cryptic proportion ($r(84) = -0.389$, $p < 0.001$). However, there was no correlation between age and either total reasons ($r = -0.038$) or mental reasons ($r = -0.043$). This indicates that older adults do not report more reasons for giving up cryptic crosswords than younger adults.

The results in Studies Three and Four indicated that cryptic crosswords had a larger impact on subjective memory ratings of older compared to younger adults. Therefore, the correlations were repeated for the youngest and oldest age groups. There was no significant correlations between cryptic crossword frequency ($r = 0.123$) or cryptic proportion ($r = 0.138$) with total reasons. This was also the case for mental reasons, there was no significant correlation between either cryptic crossword frequency ($r = 0.091$) or cryptic proportion ($r = 0.049$) for the youngest participant group. However for the oldest subgroup, the results showed a significant correlation between cryptic crossword frequency ($r (102) = -0.240$, $p = 0.015$) and cryptic proportion ($r (34) = -0.579$, $p < 0.001$) with total reasons. The results also showed significant correlations between mental reasons with both cryptic crossword frequency ($r (102) = -0.259$, $p < 0.01$) and cryptic proportion ($r (34) = -0.524$, $p < 0.001$). Although both of these correlations indicate that older people reported more total reasons and mental reasons for not taking part in cryptic crosswords, t-tests did not confirm a significant difference in the number of reasons reported between younger and older adults for either total reasons ($t = 0.778$) or mental reasons ($t = 0.196$). ANOVA analysis including cryptic crossword frequency, median cryptic crossword frequency and cryptic proportion with the youngest and oldest age group did not produce any results of note for either dependent variables.

To summarise, the results confirmed a negative relationship between cryptic crossword frequency and the number of reasons participants gave for giving up such crosswords. There were also significant negative correlations between the reported number of reasons for giving up cryptic crosswords and the proportion of such crosswords completed in the past. The correlational analysis indicated that both of these relationships were more evident in older than younger adults, indicating that older adults give up attempting cryptic crosswords due to a drop in confidence in their memory ability. However, these results were not supported with t-test and ANOVA analysis, possibly due to the relatively small sample size of participants who had given up attempting cryptic crosswords.

2.5.3 Discussion

Study Four had three main aims based on Studies One, Two and Three; first, to replicate the findings with regards to the relationship between age, cryptic crossword frequency and self-reported cognitive ability. Second, to investigate whether there was a direct relationship between reported cryptic crossword ability and perceived difficulty of solving a sample of cryptic crossword clues, also leading on from Study Three, to examine whether there was a difference in terms of age groups with this relationship. The final aim was to investigate whether there was a difference between younger and older adults who had given up attempting cryptic crosswords or still attempted such crosswords with regards to their confidence in their mental abilities. This aim also analysed whether there was a difference in reported reasons, between younger and older participants, as to why they had given up cryptic crossword participation.

In brief, the results support previous research (e.g. Zelinski & Gilewski, 2004; Bandura, 1989) in that older adults report a significantly lower MemSE in both overall memory and episodic memory than younger adults. There is also evidence supporting Study Three, in that middle-aged adults who attempt more cryptic crosswords report a higher confidence in episodic memory and overall MemSE than the other two subgroups of participants. This became more apparent when the covariate of cryptic proportion was included in the analysis, which indicates that the proportion of ones life spent attempting cryptic crosswords mediates the relationship between cryptic crossword frequency and memory self-efficacy more for middle-aged and older adults than for younger adults.

There was strong support for the view that adults who attempted more cryptic crosswords believed that the sample cryptic crossword clues were easier to solve than those who attempted less cryptic crosswords. Once again, when taking into account cryptic proportion, the results showed that the relationship between cryptic crossword frequency and perceived ability to solve cryptic crossword clues was more apparent in older than younger adults. Supporting the view of Bandura (1989), these results can suggest that older adults who attempted more cryptic crosswords over the lifespan will do so because they view the crossword clues as relatively easy which promotes their MemSE. This also fits in with the view of Nelson & Narens (1990), in that the meta-level (of metacognition) is relying on feedback from the object-level (i.e. the monitoring pathway). Therefore, if older adults are successfully completing cryptic crosswords (by checking the results or completing the crosswords at the object-level) the monitoring feedback will bolster the meta-level. Therefore, as there is evidence that the perceived ability to solve cryptic crosswords is significantly positively related to cryptic crossword frequency (especially in older adults) the results support the view that cryptic crosswords can act as an aid to bolster metacognition and cognitive awareness in older adults. Study Three indicated that older adults believed that cryptic crosswords promoted cognitive awareness and the results of Study Four support that subjective opinion.

The most interesting finding in Study Four was the relationship between participants who had never attempted cryptic crosswords, given up attempting cryptic crosswords or who were still attempting such crosswords. Supporting the results of Study Three, the analysis confirmed that older adults who still attempted cryptic crosswords had a higher episodic and overall MemSE than either those who had never attempted cryptic crosswords or who had given up attempting such crosswords. This relationship became more apparent when taking into account either the proportion of life spent attempting such crosswords or the perceived difficulty of the crossword clues presented in the questionnaire.

These results support the view of Berry et al. (1989) and Bandura (1989) that older adults will only take part in cognitively stimulating activities when they feel confident in their ability to complete such an activity. Of note was the fact that participants were asked to rate the cryptic crossword clues (in terms of difficulty) before reporting episodic MemSE and overall MemSE. For younger adults, there was no evidence that the perceived ability of solving the cryptic clues had any effect on their evaluations of their own episodic memory in relation to their cryptic status (i.e. whether they still attempted, never attempted or had given up cryptic crosswords). However, the results for older adults showed that episodic memory self-efficacy was significantly lower for those who had never attempted or given up cryptic crosswords compared to those who still attempted such crosswords when the perceived ability to solve the sample clues was taken into account. This suggests that reading/attempting the cryptic clues forced older adults to re-evaluate their current cognitive functioning which, in turn, impacted on their current episodic MemSE.

This was also the case when the covariate of cryptic proportion was taken into account (i.e. the proportion of participants' life spent attempting cryptic crosswords). Older adults, who had given up attempting cryptic crosswords showed a significantly lower episodic and overall MemSE than those who still attempted cryptic crosswords. However for younger adults, this relationship was marginally reversed. This supports the view that older adults will give up attempting cryptic crosswords because the decrease in the ability to solve such crosswords reduces their confidence in their cognitive abilities. The relationship between cognitive confidence and cryptic status in younger adults is unclear; one possibility is that younger adults who have a lower MemSE may have started attempting cryptic crosswords in an attempt to promote their cognitive abilities.

The correlational analysis also showed that the relationship between the number of reasons for giving up cryptic crosswords and the frequency of attempting cryptic crosswords was significant in older but not younger adults. This was the case for overall total number of reasons and also reasons pertaining specifically to cognitive abilities. Unfortunately, due to the relatively small sample size of older adults who had given up cryptic crosswords, further statistical analysis did not illuminate a difference in the reasons for giving up such crosswords compared to younger adults. Overall, the results of the analysis for the third aim of Study Four indicate that older adults give up cryptic crosswords due to a drop in confidence in their cognitive ability. In line with the metacognition model of Nelson & Narens (1990), the results suggest that when older adults are unable/less able to complete cryptic crosswords this affects the monitoring feedback pathway between the object- and meta-level. The result is a decrease in the meta-level. Therefore, it is logical to assume that as the meta-level (i.e. MemSE) decreases older adults choose to give up attempting such tasks as the control pathway appears to be unable to adapt to the demands at the object-level (supporting the conclusions of Studies Two and Three).

It must be acknowledged that the assessment of the difficulty of solving cryptic clues only measured participants' beliefs about the clues and not the actual ability to solve the clues. Furthermore, it is important to analyse whether the relationship between self-reported episodic memory and cryptic crossword ability is dependent upon whether the participants attempt the crossword clues before or after undertaking an episodic MemSE task. Therefore, Study Four (a) investigated whether there was a difference in terms of episodic MemSE for older people who attempted to solve cryptic crossword clues before taking part in a MemSE evaluation compared to those who completed the MemSE evaluation first.

2.6 Study Four (a): The relationship between attempting cryptic crosswords, episodic MemSE and the ability to solve cryptic crossword clues.

The results of Study Four indicated that older adults who had given up attempting cryptic crosswords had a significantly lower confidence in their episodic memory ability than those who still attempted cryptic crosswords. This became more apparent when taking into account the proportion of participants' life spent attempting cryptic crosswords and the perceived ability to solve a sample of cryptic crossword clues. The design of the questionnaire in Study Four required participants to evaluate the cryptic crossword clues before estimating their MemSE. The results indicated that participants who found the crossword clues difficult to solve reported a significantly lower MemSE than those who regarded the clues easier to solve. However, this was more apparent in older than younger adults.

Therefore, Study Four (a) investigated whether there was a difference in MemSE when individuals attempted cryptic crossword clues before or after evaluating their memory functioning. According to the previous studies, it is likely that individuals who attempted the cryptic clues before reporting their MemSE would report a lower MemSE as attempting to solve the clues would encourage re-evaluation of their cognitive functioning. This was hypothesised to be significant because the sample population was restricted to older adults who report a greater deficit in cognitive (specifically episodic memory) functioning (e.g. Berry, West, Hastings, Lee, & Cavanaugh, 2010; Zelinski & Gilewski, 2004; and Studies Two and Three) and who showed a greater impact of perceived difficulty of solving cryptic crossword clues on self-reported memory/cognitive functioning (see Study Four).

2.6.1 Method

2.6.1.1 Participants

The sample consisted of 71 participants with a mean age of 70.54 (range = 60 – 86, SD = 6.572). The overall sample had a mean number of years in education of 14.85 (SD = 3.790). The sample was separated on the basis of whether the participants attempted the cryptic clues before (version 1) or after (version 2) the episodic MemSE questions. The mean age of participants in version 1 and version 2 were 70.18 (SD = 5.992) and 70.86 (SD = 7.130) respectively. There was no significant difference in either age ($t = -0.438$) or number of years in education ($t = -0.938$) between the two subsamples. All participants were sampled using the pen and paper method due to possible confounds when recruiting older adults via the internet (see Studies Two and Three for discussion).

2.6.1.2 Cognitive activity measures

Cryptic crossword frequency was measured using a Likert scale as with Studies One, Two, Three and Four. Participants were also required to report the proportion of ones life spent attempting cryptic crosswords on a five point Likert scale. Finally, participants were asked to report how much effort was required when they complete a cryptic crossword; this also used a five point Likert scale. For the cryptic proportion (i.e. the proportion of participants life spent attempting cryptic crosswords) and the cryptic effort (i.e. how much effort is required when completing a cryptic crossword) measures the values on Likert scale where: 1 = 0 – 25%, 2 = 26 – 50%, 3 = 51 – 75%, 4 = 76 – 100% and 5 = not applicable (categorised as missing data as some participants had never attempted cryptic crosswords). Although general knowledge and quick crosswords were measured in addition to cryptic crosswords, this data was not included in the analysis due to the results of the previous four studies.

2.6.1.3 Measures of self-reported episodic memory functioning and cryptic crossword clue solution ability

Episodic MemSE was assessed using the same questions presented in Studies Three and Four; however a Likert scale was not used, that is participants were required to fill in the actual percentages in correspondence to the question (see Appendix Five for full questionnaire). Two variables representing episodic MemSE were created; first, EM Prime Difference which subtracted participants reported ability (illustrated in a percentage) to recall a list of fifteen words at their current age, from the same question but when they regarded themselves as in their prime. Mean EM Total was created by calculating a mean from three questions which assess episodic memory self-efficacy at participants' current age.

Ten cryptic crossword clues were presented, which varied in difficulty. A space was provided with the appropriate number of letters (blank spaces) for participants to write the solution. If participants correctly solved the clue, they received a score of 1, but if they solved the clue incorrectly or did not solve it at all they received a score of 0. A total was calculated and this variable was entitled Cryptic Solve Total.

2.6.1.4 Design and procedure

As mentioned, two versions of the questionnaire were used. Therefore, a between-subjects design was used, essentially to compare the episodic MemSE dependent variables between version 1 and version 2 of the questionnaire. This first used correlational analysis and t-tests. Second, ANOVA analysis was used to investigate any relationship between cryptic crossword frequency, cryptic proportion, cryptic effort, cryptic solve total and number of years in education, and the two episodic MemSE dependent variables. The procedure was identical to that of the previous four studies, however, critically, participants were told to complete the questionnaire in the order it was presented and not to read through it before completing it. This was important because the aim of the study was to investigate whether attempting cryptic clues before or after undertaking an episodic MemSE test, influenced participants episodic MemSE.

2.6.2 Results

2.6.2.1 Correlational analysis

For the whole sample population, there was a significant positive correlation[12] between age and EM Prime Difference ($r\ (71) = 0.276$, $p < 0.05$), however there was no significant correlation between age and Mean EM Total ($r = -0.119$). There was the expected significantly positive correlation between cryptic frequency and Cryptic Solve Total ($r\ (71) = 0.709$, $p < 0.001$) and a significantly negative correlation between cryptic effort and Cryptic Solve Total ($r\ (16) = -0.536$, $p < 0.05$). It must be acknowledged that the sample size for those who reported cryptic effort values is relatively low, but the results confirm the hypothesis that participants who needed to put in more effort when solving cryptic clues were worse at solving such clues. There was no significant correlation between cryptic proportion and Cryptic Solve Total ($r = 0.337$) or cryptic proportion and EM Prime Difference ($r = -0.232$), but there was a borderline significant correlation between cryptic proportion and Mean EM Total ($r\ (19) = 0.430$, $p = 0.066$).

The correlational analysis was repeated for the two subsamples (i.e. version 1 and version 2 of the questionnaire). For participants undertaking version 1 (i.e. completing the episodic MemSE test before attempting the cryptic clues) the only significant correlation was between cryptic crossword frequency and Cryptic Solve Total ($r\ (34) = 0.665$, $p < 0.001$). However, for participants who attempted the cryptic clues before

[12] All correlations reported have been Bonferroni corrected.

completing the episodic MemSE test (i.e. version 2) there were a number of significant correlations.

First, there was a significantly positive correlation between age and EM Prime Difference ($r(37) = 0.341$, $p < 0.05$); this indicates that in comparison to participants who attempted version 1, participants who attempted the cryptic crossword clues before the episodic MemSE test became more aware of the difference between their current episodic memory functioning compared to their episodic memory functioning when they were in their prime. Second, there was also a significantly negative correlation between EM Prime Difference and Cryptic Solve Total ($r(37) = -0.350$, $p < 0.05$). The correlations suggest that those who were less able to solve the cryptic clues reported a higher difference between their current episodic memory functioning compared to when they regarded themselves as in their prime.

Furthermore, there were borderline and significant correlations between cryptic proportion and both EM Prime Difference ($r(12) = -0.561$, $p = 0.056$) and Mean EM Total ($r(12) = 0.603$, $p < 0.05$). As these correlations were not apparent in the version 1 subsample, the results indicate that attempting more cryptic crosswords over the lifespan mediates older adults opinions of their cognitive functioning when evaluating their functioning after, but not before, attempting cryptic crosswords. Although not significant, the results show that the relationship between cryptic effort and EM Prime Difference was negative ($r = -0.241$) for participants who attempted version 1, but positive ($r = 0.304$) for participants who attempted version 2 of the questionnaire. The relationship was also replicated for the Mean EM Total variable, that is for version 1 participants showed a positive relationship with cryptic effort ($r = 0.347$) but for version 2 the relationship was negative ($r = -0.271$).

In conclusion, the correlational analysis showed that participants who completed an episodic memory self-efficacy test after attempting the cryptic crossword clues reported a significantly lower episodic MemSE in relation to age, the ability to solve cryptic crosswords and the amount of effort taken when solving such crosswords. There was also a positive relationship between the proportion of lifespan spent attempting cryptic crosswords and episodic MemSE. The results support Studies One through Four which suggest that attempting cryptic crosswords promotes cognitive awareness in older adults.

2.6.2.2 T-test analysis

Two t-tests were used to examine the difference in terms of EM Prime Difference and Mean EM Total for those who attempted the cryptic clues before or after the two episodic MemSE tests. The results showed no significant difference between participants who attempted version 1 compared to version 2 of the questionnaire for either EM Prime Difference ($t = -0.636$) or Mean EM Total ($t = 0.492$). The lack of significant difference in both sample populations is probably indicative of the relatively small sample population.

2.6.2.3 ANOVA analysis

For both EM Prime Difference and Mean EM Total, 2 X 2 ANOVAs were used to investigate the main effects and interactions of the factor of version and other factors measured in the questionnaire. Therefore, 2-level (high versus low) were created for cryptic solve total, cryptic crossword frequency, cryptic proportion, cryptic effort and education based on median splits. Only results of note are reported, even though covariates were included in all ANOVAs.

2.6.2.3.1 EM Prime Difference results

There was no significant main effect on median cryptic solve total ($F = 1.905$) or version ($F = 0.023$) on EM Prime Difference. However, there was a significant two-way interaction for this dependent variable ($F (1, 67) = 7.401$, $p < 0.01$, $\eta^2 = 0.099$). The marginal means (see Figure 2.7) showed that participants who had a higher cryptic solve total reported a 31.31% higher EM Prime Difference when undertaking the episodic MemSE test before attempting the cryptic clues than those who had a lower cryptic solve total. However, the pattern was reversed for participants who attempted the cryptic clues before doing the episodic MemSE test; that is, those who solved more of the cryptic clues had a 57.33% lower EM Prime Difference compared to those who solved fewer of the cryptic clues. These results support the correlational analysis results; that is they suggest that being able to solve more clues before evaluating ones memory boosts episodic MemSE. As apparent in Figure 2.7, the version of the questionnaire appears to have a larger impact than the ability to solve the cryptic clues. The results were maintained when covariates were included separately in the analysis.

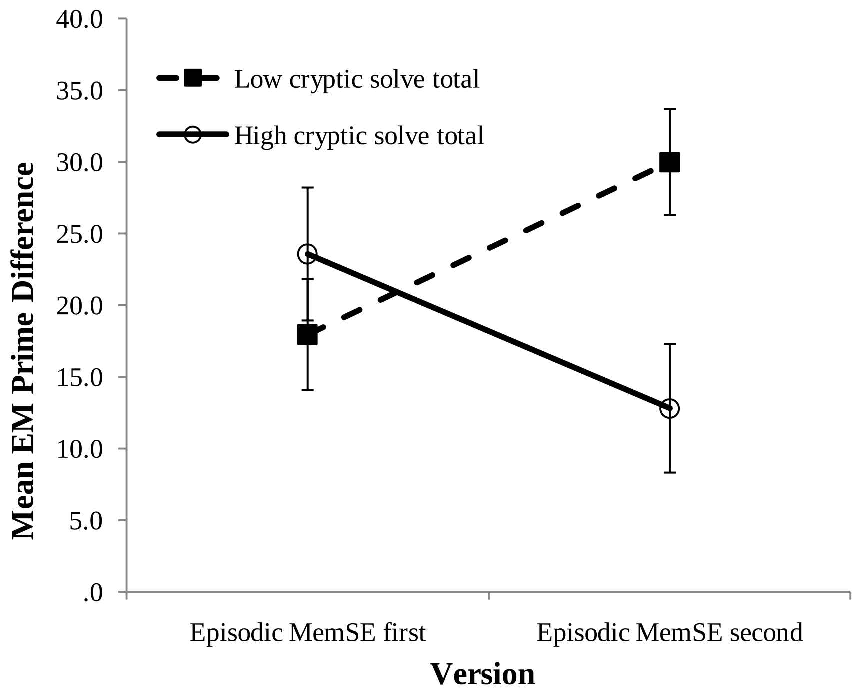

Figure 2.7. Significant two-way interaction between version and median cryptic solve total on Episodic Memory Prime Difference (EM Prime Difference).

When the factor of version was included in an ANOVA with median cryptic crossword frequency, there was no significant main effect of either version (F = 0.029) or median cryptic crossword frequency (F = 0.170) for this dependent variable. Furthermore, there was no significant two-way interaction between the two factors (F = 1.998). This was also the case for the version X cryptic proportion ANOVA (main effect of version: F = 1.751, main effect of cryptic proportion: F = 0.133 and interaction: F = 1.742), version X median cryptic effort (version: F = 0.324, median cryptic effort: F = 0.036 and interaction: F = 0.117) and version X median education (version: F = 0.198, median education: F = 1.690 and interaction: F = 0.277). The inclusion of covariates did not change the significance of the results for any of the above ANOVAs.

Overall, the results did not show that cryptic crossword frequency, the proportion of ones life spent attempting cryptic crosswords, the amount of effort required when completing such crosswords or the number of years in education had any affect on ratings of EM Prime Difference. Furthermore, none of these factors appeared to interact with the factor of version, that is, these demographic/background factors did not produce a significantly different episodic memory evaluation when taking into account whether participants attempted the episodic MemSE test before or after attempting the cryptic clues. However, the ability to solve the cryptic clues had an influence on episodic MemSE when taking into account which version of the questionnaire participants attempted. The results show that being more able to complete the cryptic clues before attempting the MemSE questionnaire boosts episodic memory evaluation. However, the difference in episodic MemSE for those who attempted the cryptic clues after the MemSE test was much smaller and in the opposite direction. So, it can be concluded that attempting cryptic clues before taking an episodic MemSE test can have a significant influence depending on the ability to solve the clues.

2.6.3 Mean EM Total results

The analysis was repeated for the dependent variable of Mean EM Total. A 2 X 2 ANOVA showed no significant main effect of version (F = 0.091) on Mean EM Total. However, there was a significant main effect of median cryptic solve total on this dependent variable ($F(1, 67) = 5.546$, $p < 0.05$, $\eta^2 = 0.076$). The marginal means showed that participants who were more capable of solving the cryptic clues had a 13.82% higher average Mean EM Total than those who were less able to solve the cryptic clues. There was no significant two-way interaction (F = 1.003). However, when including cryptic crossword frequency in a three-way ANOVA, the results showed a significant two-way interaction between version and median cryptic solve total on this dependent variable ($F(1, 57) = 4.130$, $p < 0.05$, $\eta^2 = 0.068$). The marginal means showed that although participants who were more capable had a higher Mean EM Total in both groups (compared to those who had a lower cryptic solve total score), the Mean EM Total was 15.09% higher, on average, when participants attempted the cryptic clues before the episodic MemSE test.

A two-way ANOVA with version and median cryptic proportion did not produce any significant main effects or two-way interactions for Mean EM Total (version: $F = 1.109$, median cryptic proportion: $F = 0.972$ and interaction: $F = 1.165$). The only noteworthy result was when median cryptic solve total was included in a three-way ANOVA. The results showed a significant main effect of median cryptic proportion on Mean EM Total ($F (1, 64) = 3.938$, $p = 0.05$, $\eta^2 = 0.058$). On average, participants who had attempted cryptic crosswords for a larger proportion of their lives had a 21.66% higher Mean EM Total than those who had attempted such crosswords for a smaller proportion of their lives.

The ANOVAs involving version X median cryptic crossword frequency (version: $F = 0.169$, median cryptic crossword frequency: $F = 0.272$ and interaction: $F = 0.006$), version X median cryptic effort (version: $F = 0.881$, median cryptic effort: $F = 0.278$ and interaction: $F = 0.679$) and version X median education (version: $F = 0.198$, median education: $F = 1.690$ and interaction: $F = 0.277$) supported the correlational results and did not provide any findings of note. This was also the case when covariates were included in the analysis.

In summary, the results support the correlational analysis and those of the EM Prime Difference ANOVAs; that is, the ability to solve the cryptic clues had a significant impact on episodic MemSE, particularly when participants attempted the clues before doing the MemSE test. Unlike the EM Prime Difference ANOVA, but supporting the correlational analysis, the results suggest that participants who had attempted cryptic crosswords for a larger proportion of their lives had a significantly higher confidence in their episodic memory functioning than those who attempted such crosswords for a smaller proportion of their lives. The results do not indicate that either the number of years in education or the amount of effort required to complete cryptic crosswords had an influence on episodic MemSE when taking into account which version of the questionnaire participants completed.

2.6.4 Discussion

The primary aim of Study Four (a) was to investigate whether participants evaluated their episodic memory differently if they attempted cryptic crossword clues before, compared to after, undertaking a MemSE test. Based on Studies One through Four, it was hypothesised that attempting cryptic clues would force older adults to re-evaluate their current cognitive functioning. A secondary aim was to investigate whether demographic factors related to cryptic crossword history and/or the number of years in education had any effect on the primary aim. Studies Three and Four in particular suggested that the perceived ability of solving cryptic crosswords had a direct and indirect (in combination with cryptic crossword frequency) affect on metacognition and MemSE (particularly in relation to episodic memory). However, it was unclear as to whether this relationship was also in existence when measuring actual cryptic crossword ability.

First, the overall correlations showed that, even in a sample restricted to adults aged over 60, episodic MemSE declined with age. This supports previous research (e.g. Berry et al., 2010; Zelinski & Gilewski, 2004; Bandura, 1989 and Studies One through Four) which is also supported with objective research (e.g. Mitrushina et al., 1991). The results did not show any significant correlations between cryptic crossword frequency and episodic MemSE which were apparent in Studies Two and Three in particular; however this could be due to the sample population being restricted to older adults. Finally, regarding overall correlations, there were significantly positive correlations between cryptic frequency and the ability to solve the cryptic clues and the proportion of participants' lifespan spent attempting cryptic crosswords and overall episodic MemSE.[13]

[13] There was also a significantly negative correlation between the amount of effort participants reported while completing a cryptic crossword and their overall cryptic clue solution total.

Regarding the primary aim, there was strong support that participants who attempted the cryptic crossword clues before the episodic MemSE test re-evaluated their current cognitive functioning. For example, there was no significant correlation between age and EM Prime Difference for those who undertook the MemSE test before attempting the cryptic clues, but for participants attempting the cryptic clues first, the results show a significant positive correlation between age and EM Prime Difference. The results also showed that participants who attempted more cryptic crosswords throughout their lives, also reported a significantly negative correlation with EM Prime Difference and a significantly positive correlation with overall episodic MemSE, but only when they attempted the cryptic crosswords before doing the MemSE test. Although not significant, the results also indicated that participants who reported putting more effort in to complete a cryptic crossword, had a lower episodic MemSE if they attempted the cryptic clues before in comparison to participants who completed the MemSE test first. These results support those discussed in Studies One through Four, that attempting cryptic crosswords promotes the monitoring feedback identified by Nelson & Narens (1990). Self-testing, which is associated with solving cryptic clues (e.g. Forshaw, unpublished; Nickerson, 1977), has also been shown to increase older adults' awareness of their episodic memory (e.g. Dunlosky et al., 2007; Dunlosky et al., 2003).

Analysis using t-tests and ANOVAs did not confirm a main/similar effect of version on either measures of episodic MemSE. It is likely that this is due to the relatively small sample size which reduced the power of the t-tests in particular. Furthermore, the use of the ANOVA analysis was specifically aimed at investigating the possible interaction or mediation of other variables associated with cognition and cryptic crosswords (e.g. frequency or the ability to solve the sample clues).

Participants who attempted the episodic MemSE test before trying to solve the cryptic clues showed a relatively small difference in terms of episodic memory evaluation when the results compared participants who were more able to solve the cryptic clues than those who were less able. However, when undertaking the episodic MemSE test after attempting the cryptic clues, the results showed that those who were more able to solve the clues had a much higher level of confidence in their MemSE than those who were less able to solve the clues.

Furthermore, the results showed that participants who were more capable of solving the cryptic clues reported a higher overall mean episodic MemSE than those who solved fewer clues. This relationship became more evident when taking into account both the reported cryptic crossword frequency and the version of the questionnaire which participants completed. The results showed that the relationship between the ability to solve the cryptic clues and episodic MemSE was greater when participants attempted the cryptic clues before doing the MemSE test.

In conclusion, the results support the view that attempting cryptic crosswords promotes the awareness of one's episodic memory functioning. Following on from Study Four, the results showed that the actual ability to solve cryptic crosswords encourages older adults to re-evaluate their assessment of their own cognitive abilities. This supports the view that cryptic crosswords promote the monitoring pathway in the model of metacognition (e.g. Nelson & Narens, 1990; see Figure 1.1). The assumption is that when older adults are more able to complete the cryptic crossword clues, the monitoring pathway boosts the meta-level (i.e. MemSE). This supports the view of West et al. (2008) and Bandura (1989) such that receiving positive feedback can promote MemSE. However, the opposite also appears to be true; that is, if a participant is less able to complete cryptic clues, they re-evaluate their metacognition through the monitoring pathway which affects the meta-level in the metacognition model (see Figure 1.1). This supports the view of Jopp & Hertzog (2007) who suggest that cognitive decline reduces participants' ability to undertake certain cognitive activities and therefore through feedback to the MemSE system such participants choose to give up attempting such activities (see Chapter Six for further discussion).

2.7 General Discussion

Previous research that has used self-report measures of cognitive activities have failed to discriminate between different types of crosswords when taking measures of crossword frequency (e.g. Jopp & Hertzog, 2007; see Chapter One and Chapter 2.1). However, there is a difference in the cognitive functioning required to solve a cryptic crossword compared to either a general knowledge or quick crossword (e.g. Forshaw, unpublished; Nickerson, 1977). The act of solving a cryptic crossword involves solving two parts of the clue and ensuring that they both match each other to provide the solution. This requires cryptic crossword solvers to repeatedly self-test, which has been shown to increase episodic memory performance and awareness in older adults (e.g. Dunlosky et al., 2007).

2.7.1 Summary of Study One

The results of Study One showed that there was no dissociation in terms of reported number of cognitive failures between younger and older adults who attempt quick or general knowledge crosswords frequently or infrequently. However, the results showed that with regard to cryptic crosswords, older adults who attempt more of this type of crossword report more cognitive failures than those who attempt fewer cryptic crosswords. Initially, this did not appear to support the use-dependency theory as crossword participation in older adults has been positively associated with cognitive functioning (e.g. Hertzog et al., 2009; Verghese et al., 2003; Hambrick et al., 1999). However, self-testing has been shown to promote metacognition (e.g. Dunlosky et al., 2007) and therefore it is possible that older adults who attempt more cryptic crosswords have more awareness of their cognitive abilities and cognitive failures (i.e. metacognition) than those who do not attempt as many cryptic crosswords. Furthermore, Rabbitt et al. (1995) postulated that the reason why their research did not show a significant increase of cognitive failures as a product of age may be because older adults undertake fewer cognitively demanding activities and therefore are not aware of their decline in cognitive functioning.

2.7.2 Summary of Study Two

Study Two used a reliable metacognition questionnaire (Troyer & Rich, 2002) to investigate the frequency of taking part in each type of crossword, self-reported cognitive awareness and strategies used to aid memory. The results supported those of Jopp & Hertzog (2007), for example, such that participants who attempted more cryptic, quick and general knowledge crosswords had more confidence in their cognitive abilities. This suggested that taking part in crosswords promoted the meta-level of metacognition through promoting the monitoring pathway between the object-level and meta-level (see Figure 1.1; Nelson & Narens, 1990). However, there was no evidence that for quick or general knowledge crosswords metacognitive awareness was promoted to a greater degree in older adults than in younger adults.

With regards to cryptic crosswords, when taking into account cryptic crossword completion rates, there was evidence to support the conclusion of Study One. Specifically, older adults who attempted fewer cryptic crosswords had a significantly higher confidence in their cognitive functioning than younger adults, which is converse to studies that have investigated the relationship of metacognition/MemSE and age (e.g. West et al., 2008; Zelinski & Gilewski, 2004; Bandura, 1989). However, participants who attempted more cryptic crosswords showed the expected lower confidence in their cognitive abilities for older compared to younger adults. Although not significant, the results indicated that older adults who completed a larger proportion of cryptic crosswords and a higher frequency of such crosswords showed more confidence in their cognitive abilities than those who reported a lower completion rate and participated in fewer cryptic crosswords. This supports the view of Hertzog (2009), which states that older adults will only undertake activities which boost their MemSE/confidence. So, it is possible that participants who did not complete a good proportion of cryptic crosswords gave up attempting such crosswords in order to preserve their MemSE (see Study Four and Four (a)).

Once again, the results support the view that attempting cryptic crosswords promotes the monitoring feedback and enables older adults to maintain a realistic view of their cognitive ability (i.e. the meta-level). However, there was no evidence that undertaking any type of crossword promoted the control pathway in Nelson & Narens' (1990) model. To clarify, there was no direct relationship between any specific or total crossword frequency and the reported use of memory strategies. Furthermore, this was the case for the whole sample population and also, critically, for the older participants. These results suggest that even though attempting cryptic crosswords, in particular, promote the cognitive awareness of older adults, there is no evidence that older adults use this enhanced awareness to adapt their strategies to enhance their cognitive performance. However, it must be acknowledged that the memory strategies questionnaire of Troyer & Rich (2002) focused on prospective memory using external aids to enhance memory functioning. Objective research has shown that episodic memory shows the greatest decline in healthy aging (e.g. Dunlosky & Salthouse, 1996) and that attempting cryptic crosswords promotes self-testing (e.g. Forshaw, unpublished). Therefore, it is possible that cryptic crosswords may promote internal aspects of the control pathway that were not measured in the Troyer & Rich (2002) memory strategies questionnaire.

2.7.3 Summary of Study Three

One question which remained unanswered after Study Two was whether adults (in particular older adults) were aware of the potential benefits of attempting cryptic crosswords. Therefore, Study Three used a more direct approach to investigate whether participants felt that attempting cryptic or general knowledge crosswords promoted certain aspects of their cognitive functioning. Using factor analysis two themes appeared which arguably mapped onto the relationship between attempting cryptic and general knowledge crosswords to promote the control or monitoring pathways of metacognition.

The overall sample population believed that both cryptic and general knowledge crosswords promoted both the control and monitoring pathways. However, there was no difference in this belief between younger and older adults, with regards to the control pathway, which does not provide support for the use-dependency theory. Conversely, when controlling for cryptic crossword completion rate there was evidence that middle aged and older adults had a stronger belief that cryptic crossword participation promoted cognitive awareness (i.e. the monitoring pathway) more than younger adults.

These results support the research by Christensen & MacKinnon (1993) which suggested that adults in middle age and old age undertake cognitively stimulating activities with the primary aim to stave off cognitive decline and dementia (e.g. Wilson et al., 2007). Their results also suggested that a high level of cognitive activity in mid-life can reduce cognitive decline and the development of dementia. Participants who show a lower level of cognitive activity in mid-life also show an increased risk of developing dementia. Christensen & MacKinnon (1993) used objective measures of cognitive functioning and self-report measures of cognitive activity, but Study Three's results seem to indicate that a higher level of cognitive stimulation (e.g. doing cryptic and general knowledge crosswords) also promotes subjective measures of cognitive functioning. However, as noted by Christensen and MacKinnon (1993) caution is needed when using cross-sectional data for adults in middle age because it is difficult to rule out the possibility of preclinical dementia.

Hambrick et al. (1999) showed that there was no significant difference between younger and older adults in terms of fluid intelligence based on crossword proficiency. Souchay & Isingrini (2004) among others, have shown a relationship exists between fluid intelligence, executive functioning and metacognition. The results of Study Three do not support those of Hambrick et al. (1999) as older adults in Study Three report a greater belief that cryptic crosswords promote cognitive awareness than younger adults. Hambrick et al. (1999) did not take into account self-reported measures of cognitive function such as those in Studies One, Two and Three; therefore it is possible that the results of Hambrick et al. (1999) were only tapping into the control pathway of metacognition and not the monitoring pathway. Study Eight (Chapter Five) investigated whether attempting cryptic crosswords and the completion rate of attempting cryptic crosswords had a differential effect on objective compared to subjective measures of cognition.

However, none of the crosswords which Hambrick et al. (1999) used could be truly described as a pure cryptic crossword. This is important because there appears to be a cultural difference in the compilation of crosswords between the UK and USA. This must be taken into account when considering the results of Studies Two and Three as many participants were recruited from the internet, from sites which advertised crosswords but were accessible to UK and North American servers. Unfortunately it was not possible to distinguish between the nationalities of the participants. Even though some participants from the USA contacted the researchers to clarify the definition of each type of crossword, it has recently come to light that even general knowledge crosswords in the USA are different to those in the UK. Therefore, for subsequent studies only participants from the UK were recruited to eliminate possible confounds.

In summary, Study Three supported the hypothesis that older adults are conscious (or at least believe) that undertaking cryptic crosswords promotes cognitive awareness. However the results did not show that with this enhanced awareness older adults believed that they could use it to promote their actual cognitive functioning. Following on from Study Three it was of interest to assess the relationship between MemSE and episodic MemSE, and the perceived difficulty of solving a selection of cryptic clues. Therefore Study Four investigated this relationship while taking into account cryptic frequency. A further question which arose from Study Two and Three was whether older adults had given up attempting cryptic crosswords due to a decline in their cognitive abilities. Therefore one of the main aims of Study Four was to investigate whether there was a difference in terms of self-reported cognitive functioning between participants who still attempted cryptic crosswords, never attempted cryptic crosswords or had given up cryptic crosswords.

2.7.4 Summary of Studies Four and Four (a)

The results show that perceived cryptic clue difficulty had a significant impact on MemSE, particularly relating to episodic memory. The results suggested that individuals who regarded the cryptic clues as easier to solve had a higher episodic MemSE that those who believed the clues to be more difficult. This relationship was more evident in older than younger adults suggesting that attempting cryptic clues have a direct impact on the monitoring pathway and affects the meta-level of metacognition. Once again, this does not support the view of Hambrick et al. (1999); the results indicate that older adults, in particular, take into account their ability to solve cryptic crosswords, and in turn this appears to affect the confidence in older adults' evaluations of their own memory ability. It must be pointed out that Hambrick et al. (1999) did not take into account previous cryptic crossword frequency and asked participants to attempt a number of different crosswords.

Furthermore, older adults who had given up attempting cryptic crosswords reported a significantly lower evaluation of their MemSE than older adults who still attempted cryptic crosswords. This relationship was not replicated for younger adults. One characteristic of the questionnaire was that participants rated the clues before taking the MemSE tests. It is possible that this had an effect on the older adults and encouraged them to re-evaluate their cognitive functioning. As MemSE declines with age (e.g. West et al., 2008) it was expected that older adults who had given up attempting cryptic crosswords would report more reasons for doing so than younger adults, especially based on the evidence that such crosswords encouraged older adults to re-evaluate their cognitive functioning more than younger adults. The correlational analysis supported this view; that is there was a positive relationship between the number of reasons given for giving up cryptic crosswords and the age of the participants. This was the case for reasons which pertained to cognitive functioning and reasons which pertained to other difficulties as well as cognition (e.g. physical ability, social influences and a lack of access to such crosswords). The effects of potential mediating factors of the impact of attempting cryptic crosswords on subjective and objective measures of cognitive functioning were explored in Chapter Five.

In line with the notion that self-testing has a greater effect on older than younger adults (e.g. Dunlosky et al., 2007), one reason why the relationship between cryptic crossword frequency, perceived clue difficulty, age and MemSE was apparent may have been the order of the questionnaire. That is, participants attempted the cryptic clues before undertaking the two MemSE evaluations. So, based on Studies One, Two and Three the results of Study Four suggest that the design of the questionnaire had a direct influence on the results for older adults but not younger adults.

Therefore Study Four (a) investigated whether the order of attempting cryptic clues and undertaking a MemSE test had a direct impact on older adults MemSE. The results supported those of Dunlosky et al. (2007) and showed that older adults who attempted the MemSE test after attempting ten cryptic clues had a significantly lower evaluation than older participants who did the MemSE test first. This provides strong evidence that attempting cryptic crosswords (at the object-level) influences the meta-level through the monitoring pathway.

Actual cryptic clue solving ability and not perceived clue solving ability was used in Study Four (a). The results showed that the relationship between the order in which participants attempted the questionnaire and their episodic MemSE was mediated by factors such as cryptic crossword frequency, the proportion of ones life spent attempting cryptic crosswords and the actual ability to solve the sample clues (but only for participants who attempted the clues before the MemSE evaluations). Not only do these results show that cryptic crosswords may provide a technique to encourage older adults to form a more realistic view of their cognitive ability but it also supports the notion that older adults show a large amount of heterogeneity and that mediating factors have a larger impact on an older sample population compared to a younger sample group (e.g. Glisky & Glisky, 1999).

2.7.5 Overall summary and conclusion

One theme that is evident throughout this chapter is that older adults who attempt cryptic crosswords appear to be more aware of their cognitive functioning than older adults who do not attempt such crosswords. As discussed, it is likely that attempting such crosswords has a direct impact on the metacognition and enables older adults to be more aware of their current level of cognitive functioning. In line with Hertzog (2009) there is evidence that older adults give up attempting cryptic crosswords because attempting such crosswords cause some older adults to lose confidence in their overall memory ability. However, the drop in confidence is likely to be due to effect that older adults have lost the cognitive abilities to complete the specific activity (e.g. Jopp & Hertzog, 2007). Therefore, contrary to the recommendations of West et al. (2008) or

Bandura (1989) it can be argued that a boost in MemSE is inappropriate for some older adults. This concept is explored further in Chapters Five and Six.

Taking into account the view of Nelson & Narens (1990), adults need a realistic awareness of their cognitive functioning (meta-level) to ensure that they exert adequate cognitive effort for future cognitive tasks. Therefore, boosting an individual's MemSE may be detrimental to their overall cognitive functioning as their meta-level of metacognition will be out of sync with reality (i.e. the object-level). In turn, this will not allow healthy metacognitive functioning and may be more detrimental to MemSE/metacognition in the long term when individuals continually fail to function adequately.

In conclusion, the results suggest that cryptic crosswords enable older adults to produce a realistic meta-level (MemSE) through the process of self testing (e.g. Dunlosky et al., 2007; Forshaw, unpublished). Previous research which has investigated the cognitive reserve hypothesis or use-dependency theory has potentially missed the apparent value of cryptic crosswords due to measuring overall crossword frequency and not specific crossword frequency (e.g. Jopp & Hertzog, 2007). Furthermore, other factors (e.g. crossword completion rate, ability to solve crossword clues, proportion of one's life spent attempting specific crosswords) have been shown to mediate the relationship between self-reported cognitive activity and self-reported cognitive functioning. The assumption that an increase in cognitive activity must be related to an increase in cognitive functioning (Wilson et al., 2007) is questionable, due to the fact that older adults who attempt more cryptic crosswords show a lower MemSE. Furthermore, there is evidence that the order of presentation of questionnaires or cognitive assessments can be mediated by other factors in the questionnaire (e.g. cognitive activities which encourage older adults to self-test). Therefore, the results of this chapter not only question the cognitive activity measures used in previous research, but also suggest that cryptic crosswords may provide an intervention activity to promote metacognition in older adults (see Study Eight, Chapter Five).

CHAPTER THREE
TESTING THE COGNITIVE RESERVE HYPOTHESIS: THE EFFECTS OF WORD FREQUENCY AND AGE OF ACQUISITION ON RECALL, CONSOLIDATION AND ENCODING IN YOUNGER AND OLDER ADULTS

3.1 Background

3.1.1 Introduction

The use-it-or-lose-it theory can be regarded as an umbrella term, which covers the cognitive reserve hypothesis and the use-dependency theory. Chapter One reviews both theories and there is a significant amount of empirical evidence in support of each theory (e.g. Wilson et al., 2002). However, there are questions over the research techniques which have been used to investigate each theory. One criticism of the methodology used to investigate both approaches is that studies have used a between-subjects technique, which compares older adults who are relatively cognitively active or inactive (e.g. Verghese et al., 2003; Christensen & McKinnon, 1993). This means that the evidence used to support either the use-dependency theory or cognitive reserve hypothesis may be a product of other demographic factors which mediate both cognitive ability and leisure or vocational activities (e.g. Schooler & Mulatu, 2001). Therefore, it is almost impossible, when using a within-subjects technique, to identify whether an increase in cognitive activity can be protective of cognitive decline associated with healthy aging.

An ideal experiment to investigate the cognitive reserve hypothesis would match participants on the basis of demographic factors and manipulate only one factor; specifically current level of cognitive activity. However this is not possible, that is, it is impossible to find two individuals who have the same demographic variables which are outlined in Chapters One and Two, but who differ on levels of cognitive activity. It is also the case that some research theorises that a higher number of years in education (which has been regarded as a hallmark of a greater amount of cognitive reserve, e.g. Mortimer et al., 2003), can have effects on other demographic factors which can have a mediating effect on cognitive functioning, for example healthcare or lifestyle. As reported by Schooler & Mulatu (2001) individuals who have a higher level of educational attainment tend to have a higher earning capacity and better access to healthcare. These individuals also report undertaking more cognitively stimulating leisure activities.

Therefore it is necessary to find a cognitive construct which can be investigated using a within-subjects technique to examine whether regular use of part of this construct increases its availability in memory compared to another part of the constructs which is activated less frequently. Language was chosen because there are a number of factors which can be manipulated with regards to the study of words, specifically word frequency and age of acquisition (AoA). Therefore the aim of Studies Five and Six was to use a within-subjects technique to investigate whether either manipulations in word frequency or AoA could be used as an analogy of the cognitive reserve hypothesis (see Section 4.13 and 4.14 for explanation).

3.1.2 The effects of age on episodic memory

Chapter One and Two reviewed the research with regard to episodic memory loss and aging. There is a consensus within cognitive psychology that healthy aging results in a significant loss in episodic memory capacity (e.g. Craik, 1977). Throughout the decades research has suggested possible explanations for this age-related deficit in episodic memory. It is accepted that older adults show a deficit in both encoding and consolidation/retrieval (e.g. Bleeker et al., 1988; Craik, 1977; Gordon & Clark, 1974 and Erber, 1974). The use of a multi-trial technique, which is explained in Section 3.2.1.3, has shown that older adults show deficits in both encoding and consolidation compared to younger adults (e.g. Dunlosky & Salthouse, 1996). There is also evidence, from savings scores, that younger adults retain/retrieve words significantly better than older adults over a longer time period (e.g. Dunlosky & Salthouse, 1996).

3.1.3 The cognitive reserve hypothesis versus the use-dependency theory

Chapter One differentiated the cognitive reserve hypothesis and the use-dependency theory. In brief, the cognitive reserve hypothesis predicts that a person can build up a cognitive reserve when the brain is at its most plastic, that is, at a relatively younger age. The hypothesis dictates that this reserve can then act in a compensatory way during older age when the person inevitably suffers cognitive decline, which can either be due to healthy aging or pathology, for example, dementia (Katzman, 1993). The use-dependency theory agrees that cognitive activity can produce a significant amount of reserve when a person is cognitively active at a relatively young age. However the use-dependency theory states that cognitive plasticity does not only exist at a younger age but also persists throughout the lifespan (Salthouse, 1991).

For a within-subjects technique to produce an analogy of the use-dependency theory phenomenon one would have to match an inherent activity which would then have to be separated in terms of being regularly activated or not being activated as often, this approach is covered in Chapter Five. However, Chapter Four focuses on an analogy of the cognitive reserve hypothesis. An analogy of the cognitive reserve hypothesis can compare aspects of a cognitive system which has been activated often or which has been relatively inactive. A good example of this is the phenomenon of word frequency in language; words which have a high-frequency rating in a specific language will have their specific cognitive representation[14] activated quite often, however words which have a low-frequency rating in the same language will not have their cognitive representation activated as often. This can be viewed as a example of the cognitive reserve hypothesis in that certain cognitive representations are more highly activated that others.

The phenomenon of AoA in the field of language is another example of how one can draw an analogy to the cognitive reserve hypothesis but also use a within-subjects

[14] According to Li (2009) and Elman (2009) it is impossible to differentiate between lexical, semantic, phonological, grammatical and episodic information of words stored in cognitive representations. That is, when an individual stores a specific word (especially a noun) or the above constructs interact when the word is presented.

technique. The cognitive reserve hypothesis highlights the fact that cognitive/neuronal networks are more plastic at a younger age (e.g. Li, 2009), therefore the hypothesis predicts that cognitive activity at a younger age will have a more long-term effect on the amount of cognitive reserve a person has (e.g. Wilson et al., 2005). A logical continuation of this would predict that words or information which is acquired at an earlier age will receive more cognitive activity and thus will be stored in more interconnected cognitive networks than words learnt at a later age. This has been supported by using connectionist modelling (Ellis & Lambon-Ralph, 2000) and in the study of verbal fluency of participants with dementia (Forbes-McKay et al., 2005).

The pioneering research from Ellis & Lambon-Ralph (2000) is still regarded by many to be the best description of how age-critical learning affects the construction and integration of cognitive representations in the brain (Johnston & Barry, 2006). This work has been bolstered by further connectionist modelling (e.g. Steyvers & Tenenbaum, 2005). There is also evidence from investigations of long-term potentiation (LTP) in vivo studies and studies which have attempted to model LTP using computational techniques (e.g. Thomas, Watabe, Moody, Makhinson & O'Dell, 1998; Blum & Abbott, 1996). All the research indicates that not only does neuronal plasticity decrease with age but also that cognitive/neuronal representations acquired earlier in life are stored in closer associated cognitive/neuronal networks than information acquired later in life. The biological research has also indicated that neurogenesis reduces with age, particularly when older adults show sleep abnormalities (e.g. Kudrimoti, Barnes & McNaughton, 1999), which is a common symptom of both healthy and pathological aging (e.g. Mirmiran et al., 1992).

Therefore, the study of language seems to provide the opportunity, using a within-subjects technique, to produce an analogy of the cognitive reserve hypothesis. By manipulating word frequency and AoA of to-be-remembered words Studies Five and Six will investigate the cognitive reserve hypothesis while eliminating the effects of demographic factors or individual differences, which have arguably had a large impact on previous research that has been deemed to provide support for the cognitive reserve hypothesis.

3.1.4 The effects of word frequency and AoA on reading latencies and memory

A number of studies have investigated naming and reading latencies for words which differ in terms of AoA and word frequency (e.g. Morrison, Hirsh, Chappell & Ellis, 2002; Morrison & Ellis, 2000; Taylor, 1998; Guttentag & Carroll, 1994; Brown & Watson, 1987; Carroll & White, 1973). The results have shown that high-frequency words are read significantly faster than low-frequency words in individuals who do not have psychological impairment and in individuals who are suffering from dementia (e.g. Taylor, 1998). Furthermore, a number of results have shown that words acquired at an earlier age are read faster than words acquired at a later age in healthy adults (e.g. Morrison & Ellis, 2000).

Taking into account the reading latency studies it is logical to assume that early-acquired words (compared to later-acquired words) and high-frequency (compared to low-frequency) words are stored in more interconnected cognitive representations (e.g. Li, 2009; Steyvers & Tenenbaum, 2006). Therefore, studies that have investigated recall of words which differ in terms of frequency or AoA should show a recall advantage for high-frequency and early-acquired words over low-frequency and later-acquired words. Several studies, using a pure-list technique, have confirmed that high-frequency words are recalled significantly better than low-frequency words (e.g. Ward, Woodward, Stevens & Stinson, 2003; Watkins, LeCompte & Kim, 2000; Tan & Ward, 2000; DeLosh & McDaniel, 1996; Gregg, 1976; Postman, 1970; Sumby, 1963; Murdock, 1960; Deese, 1960; Hall, 1954). However there is little evidence of a recall advantage for early-acquired words over later-acquired words, especially when using a pure-list technique (e.g. Dewhurst, Hitch & Barry, 1998; Coltheart & Winograd, 1986; Morris, 1981)[15].

Research investigating recall of words that differ in either word frequency or AoA, generally uses one of two techniques; either the study of pure-lists or mixed-lists of words. A pure-list technique will involve participants studying word lists which contain

[15] However, it must be acknowledged that the recall advantage of high-frequency words is eliminated when using a mixed-list technique (e.g. Ward et al., 2003).

solely high- or low-frequency words (or early- versus later-acquired words). In the past, these techniques have generally used a between-subjects design (e.g. Postman, 1970). Alternatively researchers have used a mixed-lists, within-subjects technique where participants are shown a study list which contains an equal number of high- and low-frequency (or early- and later-acquired words).

If the manipulation of either word frequency or AoA is to be used as an analogy of the cognitive reserve hypothesis then a within-subject technique must be used. However, previous research dictates that a pure-list technique must also be utilised (e.g. Tan & Ward, 2000). The main reason for this is because the cognitive reserve hypothesis will be best represented by using pure-lists of words which differ in either word frequency or AoA. The cognitive reserve hypothesis predicts that individuals who are more cognitively active will build up a greater cognitive reserve than those who are relatively less cognitively active; that is, autopsy results have shown that individuals who report undertaking more cognitive activities throughout their lifespan show a greater density of white- and grey-matter in the brain (e.g. Mortimer et al., 2003), this is also the case in animal research where rodents have been exposed to a more enriched environment throughout life (e.g. Nilsson et al., 1999). These results confirm the hypothesis that increased cognitive activity results in more interconnected cognitive/neuronal networks/representations (e.g. Salthouse, 2006; Alexander et al., 1997). Therefore, to extend the phenomenon of word type to the analogy of the cognitive reserve hypothesis a study must compare a single group of words which have been regularly activated to a separate group of words which have been activated to a significantly lesser degree i.e. pure-list of high- versus low-frequency or early-acquired versus late-acquired words.

To use the manipulation of word frequency and AoA as an analogy of the cognitive reserve hypothesis pure-lists must also be used if the inter-item association theory of the recall advantage of high- over low-frequency words is accepted (e.g. Tan & Ward, 2000; Watkins et al., 2000). Similar to the cognitive reserve hypothesis which predicts that cognitive representations will be more interconnected if individuals have been more cognitively active at a younger age, the inter-item association theory states that cognitive representation of high-frequency words will be more interconnected than representations of low-frequency words (e.g. Tulving & Patkau, 1962). There is also evidence from modelling studies and neuroimaging studies which suggest that words which are acquired at an earlier age are stored in more interconnected networks (e.g. Li, 2009). Furthermore, research investigating individuals with brain damage, semantic dementia, temporal lobe lobotomies and deep dyslexia have also showed that early-acquired words are preserved better than later-acquired words (e.g. Barry & Gerhand, 2003; Kremin et al., 2001; Bell, Davies, Hermann & Walters, 2000; Lambon-Ralph, Graham, Ellis & Hodges, 1998). Therefore in line with the cognitive reserve hypothesis, it is expected that the cognitive representation of high-frequency and early-acquired words to have more protection against cognitive atrophy, associated with healthy aging, than low-frequency or later-acquired words (e.g. Ellis and Lambon-Ralph, 2000).

The fact that the recall advantage of high-frequency words over low-frequency words is eliminated when using mixed-lists (e.g. Ward et al., 2003; Peters, 1937) supports the inter-item association theory. This is based on two aspects of the methodology used in the study of word frequency and recall. First, mixed-lists tend to use half the number of high- and low-frequency words compared to pure-lists (e.g. Ward et al., 2003). Thus, the number of possible inter-item associations for the high-frequency words in the mixed-list condition is halved compared to the pure-list condition. Second, researchers have tended not to control for study time for the individual words in mixed-lists, therefore high-frequency words do not receive as much processing time because they are read faster than low-frequency words (e.g. Morrison & Ellis, 2000). This is supported by research by Watkins et al. (2000) which showed that there was evidence of a recall advantage for high-frequency words when using a mixed-list technique if study time was equal for high- and low-frequency words.

There is a lack of support for the inter-item association theory for recall benefits of early- compared to later-acquired words. For example, Dewhurst et al. (1998) found that there was no difference in terms of recall between words which differed in AoA when using a mixed-list technique. However, Dewhurst et al. (1998) also did not control for processing time at study, this has been shown to be important in studies focusing on word frequency. For example, Watkins et al. (2000) showed how the recall advantage for high-frequency words is restored in mixed-lists when study time is controlled for.

Furthermore, classification of early-acquired words does not match the classification of AoA of words in studies which have investigated reading latencies. Dewhurst et al. (1998) classified early-acquired words as having a mean learning age of 66 months, whereas naming latency studies have used a mean age of 26.2 months. In fact, Morrison et al.'s (2002) late acquired words had a mean age 64.8 months which was more closely associated with Dewhurst et al's (1998) early-acquired words classification. This is significant as Li (2009) demonstrated that there is a large increase in language acquisition at the early stages of life, specifically when a child starts to speak which is typically between 18 and 24 months of age. Therefore Dewhurst et al's (1998) classification of early-acquired words did not match the research findings of both computer modelling and behavioural studies (e.g. Li, 2009).

Although other research has shown that there is no significant difference in terms of recall between early- and later-acquired words (e.g. Coltheart & Winograd, 1986: Morris, 1981), there is a question over the methodology used to classify AoA of the stimulus. Dewhurst et al. (1998) and the above mentioned research employed the tactic of calculating AoA on adult's estimates of their age when they learnt specific words (e.g. Gilhooly & Logie, 1980), whereas reading latency studies have used children's ability to name pictures as a more objective measurement of AoA (Morrison et al., 1997). Therefore, it is necessary to match the AoA measurements used in reading latency studies when investigating the impact of AoA on recall. This is supported by the view of Johnston & Barry (2006) and Zevin & Seidenberg (2002) who indicate that in the absence of frequency trajectory measurements objective measures of AoA (such as Morrison et al., 1997) should be used instead of adults' estimates of AoA.

3.1.5 Aims and Objectives

Due to the fact that both word frequency (Sumby, 1963) and age (Dunlosky & Salthouse, 1996) appear to show a greater impact on episodic memory, compared to working or semantic memory, it is logical to investigate the effect of word frequency and AoA on episodic memory. Furthermore, it is a logical continuation of the cognitive reserve hypothesis to focus on episodic memory if stimulus characteristics (specifically word frequency and AoA) are to be used as an analogy of this hypothesis.

Unlike Dunlosky & Salthouse (1996) this research will focus on episodic memory, so the words used in the study phase will be presented in a random order for each trial. Furthermore, a distracter task will be used before each recall trial. The reason for focusing on episodic memory is that age takes a large toll on episodic memory compared to any other memory system (e.g. Allen, Sliwinski & Bowie, 2002). Therefore it is logical to assume that a cognitive reserve will provide greater protection, against healthy aging, for the episodic memory system rather than any other cognitive domain.

The use of a multi-trial technique will enable analysis of recall, encoding, consolidation and savings. There has been no consensus as to whether stimulus characteristics, such as word frequency or AoA, have a larger effect on encoding or consolidation. For example, Postman (1970) showed that word frequency had a significantly larger effect on consolidation as opposed to encoding. However, both Balota & Neely (1980) and DeLosh & McDaniel (1996) believed that the recall advantage of high-frequency over low-frequency words was due to superior encoding of high-frequency words. There has been no investigation of the effects of AoA on encoding or consolidation.

To summarise, Studies Five and Six will use a multi-trial technique to see if word frequency or AoA can be used as an analogy of the cognitive reserve hypothesis. As age takes a larger toll on episodic memory it is logical to assume that older adults will show a significantly greater memory deficit for low-frequency and later-acquired words than high-frequency and earlier-acquired words compared to younger adults. A multi-trial technique will allow this investigation to differentiate between encoding and consolidation, not just overall recall. Furthermore the measure of savings will also enable the study to investigate retrieval over a longer period of time.

3.2 Study Five: Word frequency as an analogy of the cognitive reserve hypothesis.

Study Five used a manipulation of stimulus characteristics, specifically word frequency, as an analogy of the cognitive reserve hypothesis. Section 3.2.1.3 describes the exact intertrial technique used to discriminate between encoding, consolidation and retrieval. The study investigated the effect of word frequency on recall, encoding, consolidation and retrieval/retention in younger and older adults.

3.2.1 Method

3.2.1.1 Participants

Two samples of participants were tested. The younger sample consisted of 20 participants with a mean age of 25.7 (SD = 9.83), who had a mean number of years in full time education of 15.55 (SD = 3.32). The older sample population consisted of 22 participants with a mean age of 75.64 (SD =7.44) and a mean number of years of education of 12 (SD =2.94). The two sample groups were significantly different on the basis of number of years in education, with the older adults having received significantly less education (t = 3.654, df = 38.225, p=0.001). All older adults undertook the mini-mental state examination (Folstein, Folstein and McHugh, 1975); all scored over 27/30 indicating absence of cognitive impairment. All participants gave informed consent.

3.2.1.2 Stimuli

Stimulus words were taken from the Celex Lexical database (1993) and were chosen on the basis of wordform frequency. Two pure word lists consisting of 30 words were created (see Appendix Six); the low-frequency words (e.g. *windmill, cannon*) had a mean overall frequency per million of 10.77 (SD = 14.771) and the high-frequency words (e.g. *jumper, cigarette*) had a mean of 88.93 (SD = 123.016). The word lists were significantly different in terms of frequency ($t = 3.456$, $df = 29.836$, $p < 0.001$). A third word list was used as a practice list. The two experimental word lists were matched on the basis of starting letter, number of syllables and imageability (all concrete nouns). Unfortunately the word lists were not matched on the basis of AoA, therefore item analysis was conducted to investigate the impact of word frequency, AoA, frequency trajectory and imageability on recall. The word lists were presented 10 words at a time using size 24 Arial type font and participants were required to rate each word for pleasantness on a scale of 1 to 7 to ensure each word was processed (see Roediger III & Gallo, cited in Naveh-Benjamin, Moscovitch & Roediger III, 2002). Feigenbaum & Simon (1962) emphasised the need to use a rating system to ensure that participants pay attention to each study item.

3.2.1.3 Dependant Variables

Four dependant variables were measured in Study Five, which were Intertrial Recall (ITR), Intertrial Consolidation (ITC), Intertrial Encoding (ITE) and Saving Scores (as a measure of retention/retrieval). Section 3.2.1.4 describes the design and procedure, this was similar to the intertrial technique used by Dunlosky & Salthouse (1996). ITR was a measure of recall across the five initial consecutive trials in each experimental condition. There was a possible range of recall scores of 0 to 30. Unlike previous research (e.g. Mitrushina et al., 1991) thirty words were used to reduce the possibility of ceiling effects.

ITE was calculated in an identical way to gained access described by Dunlosky & Salthouse (1996) with the section that ITE (or gained access) was calculated for the first trial. ITE is calculated by counting the number of ways which have been acquired between trial n and trial n+1. This is then calculated as a proportion of the number of words available that could be acquired. These are calculated as a percentage to remove scaling effects. Unlike Dunlosky & Salthouse (1996) ITE was calculated for the first trial due to the fact that the recall of this trial can only be attributed to encoding and not consolidation from the previous trial (Tulving & Arbuckle, 1963).

ITC was calculated by subtracting lost access from 100. Lost access is the number of words that a participant fails to recall on trial $n + 1$ compared to trial n. This is then calculated as a proportion of the number of words recalled on trial n. Dunlosky & Salthouse (1996) described how lost access could be viewed as an inverse representation of consolidation. Due to the fact that lost access was also calculated as a percentage it was possible to subtract this figure from 100 to give a direct representation of the level of consolidation for each trial, however, it was not possible to calculate a consolidation score for trial five. There have been discussions as to whether lost access represents consolidation or retrieval (e.g. Woodard et al., 1999). However, the view must be taken that retrieval can only occur if an item was consolidated, but it is possible that an item could be consolidated but not retrieved. Therefore it is appropriate to view lost access as a more accurate representation of consolidation rather than retrieval.

Saving Scores were calculated by comparing the number of words which were recalled on the one week delay trial to the number of words recalled on the final trial (trial five on the initial intertrial technique). Once again these were calculated as proportions to remove scaling effects. It is difficult to discriminate between whether this figure represents retrieval or advanced consolidation, however as acknowledged by Woodard et al. (1999) it is likely that all words recalled on the final trial (i.e. trial five) would have been consolidated, therefore it is logical to assume that the process involved one week later requires effortful retrieval. However, from here on the saving scores will be deemed to represent either retrieval or long-term retention (see Woodard et al., 1999 or Dunlosky & Salthouse, 1996 for further discussion).

3.2.1.4 Design and Procedure

Section 3.2.1.3 defines recall, encoding, consolidation and retrieval/retention as used in this type of intertrial technique. The study used a mixed design where all participants were exposed to both high- and low-frequency words. Participants filled in a general information sheet, then proceeded to undertake the rating of the practice list of words. Participants received one minute to complete the rating of all 30 words, older adults received 50% extra study time to remove possible effects of cognition speed (see Naveh-Benjamin, Hussain, Guez & Bar-On, 2003 and Canestrari, 1963). After rating all 30 words participants were required to undertake a standard five figure digit span task to clear working memory and avoid the recency effect. A free recall task then followed; once again younger participants were allotted 60 seconds while older participants were allotted 90 seconds.

The study, distracter and free recall task was then repeated 5 times for the intertrial learning of the stimuli. Presentation of high- and low-frequency words always followed each other but were counterbalanced across each participant group. Once the five trials were completed participants were required to return one week later. The first task upon return was a delay recall task of all words encountered in the first intertrial task. Participants then repeated the five learning trials for the subsequent 30 words. At the beginning of each trial participants received the same instructions and were not informed that they were being presented with the same words. Participants were contacted one week later by phone and the second delayed recall task was performed. Due to the counterbalancing of the high- and low-frequency words there was an equal number of younger and older participants who did the delayed recall by phone for each word type. Debriefing then took place.

3.2.2 Results

3.2.2.1 Intertrial recall (ITR)

A 2 X 5 X 2 (Age Group x Trial x Stimulus Characteristic i.e. word frequency) mixed ANOVA was used to investigate the impact of age, number of trials and word frequency on overall ITR. Figure 3.1 shows that the younger sample group appears to recall more words across the entire study. This was significant ($F (1, 40) = 46.339$, $p < 0.001$, $\eta^2 = 0.537$). There was a significant main effect of trial on ITR ($F (4, 160) = 130.028$, $p < 0.001$, $\eta^2 = 0.765$), in which mean recall increased across number of trials (excluding the one week delayed recall). There was also a significant main effect of word frequency on ITR, specifically participants recall more high-frequency words (e.g. *table, dog* etc) than low-frequency words (e.g. *helicopter, bear* etc) ($F(1, 40) = 13.660$, $p = 0.001$, $\eta^2 = 0.255$). The marginal means show that on average 15.42% more high than low-frequency words were recalled.

There was a significant interaction between trial and age group on ITR ($F(4, 160) = 13.052$, $p < 0.001$, $\eta^2 = 0.246$); younger participants recalled increasingly more words across trials than older adults. The two-way interactions between word frequency and age, and word frequency and trial on ITR were both non-significant ($F = 0.032$ and $F = 0.970$ respectively).

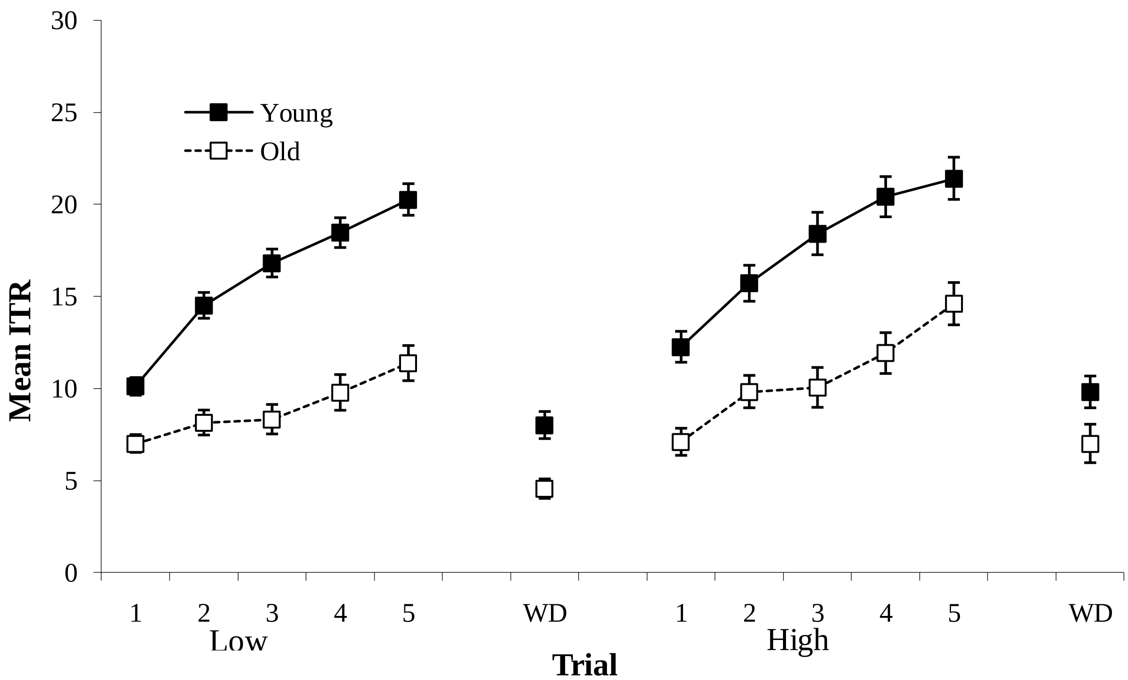

Figure 3.1. Mean intertrial recall (ITR) for younger and older adults studying high- and low-frequency words.

The results showed a significant three-way interaction between trial, word frequency and age group on ITR ($F(4, 160) = 2.776$, $p < 0.05$, $\eta^2 = 0.065$). As Figure 3.1 illustrates there was no difference in the recall of high- and low-frequency words across the five initial trials for younger participants. However, older adults appear to show a depressed rate of learning of low-frequency words compared to younger adults. This is not apparent for older people learning high-frequency words, in fact the figure shows that older adults, compared to younger adults, show a steeper learning gradient for high-frequency words, particularly across the final two to three trials. Therefore the results indicate that older adults have a superior recall advantage of high-frequency words compared to low-frequency words, across trials, which is not evident in younger participants.

3.2.2.2 Intertrial consolidation (ITC)

In line with Tulving (1964) and Dunlosky & Salthouse (1996) intertrial encoding and consolidation were calculated on an item by item basis. ITC was analysed by using a 2 X 4 X 2 (Age Group x Trial x Stimulus Characteristics) mixed ANOVA. Figure 3.2 shows the ITC for younger and older participants studying high- and low-frequency words.

The results show a significant main effect of age group on ITC ($F(1, 40) = 14.479$, $p< 0.001$, $\eta^2 = 0.266$). As Figure 3.2 shows older participants have a lower ITC than younger participants. There was also a significant main effect of trial on ITC ($F(1, 129) = 5.491$, $p< 0.001$, $\eta^2 = 0.121$). With the exception of trials 1-2, consolidation increased across trials. There was no significant main effect of word frequency on ITC ($F = 0.004$). There was no significant interaction of either trial and word frequency ($F = 1.001$), trial and age ($F = 0.371$) or word frequency and age ($F = 1.526$) on ITC. Furthermore, there was no significant three-way interaction between all the factors on ITC ($F = 0.109$).

The results showed a significant three-way interaction between trial, word frequency and age group on ITR ($F(4, 160) = 2.776$, $p < 0.05$, $\eta^2 = 0.065$). As Figure 3.1 illustrates there was no difference in the recall of high- and low-frequency words across the five initial trials for younger participants. However, older adults appear to show a depressed rate of learning of low-frequency words compared to younger adults. This is not apparent for older people learning high-frequency words, in fact the figure shows that older adults, compared to younger adults, show a steeper learning gradient for high-frequency words, particularly across the final two to three trials. Therefore the results indicate that older adults have a superior recall advantage of high-frequency words compared to low-frequency words, across trials, which is not evident in younger participants.

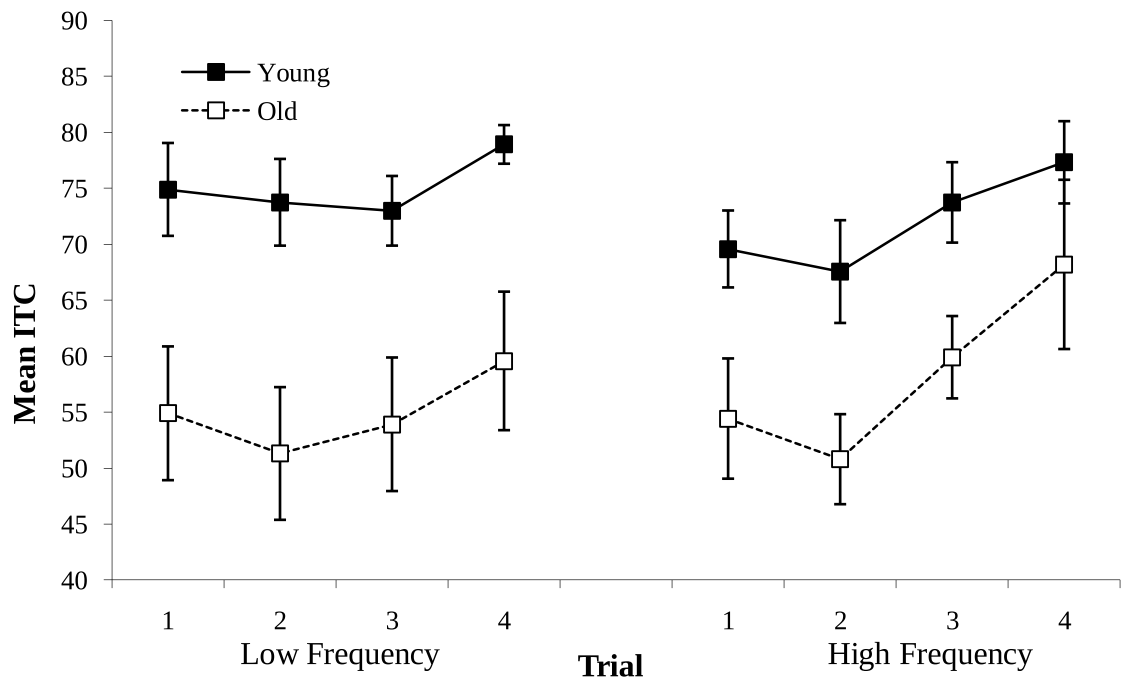

Figure 3.2. Mean intertrial consolidation (ITC) for younger and older adults studying high- and low-frequency words.

3.2.2.3 Intertrial encoding (ITE)

ITE analysis used a 2 X 5 X 2 (Age Group x Trial x Stimulus Characteristic) mixed ANOVA. Figure 3.3 shows the mean ITE for younger and older adults when studying high- and low-frequency words. The results showed a significant main effect on ITE of trial ($F (4, 100) = 21.384$, $p < 0.001$, $\eta^2 = 0.348$), age of participant ($F (1, 40) = 47.310$, $p < 0.001$, $\eta^2 = 0.542$) and word frequency ($F (1, 40) = 19.542$, $p < 0.001$, $\eta^2 = 0.328$). The results show that encoding increased across trial for all participants. The results also show that younger participants had a higher mean encoding than older participants. Marginal means also showed that participants had a 19.31% higher mean encoding for high-frequency words than low-frequency words.

There was a significant two-way interaction between trial and age on ITE ($F(4, 160) = 5.124$, $p = 0.001$, $\eta^2 = 0.114$). As Figure 3.3 shows younger participants encoded a higher proportion of words across the five trials than older participants. There was no significant interaction between trial and word frequency ($F = 0.913$) or word frequency and age ($F = 0.587$) on ITE. Furthermore there was no significant three-way interaction between all factors on ITE ($F = 1.405$).

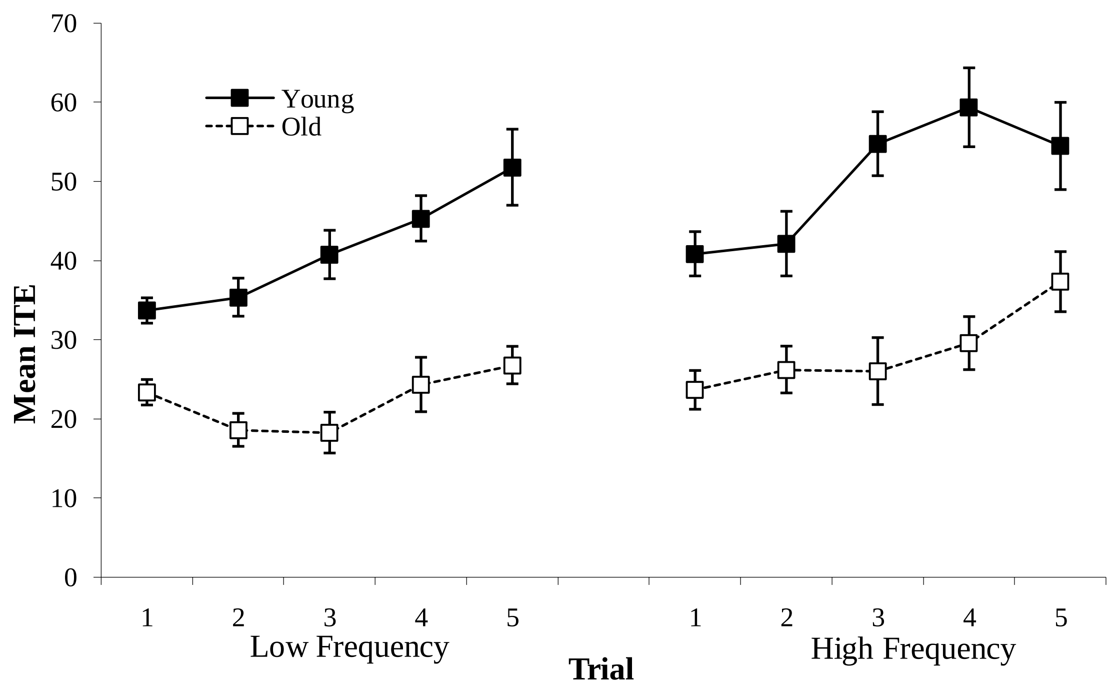

Figure 3.3. Mean intertrial encoding (ITE) for younger and older adults studying high- and low-frequency words.

3.2.2.4 Savings scores

In line with Dunlosky & Salthouse (1996) and Moulin et al. (2004) savings scores were calculated. The analysis used a 2 X 2 (Age Group x Stimulus Characteristics) mixed ANOVA to assess the impact of age of participant and word frequency on savings. The results showed no significant main effect of age ($F = 0.803$) or word frequency ($F = 2.562$) on savings. There was also no significant interaction between age and word frequency on savings ($F = 0.055$).

3.2.2.5 Item analysis

Following the analysis by subject an item analysis was carried out, essentially with the data transposed in SPSS with each item being given an average score for the performance within each group (young and old). From these item-by-item mean performance levels for each item and each trial (60 X 5 = 300 items) a number of new summary variables were created. Slope calculates the rate at which items were learned across trials, with each item being given a slope value. Mean recall was calculated for all trials and the mean recall of Trial 1 was considered as raw data. The strategy was to first replicate the subject analysis using ANOVAs, but to continue to a regression based item analysis which considered which factors influenced recall separately in each group. The main motivation for this analysis was to try and consider the confound of AoA on word factor (recall).

Simple correlations of performance between groups show that the recall of the old group correlates strongly with the recall of the young group, $r(60) = 0.694$, $p < 0.001$. This suggests that the same words that were recalled well in the young group were also recalled well in the old group. The slope values did not correlate with mean recall across all trials in either group (both, $p > 0.78$). Interestingly, trial 1 performance did correlate with slope values in both groups, (Young $r(60) = -0.713$; old $r(60) = -0.509$, both $p < 0.001$), such that the items that were less well recalled on Trial 1 had steeper slope functions.

3.2.2.5.1 ANOVA results

Analysis A: For the Trial 1 performance, a 2 X 2 repeated measures ANOVA compared the recall performance for high- and low-frequency words for older and younger participants. There was the expected significant main effect of age on recall ($F(1, 58) = 44.792$, $p < 0.001$, $\eta^2 = 0.436$) with the young group outperforming the old. There was no significant main effect of word frequency ($F = 0.587$), and no significant interaction, ($F = 2.195$). This indicates that on a single trial the recall advantage of high- over low-frequency words is not apparent. Furthermore there is no evidence that, on the first trial, younger and older adults show a significant difference in the recall of high- and low-frequency words.

Analysis B: For mean recall, a 2 X 2 repeated measures ANOVA compared mean recall across the five trials for high- and low-frequency words for younger and older adults. Once again there was the expected significant main effect of age on recall ($F (1, 58) = 292.791$, $p < 0.001$, $\eta^2 = 0.835$). Similar to analysis A there was no significant main effect of word frequency on mean recall ($F = 2.480$) and no significant interaction between age group and word frequency ($F = 0.030$). The results support the view that mean recall is not significantly different for high- and low-frequency words and that there is no dissociation between the mean recall of both types of words between younger and older adults.

Analysis C: To investigate the rate of recall across trial, the factor of slope was included in a 2 X 2 ANOVA with the factor of age group for the dependent variable of recall. Again, the analysis matched the above, with the exception that the interaction approached significance ($F (1, 58) = 2.652$, $p = 0.1$, $\eta^2 = 0.044$), suggesting that the rate of acquisition of items was somewhat different in the two groups according to materials, paralleling what was seen in the subjects' analysis.

Analysis D: Correlational analysis was used to investigate the relationship between total recall for the younger and older group, slope for both age groups and stimulus characteristics of the items. Trial 1 was not included in the analysis due to the fact that it was negatively correlated with slope for both age groups. The results did not indicate a significant correlation between total recall and any stimulus characteristics for either age group. However, the results show a correlation which approaches significance for older adults slope and total word frequency ($r (60) = 0.226$, $p = 0.08$). This relationship was not significant in the younger sample population ($r = -0.059$). Furthermore there was a highly significant correlation between older adults slope and spoken word frequency ($r (60) = 0.322$, $p = 0.01$). Once again this was absent for the analysis of younger adults. No other stimulus characteristics significantly correlated with the slope of either younger or older adults.

3.2.2.5.2 Regression Analysis

As mentioned in section 3.2.1.2 the word lists were unfortunately not matched on the basis of AoA. The above analysis suggests that word frequency has a larger impact than AoA for recall in older adults. This does not appear to be the case for the younger adults results. Therefore for completeness regression analysis was used to investigate the impact on different stimulus characteristics on both total recall and slope in younger and older adults.

Table 3.1. A linear regression showing the effect of specific stimulus characteristics on the rate of acquisition of words in older adults.

	β-values	t-value
Spoken frequency per million	0.594	2.455*
Written frequency per million	-0.250	-0.700
AoA	-0.340	-2.043*
Frequency trajectory	-0.167	-0.511
Imageability	-0.354	-2.479*

*p < 0.05

The analysis did not indicate that any stimulus characteristic accounted for a significant proportion of the total recall variants in younger and older adults. However, the regression analysis for slope supported the earlier result in that older adults appear to acquire high-frequency words at a greater rate over trial than low-frequency words. The regression equation for older adults was significant when all stimulus characteristics were included as predicted (adjusted $R^2 = 0.154$, $F(5, 59) = 3.148$, $p = 0.01$). Table 3.1 shows that (spoken) word frequency, AoA and imageability all account for a significant amount of the variants associated with slope in older adults. Furthermore the β-values indicate that word frequency has a larger affect on the rate at which older people acquire words than either imageability or AoA. This was not evident in the regression analysis for younger adults, that is, no stimulus characteristic predicted rate of acquisition for younger adults.

3.2.3 Discussion

The results support the view of Dunlosky & Salthouse (1996) in that older adults display a recall deficit which can be seen to be due to both encoding and consolidation difficulties. This supports the view that age-related shortfalls in episodic memory are caused by both encoding and consolidation deficits and not by an encoding deficit alone as suggested by Mitrushina et al. (1991).

Although older adults showed significantly poorer recall, encoding and consolidation there was no evidence of an age-related deficit on the savings score. This suggests that the consolidation measure is tapping into a different cognitive construct to the saving scores. It is probable that the consolidation does not measure retrieval as much as consolidation but the savings scores rely more on the construct of retrieval as opposed to consolidation (e.g. Woodard et al., 1999).

Due to the fact that the recall was restricted to episodic memory and study time was matched for high- and low-frequency words the results lend support to the inter-item association theory of the recall advantage of high- over low-frequency words (e.g. Tan & Ward, 2000). This is because storage of high-frequency words appear to be more interconnected than low-frequency words when episodic memory is investigated compared to working memory (e.g. Sumby, 1963). This supports the view of Ellis & Lambon-Ralph (2000) and Li (2009) who showed that cognitive networks are influenced by both word frequency and AoA. Hence, when words are encountered more frequently they are stored in more interconnected networks and previous research suggests that reactivating such cognitive representations also activates connected networks/representations (e.g. Kahana, 1996). It is also likely that this theory has been supported due to the use of pure-lists of words containing thirty words. Previous research such as Ward et al. (2003) used a lower number of words in both mixed-lists and pure-lists. Not only did this increase the chance of ceiling effects but it also reduced the number of possible inter-item associations for the high-frequency words.

Regarding the inter-item association theory it is interesting to note that the results suggested that the recall advantage of high-frequency words appear to be due to enhanced encoding of these words, compared to low-frequency words. There was no evidence that high-frequency words were consolidated more effectively than low-frequency words. Taken with the reading and naming latency advantage of high- and low-frequency words the results support the view that high-frequency words are accessed faster (e.g. Watkins et al., 2000) and therefore can be encoded faster and at a greater depth than low-frequency words. Furthermore there was no evidence of a recall advantage on savings scores of high or low-frequency words. This indicates that word frequency does not influence long-term retention or retrieval.

The ITR results present support for the cognitive reserve hypothesis in that older adults show a greater recall of high-frequency words, across the five initial trials, compared to low-frequency words. This is not evident in younger adults, that is, younger adults do not show a difference in recall rate of high- and low-frequency words across the five trials. Furthermore item analysis concludes that over the five trials (spoken) word frequency has a significant effect on recall for older but not younger adults. The item analysis also indicates a significant influence of AoA and imageability on recall for older adults. This influence of spoken word frequency, AoA and imageability was not apparent for the first trial which was used as a comparison in the item analysis. Overall the results support the view that words that are encountered more frequently are stored in more interconnected cognitive representations (e.g. Tan & Ward, 2000; Watkins et al., 2000).

Furthermore the results support previous research which has investigated pathological aging which has shown that high-frequency words are afforded a greater amount of protection from cognitive/neuronal atrophy than low-frequency words (e.g. Taylor, 1998). This suggests that there are similarities in how cognitive representations of words are lost in healthy aging and pathological aging. Interestingly, the ITE and ITC results did not show a dissociation between younger and older adults in the encoding or consolidation of high- and low-frequency words. Therefore it is logical to assume that cognitive activity, as defined by the cognitive reserve hypothesis, protects encoding and consolidation at an equal level which was not detected significantly in this sample population.

In conclusion, the results supported the view of Craik (1977) and Erber (1974) that age-related deficits in episodic memory are produced by problems with both encoding and consolidation. However, there was no evidence for a long-term retrieval/retention deficit in older adults (e.g. Dunlosky & Salthouse, 1996). The results supported the inter-item association theory of word frequency and suggested that the recall advantage of high- over low-frequency words was due to more efficient encoding of high-frequency words. There was no evidence that high-frequency words were consolidated or retained/retrieved better than low-frequency words. Finally, the results provide support for the cognitive reserve hypothesis, that is (compared to younger adults) older adults display a greater recall advantage across trials for high-frequency words than low-frequency words. This was supported with item analysis which shows that spoken word frequency, AoA and imageability all contribute to the rate at which older adults learn words as measured by slope values. This was not measured in the analysis of younger adults. The intertrial results were unable to ascertain whether this word frequency recall advantage, across trials, in older adults was due to an encoding or consolidation benefit of high-frequency over low-frequency words. It must be noted however that there was no support for the cognitive reserve hypothesis in terms of long-term retention/retrieval (as measured by saving scored). That is, there was no dissociation in terms of retrieval of high- and low-frequency words between younger and older adults.

3.3 Study Six: AoA as an analogy of the cognitive reserve hypothesis.

As in Study Five, Study Six manipulated stimuli characteristics to produce an analogy of the cognitive reserve hypothesis. In the case of Study Six the stimuli characteristics which were manipulated was the AoA of the to-be-remembered words. The study therefore investigated the recall, encoding, consolidation and retention of early- and later-acquired words in younger and older adults.

3.3.1 Method

3.3.1.1 Participants

The sample population consisted of two groups of participants separated on the basis of age. This was a different sample population to that used in Study Five. The younger group consisted of 19 participants with a mean age of 27.84 years (SD = 9.33). The group had a mean number of 14.74 years (SD = 2.81) in full time education. The older sample population consisted of 23 participants whose mean age was 70.22 years (SD = 6.13). Their mean number of years in education was 14.30 (SD = 4.20). The two samples were significantly different on the basis of age ($t = -16.99$, $df = 30.01$, $p<0.001$), however there was no significant difference between the number of years in education ($t = 0.40$). All individuals in the older sample population undertook the Mini-Mental State Examination (Folstein, Folstein and McHugh, 1975) and scored over 28/30 indicating normal cognitive functioning. All participants gave informed consent.

3.3.1.2 Stimuli

The stimuli (see Appendix Seven) consisted of words which were taken from Morrison, Chappell & Ellis (1997). The stimuli were separated on the basis of AoA and two pure word lists were formed, each containing thirty words. A further thirty words were taken from Morrison et al., (1997) to form a practice trial. The two experimental lists were termed ‘early’ or ‘late’ depending upon the mean AoA of the words. The early word list (e.g. *clown, slide* etc) had a mean AoA of 37.48 months (SD = 7.85) while the late word list (e.g. *accordion, chisel* etc) mean AoA was 76.64 months (SD = 14.12). There was a significant difference in terms of AoA between the two word lists ($t = -13.28$, $df = 45.37$, $p<0.001$). The two experimental word lists were matched on the basis of starting letter, number of syllables and imageability (all concrete nouns). Unfortunately, the words were not matched on word frequency, just as in Study Five item analysis was completed (see section 3.3.2.5). The words were presented thirty per page in size 22 Arial font and participants were required to rate each word for pleasantness on a scale of 1 to 7. The order of presentation of early- and late-acquired words were counterbalanced in each participant group.

3.3.1.3 Design and Procedure

Study Six used an identical design and procedure to that of Study Five with the exception that words in each trial were presented on one sheet not three separate sheets as in Study Five. The dependent variables were identical to those in Study Five (see 3.2.1.3 for details).

3.3.2 Results

3.3.2.1 Intertrial Recall (ITR)

As in Study Five a 5 X 2 X 2 (trial X age group X stimulus characteristics i.e. AoA) ANOVA was used to analyse the result for this dependent variable. Figure 3.4 illustrates the recall of younger and older participants studying early- and later-acquired words across the five initial trials and weekly delayed recall. There was a significant main effect of age in that younger participants recall more words than older participants ($F (1, 40) = 3.933$, $p = 0.05$, $\eta^2 = 0.090$). There was also a significant main effect of trial on ITR ($F (4, 160) = 188.846$, $p < 0.001$, $\eta^2 = 0.824$). These results confirm the findings of Study Five in that ITR increased over the five trials. There was also a significant main effect of AoA on ITR ($F (1, 40) = 6.684$, $p = 0.01$, $\eta^2 = 0.143$). Participants recalled 9.29% more early-acquired than later-acquired words. There was no significant two-way interactions of age of participants and AoA ($F = 0.581$), trial and age of participants ($F = 0.372$) or AoA and trial ($F = 0.281$) on ITR. Finally there was no significant three-way interaction between these three factors on ITR ($F = 1.681$).

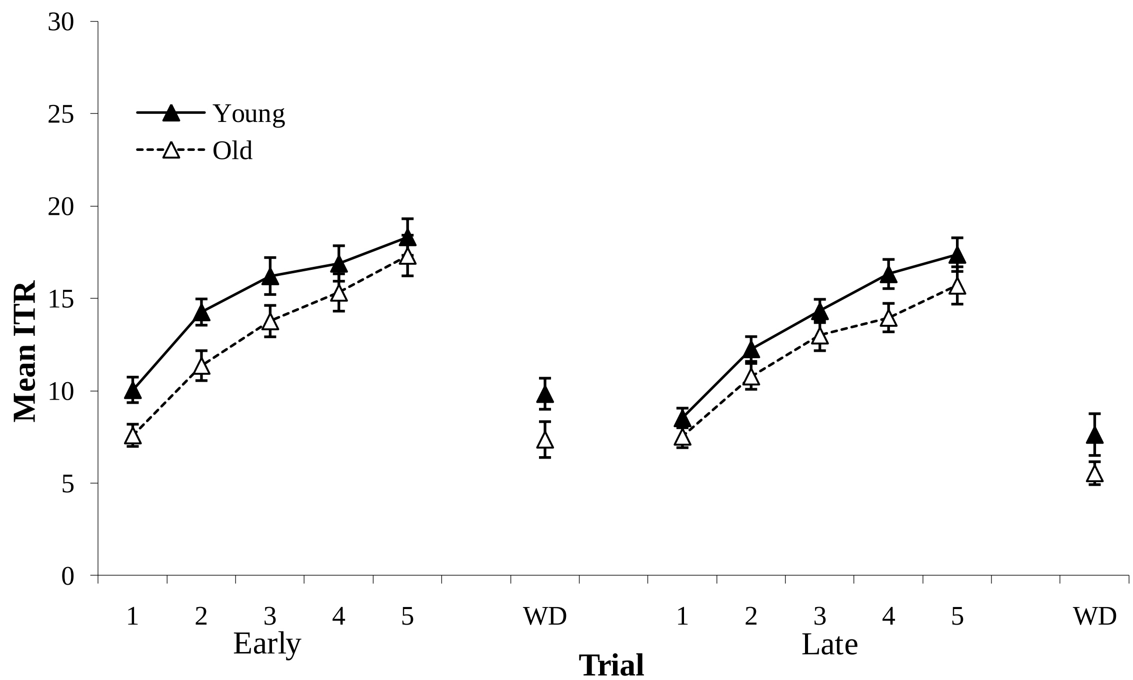

Figure 3.4. Mean intertrial recall (ITR) for younger and older adults studying early- and later-acquired words.

3.3.2.2 Intertrial Consolidation (ITC)

Figure 3.5 shows the mean consolidation across trials for younger and older adults studying early- and later-acquired words. A significant main effect of trial was observed on ITC ($F(3, 120) = 5.765$, $p = 0.001$, $\eta^2 = 0.16$). In line with previous research consolidation increased across trial. There was a borderline significant main effect of age on ITC ($F(1, 40) = 3.933$, $p = 0.054$, $\eta^2 = 0.09$). The marginal means indicated that the younger participants had a mean consolidation score which was 8.98% higher than older adults. There was no significant main effect of AoA on ITC ($F = 1.313$). For this dependant variable, there were no significant two-way interactions between either AoA and age ($F = 0.002$), AoA and trial ($F = 1.294$) or trial and age ($F = 0.703$). Furthermore, there was no significant three-way interaction between all three factors on ITC ($F = 1.404$).

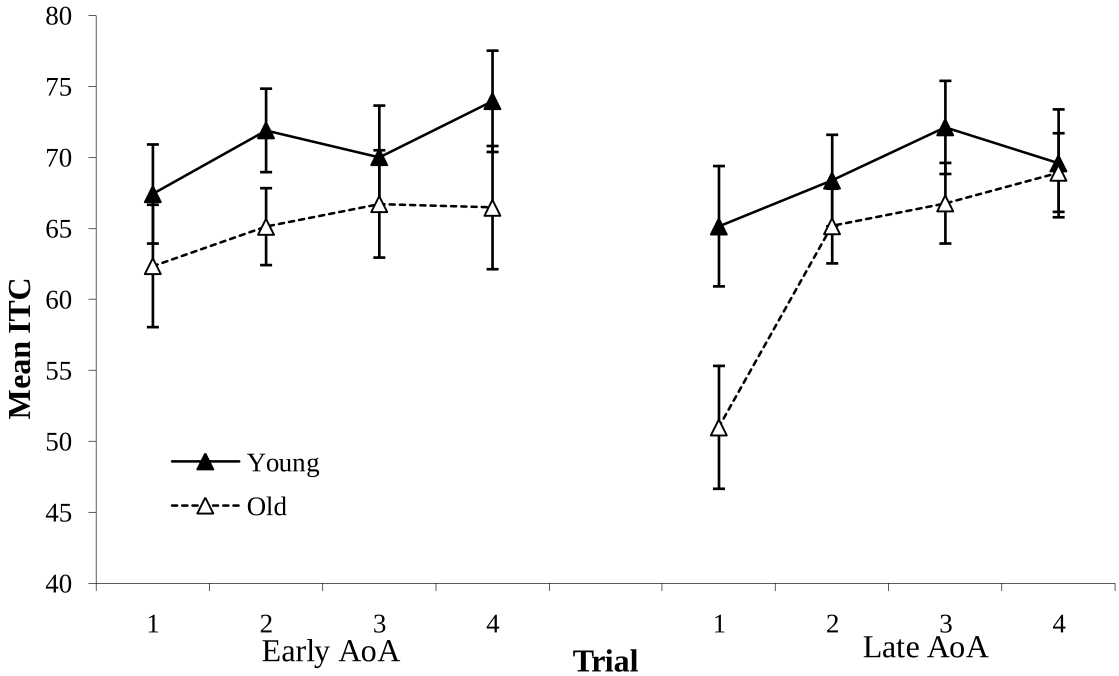

Figure 3.5. Mean intertrial consolidation (ITC) for younger and older adults studying early- and later-acquired words.

3.3.2.3 Intertrial Encoding (ITE)

The analyses showed a significant main effect of trial on ITE ($F(4, 160) = 23.412$, $p < 0.001$, $\eta^2 = 0.369$). As Figure 3.6 demonstrates encoding increased across trial for all participants. There was also a significant main effect of AoA on ITE ($F(1, 40) = 6.689$, $p < 0.05$, $\eta^2 = 0.143$), overall participants had a 7.87% higher encoding score for words which were acquired at an earlier age than words acquired later. There was no significant main effect of age of participants on ITE ($F = 0.754$). There was no significant two-way interaction between either AoA and age ($F = 0.155$), AoA and trial ($F = 0.260$) or trial and age ($F = 0.819$) on ITE. There was a significant three-way interaction between all three factors on ITE ($F(4, 160) = 3.015$, $p < 0.05$, $\eta^2 = 0.070$). As shown in Figure 3.6 older adults encode early-acquired words at a greater rate across trial than later-acquired words. This enhanced encoding of early-acquired words over later-acquired words is not evident in younger adults.

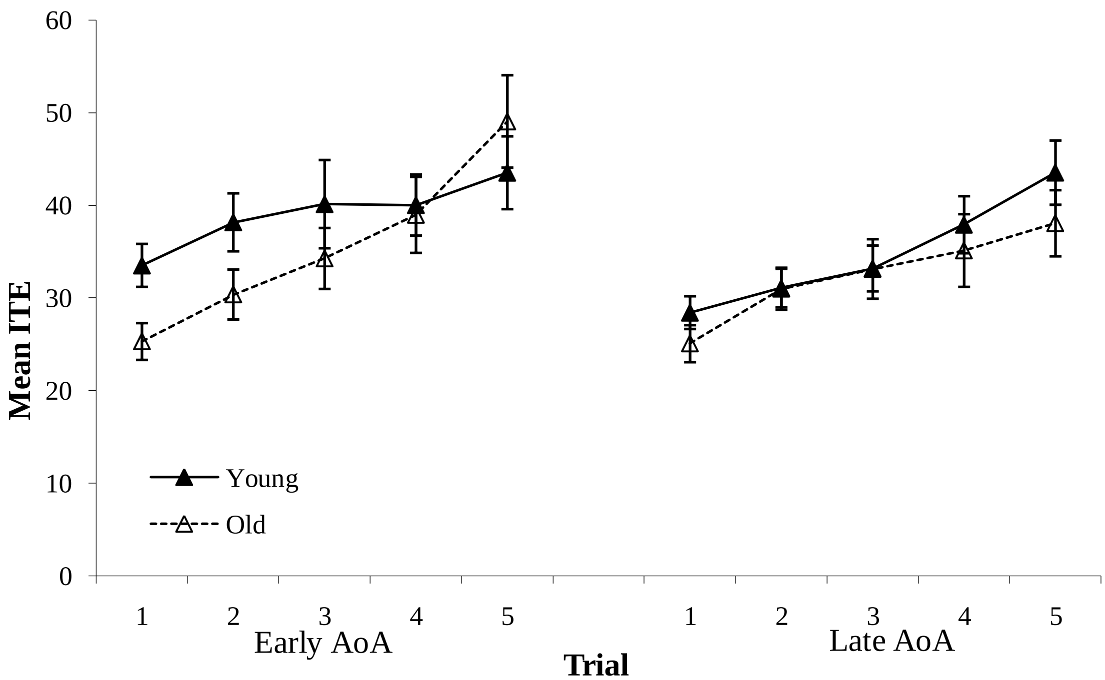

Figure 3.6. Mean intertrial encoding (ITE) for younger and older adults studying early- and later-acquired words

3.3.2.4 Savings Scores

The results show no significant main effect of age on savings (F =2.592). However there was a significant main effect of AoA on savings ($F(1, 40) = 5.878$, $p<0.05$, $\eta^2 = 0.128$). Marginal means indicate that earlier-acquired words savings scores were 27% higher than words acquired later in age. There was no significant interaction between AoA and age on savings scores (F =0.711).

3.3.2.5 Item analysis

As in Study Five, following by subject analysis an item analysis was carried out (see 3.2.2.5 for details of the technique used). All the variables covered in 3.2.2.5 were calculated for the data in Study Six. The main motivation for this was to consider the confound of word frequency on the word factor (recall).

Simple correlations of performance between groups showed that the recall of the older adult group strongly correlates with the recall of the younger adult group, r (60) =

0.478, $p < 0.001$. This suggests that, as in Study Five, the same words in Study Six were recalled by younger and older adults. Once again, the correlations for younger ($r(60) = -0.627$, $p<0.001$) and older adults ($r(60) = -0.405$, $p = 0.001$) indicated that items which were less well recalled on trial one had a steeper slope value.

3.3.2.5.1 ANOVA results

Analysis A: As in section 3.2.2.5 a 2 X 2 ANOVA compared recall performance for early- and later-acquired words for younger and older participants. There was a significant main effect of age on mean recall ($F(1, 58) = 5.185$, $p < 0.05$, $\eta^2 = 0.081$). However there was no significant main effect of AoA ($F = 0.849$) nor a significant interaction between AoA and age group ($F = 1.401$). This indicates that over the whole study there is no difference in the type of words participants recall (i.e. early- versus later-acquired words) and that there is no dissociation between the type of words younger and older participants recall.

Analysis B: The factor of slope and age group was included in a 2 X 2 ANOVA to investigate whether younger and older participants acquired early- and later-acquired words at a different rate over the five trials. The results showed no significant main effect of age group on slope ($F = 0.845$). There was also no significant main effect of AoA on slope value ($F = 0.003$). Finally there was no significant two way interaction between age of participants and AoA on slope value ($F = 2.461$). The results indicate that the rate of recall across trials was not significantly different for early- or later-acquired words. The results indicate that neither younger or older participants recall words at a different rate across the five trials. The result also indicates that there is no difference, between younger and older participants, in the rate that they recall words that differ in AoA. This was supported by the correlational analysis which showed that neither younger slope values or older slope values were significantly correlated with the AoA variable (both $p > 0.25$).

3.3.2.5.2 Regression analysis

As mentioned in section 3.3.1.2, the factor of word frequency was unfortunately not controlled for in the stimulus list. Therefore for completeness a regression analysis was used to investigate the impact of different stimulus characteristics on both total recall and slope in younger and older participants. The results showed no significant effect of any stimulus characteristics on either total mean recall or slope value in younger or older participants.

3.3.3 Discussion

The results did not show that older adults have an encoding deficit during the initial five trials. This is not supportive of Dunlosky & Salthouse (1996) or Study Five, furthermore it is not supportive of Mitrushina et al. (1991) who found a significant deficit in encoding and not in consolidation. Furthermore the results did not show an age-related deficit in retention/retrieval as measured by the savings score. However the results confirmed that older adults had a significantly greater deficit in recall and consolidation than younger adults which supports the findings in Study Five and Dunlosky & Salthouse (1996). It is possible that the extra study and recall time that older adults received reduced the scale of the differences in the episodic memory of the older adults compared to the younger adults (e.g. Naveh-Benjamin et al., 2003).

Unlike Dewhurst et al. (1998) the results showed a significant effect of AoA on recall, in that early-acquired words had a recall advantage over later-acquired words. This supports the view of a number of researchers (e.g. Li, 2009; Steyvers & Tenenbaum, 2005; Ellis & Lambon-Ralph, 2000) that earlier-acquired words are stored in more interconnected cognitive representations than later-acquired words. This is similar to the inter-item association theory of word frequency as proposed by Tan & Ward (2000). The view that early-acquired words are stored in more interconnected cognitive representations than later-acquired words is supported by reading and naming latency studies which show that early-acquired words are read (and therefore accessed) faster than later-acquired words (e.g. Morrison et al., 2002).

Previous studies such as Dewhurst et al. (1998), Coltheart & Winograd (1986) and Morris (1981) have not shown a recall advantage of early- over later-acquired words. However, this is probably due to a number of methodological differences between previous research and the current study (Study Six). First, Dewhurst et al's (1998) classification of early-acquired words did not match those used in reading and naming latency studies. For example, Catling & Johnston (2009) suggest that studies which investigate AoA in memory and reading/naming latencies need to be matched on the basis of stimulus used. Therefore Study Six attempted to match the classification of early-acquired words to those used in naming and reading latency studies (e.g. Morrison et al., 2002).

Second, all three studies which investigated AoA and recall used a classification of AoA which was based on adults' estimation of when they would have learnt such words (e.g. Gilhooly & Logie, 1980). This has been criticised as potentially unreliable and subjective (e.g. Boning et al., 2009; Johnston & Barry, 2006; Zevin & Seidenberg, 2002), thus this study used AoA measures which were devised from children's average age of being able to name pictures (Morrison et al., 1997), which are arguably more objective. Finally, the use of nouns, verbs and abstract concepts in the stimulus of Dewhurst et al's (1998) study may have masked the effect of AoA on recall. Elman (2009) and Li (2009) have demonstrated that nouns are stored in different cognitive structures to other types of words such as verbs and abstract concepts. Furthermore Gentner (1982) stated that English speaking children acquire nouns before other types of words. Therefore an AoA effect on recall is more likely to be apparent in nouns than other word types.

The results indicated that the recall advantage of early- compared to later-acquired words was due to an encoding superiority of early-acquired words. There was no evidence that words which differed in terms of AoA were consolidated differently. Therefore, there was a dissociation between the memory processes which produced age-related differences in recall (i.e. consolidation) and the memory processes which produced the recall differences between early- and later-acquired words (i.e. encoding). However, the item analysis did not support the ANOVA and did not show that older adults acquired early- and later-acquired words at a different rate compared to younger adults. It is noteworthy that the results also showed an advantage of early- over later-acquired words on the savings scores, which suggest that early-acquired words are retained/retrieved better than later-acquired words. This is interesting, because previous research has suggested that savings scores can be viewed as a further measurement of consolidation, but these results indicate that savings scores are measuring a different cognitive process, which appears to be related to retrieval (e.g. Woodard et al., 1999).

Neither the recall, consolidation nor savings scores provide evidence for the cognitive reserve hypothesis. That is, for all three measures there was no significant dissociation between younger and older adults when learning early- and later-acquired words. However, the encoding measure showed a dissociation, across trial, between younger and older adults learning words which differed in terms of AoA. There was no evidence that younger adults encoded early- and later-acquired words at a different rate across the study. However, it was evident that older adults encoded earlier-acquired words at a greater rate (across the five initials trials) than later-acquired words. Furthermore, it was apparent that older adults encoded earlier-acquired words at a greater rate than younger participants; there was no evidence for this with regards to later-acquired words. Therefore, in support of the cognitive reserve hypothesis, the results showed that early life experiences can preserve the encoding process in older adults.[16] Although, it must be noted that such experiences do not appear to benefit consolidation, retrieval or overall recall in older adults compared to younger adults.

In conclusion, the results show that younger adults recall and consolidate significantly more words than older adults. However, there is no evidence for an age-related deficit in either encoding or retention/retrieval. The results support the theory that early-acquired words are stored as more interconnected cognitive representations than later-acquired words due to the fact that an overall recall advantage of early- over later-acquired words was found. This recall advantage appears to be because of enhanced encoding of early-acquired words. Although there is no evidence of a difference in consolidation of early- and later-acquired words there is a difference in the long-term

[16] However this was not supported when using item analysis to analyse the data.

retrieval/retention of such words in that early-acquired words are retained/retrieved significantly better than later-acquired words. The cognitive reserve hypothesis is not supported with the constructs of overall recall, consolidation or retrieval/retention. However, there is evidence that earlier experiences can protect the process of encoding from cognitive atrophy, associated with healthy aging. This is apparent due to the fact that older adults encode early-acquired words at a greater rate (across the initial five trials of the study) than younger adults and that this pattern is not repeated for later-acquired words.

3.4 General Discussion

Table 3.2 Summary of the results of Study Five (word frequency)

	Recall	Consolidation	Encoding	Savings Score
Age main effect	Yes	Yes	Yes	No
Word frequency main effect	Yes	No	Yes	No
Age X word frequency interaction	No	No	No	No
Age X word frequency X trial interaction	Yes	No	No	No

The aim of Studies Five and Six was to manipulate stimulus characteristics to produce an analogy of the cognitive reserve hypothesis while using a within subjects technique. Study Five manipulated the word frequency of to-be-remembered words while Study Six manipulated the AoA of such words. Each study measured the recall, consolidation, encoding and savings scores (retention/retrieval) for each word type in younger and older adults. Support for the cognitive reserve hypothesis would require older adults to show better learning of high-frequency (compared to low-frequency) and/or early-acquired (compared to alter acquired) words, which was not evident in younger adults. Tables 3.2 and 3.3 provide a summary of the results for Studies Five and Six respectively.

Table 3.3 Summary of the results of Study Six (AoA)

	Recall	Consolidation	Encoding	Savings Score
Age main effect	Yes	Yes	No	No
AoA main effect	Yes	No	Yes	Yes
Age X AoA interaction	No	No	No	No
Age X AoA X trial interaction	No	No	Yes	No

3.4.1 The effect of age on constructs of episodic memory.

Both Studies Five and Six confirmed an age-related deficit in episodic memory, particularly in recall. This is supportive of a large number of theories and studies which have shown that older adults display a deficit in episodic memory (e.g. Craik, 1977). The use of the intertrial technique enables the exploration of the effects of consolidation, encoding and retention/retrieval (i.e. savings scores) in younger and older adults. In line with Dunlosky & Salthouse (1996) Study Five confirmed that older adults showed problems with both encoding and consolidation. This is supportive of previous research which has suggested that the recall deficit of episodic memory is due to a reduction in both encoding and consolidation capabilities (e.g. Bleeker et al., 1988). However, unlike Dunlosky & Salthouse (1996) there was no evidence of age deficits in longer term retention/retrieval. That is, there was no difference in the number of words younger and older participants recall as a proportion of the last trial when testing one week later. Therefore, the results suggest that longer term retrieval/retention is intact in older adults.

Study Six confirmed that older adults showed a lower level of consolidation compared to younger adults. However, there was no evidence of an age-related encoding deficit of episodic memory. Neither younger nor older participants showed a significantly different level of encoding across the study period. This is contrary to Mitrushina et al. (1991) who used a multi-trial technique and found evidence of an encoding shortfall in older adults compared to younger adults. Mitrushina et al. (1991) concluded that age-related decline in memory was due to encoding deficits rather than consolidation or retrieval deficits. However, it must be acknowledged that the age range in Mitrushina et al. (1991) was markedly less than the age range in Study Six and in Dunlosky & Salthouse (1996), which also showed a consolidation deficit in older adults.[17] Furthermore, Mitrushina et al. (1991) did not calculate gained and lost access as percentages, therefore scaling effects may have masked actual age effects in consolidation. Study Six also confirms the findings of Study Five in that there was no evidence of age differences in long-term retention/retrieval.

In summary, the results confirm that there is a deficit in episodic memory for older adults compared to younger adults. Compared to Dunlosky & Salthouse (1996) and Mitrushina et al. (1991) Studies Five and Six used an extended study list, distracter task prior to recall and the random presentation of to-be-remembered words in study lists. These controls restricted the construct to episodic memory, to achieve the aim to match the most common reported age deficit in memory and ensure the analogy of the cognitive reserve hypothesis was preserved.

3.4.2 The effects of stimulus characteristics on episodic memory

As reported in Section 4.1.4 there is evidence for a recall advantage of high-frequency over low-frequency words when using a pure-list study technique (e.g. Ward et al., 2003; Watkins et al., 2000; Tan & Ward, 2000). However, there was no evidence of a recall advantage of early- over later-acquired words in previous research (e.g. Dewhurst et al., 1998; Coltheart & Winograd, 1986; Morris, 1981). Study Five and Study Six provided evidence of a recall advantage of high- over low-frequency words and early- over late frequency words when recall was restricted to episodic memory.

The results of Study Five support the inter-item association theory of the word frequency advantage in recall (e.g. Tan & Ward, 2000). The results also support the view of Sumby (1963) who believed that the recall effect of word frequency should be

[17] The age range of the sample population in Mitrushina et al. (1991) was 57 to 85 years, compared to 18 to 94 in Dunlosky & Salthouse (1996), which closely matched the age range in Studies Fives and Six.

greatly apparent on episodic memory. As higher frequency words are read and processed faster than low-frequency words (e.g. Barry, Morrison & Ellis, 1997) it was important to control for study time during the learning stage. This meant that both word types received an equal amount of processing time and reduced the possibility that high-frequency words received less study time (e.g. Watkins et al., 2000). Furthermore, the inter-item association is supported by using an extended study list which means that there are more available inter-item associations for high-frequency, compared to low-frequency words. This has been highlighted as a problem in previous research which have compared a pure and mixed-list technique (e.g. Ward et al., 2003).

The inter-item association theory of word frequency can be transferred to the investigation of AoA and recall. Connectionist models have demonstrated that earlier-acquired words are stored in more interconnected networks than later-acquired words (e.g. Li, 2009; Steyvers & Tenenbaum, 2005; Ellis & Lambon-Ralph, 2002), so activation of one early-acquired word is likely to trigger words which are closely associated with that word, that is other early-acquired words (e.g. Elman, 2009). Due to the fact that later-acquired words are believed to be stored in less interconnected networks (e.g. Li, 2009), activation of a later-acquired word is likely to trigger activation of fewer later-acquired words (in comparison to the initial activation of an early-acquired word). The results of Study Six support this view due to the fact that there was a significant recall advantage of early-acquired words over later-acquired words.

The results from Study Six do not support previous research which has investigated the effects of AoA on recall (e.g. Dewhurst et al., 1998). A number of researchers (e.g. Johnston & Barry, 2006; Zevin & Seidenberg, 2002) have criticised the classification of early-acquired words in Dewhurst et al. (1998). The AoA of early-acquired words in studies which have investigated the effect of AoA on memory (e.g. Dewhurst et al., 1998; Coltheart & Winograd, 1986; Morris, 1981) are unrepresentative of the classification used in studies which have investigated reading and naming latencies (e.g. Morrison et al., 2002; Morrison & Ellis, 2000). Therefore, the words which were deemed to represent early-acquired words in research conducted by Dewhurst et al.

(1998), Coltheart & Winograd (1986) and Morris (1981) were not acquired at the same age as the early-acquired words used in studies which investigated naming or reading latencies (e.g. Morrison et al., 2002; Morrison et al., 1997). This important, because connectionist models (e.g. Li, 2009) suggest that it is the very early-acquired words which demonstrate the heightened interconnectivity with one another.

Furthermore, Dewhurst et al. (1998) and Morris (1981) have used AoA ratings which have been taken from adults estimations of what age they believe they learnt such words (e.g. Gilhooly & Logie, 1980). This is subjective and potentially unreliable according to Zevin & Seidenberg (2002); therefore it is arguably more objective to use ratings of mean ages of when children are able to name pictures of concrete nouns (i.e. Morrison et al., 1997).

The result of Studies Five and Six also supports the theories of Coltheart & Winograd (1986). Coltheart & Winograd (1986) believed that imageability had a larger impact on episodic memory than AoA. Item analysis showed that imageability had a larger impact than AoA in Study Five. However, neither AoA nor imageability had a significant effect on recall in Study Six. Overall the results indicate that imageability has an equal, if not larger effect on recall than AoA.

It must also be acknowledged that some previous research (e.g. Ward et al., 2003; Dewhurst et al., 1998) which has investigated the effect of word frequency or AoA has also tended to use a mixture of concrete nouns, abstract concepts (e.g. the word 'justice') adjectives, and verbs in the to-be-remembered word list. There is evidence that nouns are stored differently to other word types (e.g. Federmeier, Segal, Lambrozo & Kutas, 2000). This is also supported by connectionist models (e.g. Li, 2009) which have shown that nouns are acquired earlier than other types of words and that early-acquired nouns are therefore stored in tighter interconnected networks than words acquired later in life. This means that it is likely that the learning and retrieval of different word types will not be identical. For this reason, Studies Five and Six restricted the to-be-remembered word lists to contain only concrete nouns, to remove the confound of other aspects of stimulus characteristics (i.e. type of word) and focus on the impact of word frequency and AoA.

Studies Five and Six used an intertrial technique to investigate the consolidation, encoding and retention/retrieval of words that differ in word frequency and AoA. This technique has not been used to date and can indicate which cognitive construct is responsible for the recall advantage of high frequency and early-acquired words. Both Studies Five and Six suggest that the recall advantage of words which differ in terms of stimulus characteristics is due to a benefit in encoding and not consolidation. With regards to word frequency, this supports the view of Balota & Neely (1980) and DeLosh & McDaniel (1996) who argued that high-frequency words are encoded more efficiently than low-frequency words.[18] The results are also in contrast to early research by Postman (1970) who stated that the word frequency effect, in free recall, was due to superior consolidation of high- over low-frequency words. However, it is likely that Postman (1970) did not find an effect on encoding of word frequency because gained access (representing encoding, see section 3.2.1.3) was not calculated, even though a multi-trial technique was used.

It is interesting to note that there was no evidence that high- or low-frequency words were retained/retrieved differently. However, the results from Study Six showed that early-acquired words were retained/retrieved (as measured by savings scores) significantly better than later-acquired words. This suggests that there is a difference in terms of the cognitive constructs of consolidation (lost access, see section 3.2.1.3) and retention/retrieval (savings scores). The results did not show that stimulus characteristics affected consolidation of to-be-remembered words; however Study Six showed that stimulus characteristics (i.e. AoA) had a significant impact on the long-term retention/retrieval of to-be-remembered words. Once again, this raises doubts over the conclusions of Coltheart & Winograd (1986) with regards to the impact of AoA on episodic memory.

[18] DeLosh & McDaniels (1996) showed superior recall of high-frequency over low-frequency words and Balota & Neely (1980) showed that participants recalled more high-frequency than low-frequency words when expecting a recall and not a recognition test. The authors attribute this to superior encoding of high- compared to low-frequency words.

Both Studies Five and Six used item analysis to investigate the effects and potential confounds of stimulus characteristics on recall over the five initial trials. It is interesting that the analysis in both studies produced contrasting results; Study Five indicated that word frequency (particularly spoken), AoA and imageability all have a significant impact on recall across the five trials. The results of Study Six, however, did not confirm that any of the stimulus characteristics taken into account have any significant influence on recall over the five trials. Although Study Five indicated that word frequency had a larger impact on recall than AoA, which is contrary to the prediction of Carroll & White (1973), the results demonstrate how the effects of stimulus characteristics can have a large impact on the recall of words. Therefore it is important that future research takes stimulus characteristics into account when studying aspects of episodic memory.

In conclusion, the results support the view that high-frequency and early-acquired words are stored in more interconnected cognitive networks than low-frequency and later-acquired words respectively. The methodological design used for Studies Five and Six means that the results support the view of the inter-item association theory of recall and word frequency. This theory can also be extended to the effect of AoA on recall. The benefit of using an intertrial technique is that the results indicated that the recall advantage of high-frequency and early-acquired words over low-frequency and later-acquired words, is due to an encoding benefit and not a consolidation benefit. This has not been investigated in previous research and has support from the item analysis used in Study Five which suggests effects of both word frequency and AoA on the acquisition of words. This can be regarded as opposite to the effect of age on episodic memory because there was a clear benefit of consolidation for younger adults compared to older adults whereas the age-related effect on encoding was not evident in Study Six. The results also suggest that savings scores represent a different construct to consolidation (lost access, section 3.2.1.3). There was no evidence that word frequency affects long-term retention/retrieval however there was evidence that AoA affects this construct. This supports the view of Brysbaert & Ghyselinck (2006) and Morrison et al.

(2002) in that AoA and word frequency can have independent impacts on reading/naming latencies, and thus episodic memory.

3.4.3 Evidence for the cognitive reserve hypothesis

In brief, to produce evidence for the cognitive reserve hypothesis the results of Studies Five or Six would have to show a dissociation, in terms of learning, for words which differ in terms of either word frequency or AoA between younger and older adults. Specifically, older adults, compared to younger adults, should show enhanced recall, encoding, consolidation and/or retrieval/retention of high-frequency and/or early-acquired words compared to low-frequency and/or later-acquired words respectively. According to the cognitive reserve hypothesis this is due to the theory that cognitive atrophy should show a larger effect on cognitive representations which are not as interconnected (i.e. low-frequency and later-acquired words) than those which have a greater number of inter-item association (i.e. high-frequency and early-acquired words).

Study Five showed compelling support for the cognitive reserve hypothesis; there was a significant three way interaction between age group, word frequency and trial. The results showed that older adults recalled high-frequency words at a greater rate across the initial five trials compared to low-frequency words. This difference in rate of recall across the five initial trials between high- and low-frequency words was not evident in the younger participants. This result suggests that the regular activation of high-frequency compared to low-frequency words across the lifespan produces a produces protection against cognitive atrophy associated with healthy aging. This support for the cognitive reserve hypothesis can be endorsed due to the fact that a within–subjects technique was used, which removed the impact of demographic factors which may have confounded previous research, which investigated cognitive reserve hypothesis using a between-subjects technique.

The support for the cognitive reserve hypothesis was also apparent with the item analysis results in Study Five. The results showed that word frequency (specifically spoken word frequency) had a significant influence on the rate at which older adults acquire words over the five trials. However, no stimulus characteristics significantly accounted for the variance of words acquired by younger adults over the study period. This supports the ANOVA result in that high-frequency words appear to be gained at a greater rate than low-frequency words in the older adult sample population but not in the younger adult sample population.

The result of Study Five also indicated that healthy aging affected both consolidation and encoding of words in episodic memory (but not retention/retrieval). However, there was only evidence that word frequency affected the encoding of words (i.e. not consolidation or retention/retrieval). The intertrial technique did not indicate whether the protective influence of word frequency benefitted encoding or consolidation of high- compared to low-frequency words in older adults. It is possible that with a larger sample population the influence of word frequency on encoding and/or consolidation in older adults will become evident.

The results from Study Six did not show a dissociation, in terms of recall, consolidation or retention/retrieval of words which differ in AoA between younger and older adults. This was also the case when the impact of trial was taken into account (see table 3.3). This indicates that there is no evidence for the cognitive reserve hypothesis in the constructs of recall, consolidation and retention/retrieval when using a manipulation of AoA of the to-be-remembered words with a within-subject technique. However, there was evidence that older adults encoded early-acquired words at a greater rate across trial than later-acquired words. This dissociation was not apparent in younger adults. This can be taken as support for the cognitive reserve hypothesis within the cognitive construct of encoding. Previous research has shown that healthy aging produces deficits in encoding (e.g. Dunlosky & Salthouse 1996) and the results from Study Six indicate that early life experiences can protect this construct from the effects of healthy aging. However, it must be acknowledged that even though early life experiences appear to benefit encoding in later life there is no evidence that these experiences protect overall recall from cognitive atrophy caused by healthy aging. Furthermore, item analysis did not produce support for the ANOVA data, that is, AoA did not appear to influence the acquisition of words across the five trials and this was also the case for younger adults.

In summary, there was strong evidence from Study Five that activating a cognitive representation on a regular basis than a similar cognitive representation (i.e. a high- vs. low-frequency word) protects this construct from cognitive atrophy associated with healthy aging. This was shown to be the case with both subject analysis and item analysis, but only for the construct of recall. Study Six indicated that cognitive representations which are acquired earlier in life are protected from cognitive atrophy which affects the construct of encoding compared to cognitive representation acquired later in life (i.e. an early- vs. later-acquired word). Although it must be acknowledged that this was only evidenced with subject analysis and not item analysis. Furthermore, this apparent benefit in encoding of early- compared to later-acquired words did not show that early-acquired words were protected from cognitive atrophy when one measured overall recall, consolidation or long-term retention/retrieval compared to later-acquired words. Therefore, it can be concluded that there is strong evidence for the cognitive reserve hypothesis when controlling for demographic factors by using a within-subjects technique.

3.4.4 Conclusion

In conclusion, the results from Studies Five and Six confirm that older adults recall significantly fewer words when using the episodic memory system compared to younger adults. The results indicate that this age-related decline in episodic memory is largely due to a consolidation deficit in older adults. There is no evidence of an age-related shortfall in retention/retrieval over longer periods of time. The results also show that stimulus characteristics produce differences in recall of to-be-remembered words which can be attributed to superior encoding of certain word types. Specifically, the results show that high-frequency and early-acquired words are encoded and recalled significantly more efficiently than low-frequency and later-acquired words. This supports the view of Tan & Ward (2000) and Ellis & Lambon-Ralph (2000) that high-frequency and early-acquired words are stored in more interconnected cognitive representations/networks than low-frequency and later-acquired words respectively. The results do not show support for Dewhurst et al. (1998) who found that later-acquired words were recalled more than early-acquired words. However, this is probably because of the stimuli and methodology used by Dewhurst et al. (1998) and not an accurate representation of the effect of AoA on recall.

There was good support for the cognitive reserve hypothesis from the results of Study Five. That is, across the five initial trials older adults showed a greater rate of recall of high-frequency compared to low-frequency words, whereas the rate of recall of high- and low-frequency words in younger adults was not significantly different. This suggests that regular activation of a cognitive representation (i.e. high-frequency words) protects such cognitive representations from cognitive atrophy associated with healthy aging. This is supportive of previous research (e.g. Forbes-McKay et al. 2005; Taylor, 1998) which shows that in verbal fluency tasks older adults tend to produce more early-acquired and high-frequency words than late-acquired and low-frequency words. Unfortunately the intertrial technique did not illuminate whether the protective influence of word frequency benefitted the encoding or consolidation system of episodic memory in older adults. Study Six also produced support for the cognitive reserve hypothesis. The results showed that whereas younger adults did not encode early- or later-acquired words at a different rate across the study period, older adults showed a greater rate of encoding for early- compared to later-acquired words across the initial five trials. Once again, this provides some support for the cognitive reserve hypothesis, however the encoding benefit of early- over later-acquired words in older adults did not appear to benefit overall recall of such words. Overall, the within-subjects approach has provided good support for the cognitive reserve hypothesis by eliminating the mediating effects of demographic factors.

CHAPTER FOUR

TESTING THE USE-DEPENDENCY THEORY: THE EFFECT OF POPULARITY ON RECALL, ENCODING AND CONSOLIDATION OF PROPER NAMES IN YOUNGER AND OLDER ADULTS

4.1 Background

4.1.1 Introduction

The use-it-or-lose-it theory can be separated into the cognitive reserve hypothesis and the use-dependency theory. Previous research has used a number of different methodological techniques to investigate both theories (See Chapter One for a review). However, there still are a number of questions regarding whether techniques which have been used to provide evidence of both theories are appropriate (e.g. Shadish et al., 2002). For example, numerous studies have used a self-report technique to measure cognitive activity (e.g. Wilson et al., 2003). Furthermore some research has used self-report measures of cognitive functioning as outcome measures (e.g. Wilson et al., 2005). This is true for questionnaire studies (as investigated in Studies One, Two, Three, Four and Four (a), see Chapter Two) and intervention techniques which have investigated the effects of training on MemSE (e.g. West et al., 2008; Study Eight, see Chapter Five). It can be argued that self-report measures of activity and self-report measures of cognitive functioning (e.g. MemSE) are unreliable (e.g. Rabbitt et al., 1995; Sunderland et al., 1986).

Of particular interests for the present study is the use of a between-subjects technique in previous research to investigate the use-dependency theory. Chapter One has reviewed previous research and the majority of cross-sectional and longitudinal studies which have investigated the use-dependency theory have employed a between-subject technique. Typically, this will involve comparing two groups of participants, one who are relatively cognitively active and one who are relatively cognitively inactive (e.g. Verghese et al., 2003; Hultsch et al., 1999). The problem with using a between-subjects technique is that it is impossible to account for all the variance associated with comparing one individual to another. As discussed by Shadish et al. (2002), it is possible that there is a demographic factor which mediates both cognitive activity and cognitive functioning. Therefore a within-subjects technique is needed to eliminate the effects of individual differences when investigating the use-dependency theory.

Chapter Three used a within-subjects technique to investigate the cognitive reserve hypothesis. This involved manipulating stimulus characteristics of to-be-remembered words to produce an analogy of the cognitive reserve hypothesis. Here a study is presented which aimed to replicate the use-dependency theory by manipulating stimulus characteristics of to-be-remembered words. One set of stimulus material where such a pattern can be observed is proper names. The cognitive construct of learning proper names is an ideal area to research the use-dependency theory. This is due to the fact that older adults report a significant memory deficit for proper names (e.g. Reese & Cherry, 2004) and that empirical research has shown that older adults, compared to younger adults, display a greater learning deficit for proper names as opposed to concrete nouns (e.g. James, 2004). A logical continuum of this would predict that an increase in cognitive activity (i.e. a maintenance of popularity versus a decrease in popularity) in later life of certain proper names would increase the likelihood of such names being easier to relearn when encountered again.

4.1.2 Using recall of proper names as an analogy of the use-dependency theory

Chapter Three has explained the rationale of manipulating stimulus characteristics to produce an analogy of either the cognitive reserve hypothesis or use-dependency theory (see section 3.1.3). Briefly, for an analogy of the use-dependency theory participants must study words which have been matched for popularity and then half of these words must have shown a decrease in popularity, specifically for older adults. The reason for this is to produce use-dependency-like results, using a within-subjects design, there must be a decrease in cognitive activity in one part of a cognitive construct (i.e. proper names) while another part of the same construct remains to be activated frequently (even though both must have been matched on the basis of activity at an earlier point in time). This is similar to the Node Structure Theory (NST; e.g. Cohen & Burke, 1993; MacKay, 1987), which describes how, in theory, older adults should find it easier to learn popular names compared to unpopular names. The NST states that names which are more popular will have a greater number of cognitive representations (representing semantic, episodic, visual and phonological information about people with that specific name) compared to names which are relatively unpopular (e.g. James & Fogler, 2007).

4.1.3 Research into proper name recall and aging

Subjective evidence has indicated that older adults report an increase in difficulty for recalling people's first name (e.g. Reese & Cherry, 2004). This has been supported by objective measures of proper name recall across the lifespan (e.g. James & Fogler, 2007; James, 2004; Crook & West, 1990; Cohen & Faulkner, 1986). A prominent theory, the NST (e.g. Cohen & Burke, 1993) proposes that this is because names, compared to other nouns, are not activated (in terms of their cognitive representations) as often as other nouns. Therefore the cognitive atrophy, associated with healthy and pathological aging, is more likely to affect proper names than other nouns that are more frequently activated.

Taking the NST further researchers have investigated whether popular names are recalled more often than less popular names. The majority of research has confirmed that popular names are easier to recall when presented in pure-lists compared to less popular names (e.g. James & Fogler, 2007). The research also suggests that there is a recall advantage for popular, over unpopular names, when the names are presented in mixed-lists, providing that the lists contain an equal number of popular versus unpopular names (e.g. Valentine & Moore, 1995).

Therefore, it would be logical to predict that older adults should show a recall advantage for popular over unpopular names. This was investigated by Jones & Rabbitt (1994) who tested participants who were either aged sixty to seventy years old or over seventy years old. The results confirmed that older adults showed a recall deficit for name learning; however there was no dissociation, in terms of recall, between popular and unpopular names between the two age groups. It is possible that this was due to the use of first name and surname pairs to produce a cued recall test. It is also likely that there was an insufficient difference, in terms of age, between the two sample populations. Experiments which have investigated the effects of aging on memory have generally compared younger adults (aged under 40 years old) and older adults (aged over 60 years old), for example Dunlosky & Salthouse (1996).

James & Fogler (2007) also investigated the effect of age and name popularity on recall. Once again a cued recall technique was used whereby participants had to learn face-name pairs and recall the name of the person when presented with the face. Both younger and two groups of older adults (one group aged 65-74, and another group aged over 74 years old) recalled significantly more popular surnames than unpopular surnames. However the magnitude of the recall advantage of popular over unpopular names was not significantly greater in older adults, that is, there was no interaction between age group and name popularity. There could be two reasons for a lack of a dissociation; first the study did not focus solely on episodic memory. Research has shown that the recall of names has a larger impact on episodic memory compared to primary/short-term memory for older adults (Semenza et al., 1996). Second, Jones & Rabbitt (1994) demonstrate that older adults show a significantly greater recall deficit for first names as opposed to surnames. James & Fogler (2007) used surnames, so the potential magnitude of the affect of popularity on recall for older adults may have been attenuated.

Research has also investigated whether age deficits in name recall can be reversed by using different mnemonic techniques. Yesavage, Rose & Bower (1983) demonstrated that age-related deficits in name recall were significantly reduced when older adults used semantic processing when studying to-be-remembered names. Recently, Troyer, Halfiger, Cadieux & Craik (2006) showed that older adults show a significant improvement in name recall when study techniques employ the levels of processing (LOP) philosophy. The results of Troyer et al. (2006) support those of Yesavage et al. (1983) in that name recall significantly increased when participants processed the name at a deeper, more semantic, LOP. Furthermore, Troyer et al. (2006) showed that participants show an increase in name recall when they use an intentional learning technique as opposed to a semantic incidental study technique[19]. This is relevant to the present study because the results show that an increase in cognitive activity (i.e. a deeper LOP) results in improved recall for names. This is similar to the natural phenomenon of changes in popularity of such names.

In summary, previous research has indicated that older adults show a recall deficit for proper names, compared to younger adults, to a greater degree than other words such as common nouns (e.g. James & Fogler, 2007). Furthermore the research has indicated that popular names are easier to recall than unpopular names (e.g. Valentine & Moore, 1995). Intervention techniques have shown that both younger and older adults recall a greater number of names when they process the names at a deeper, more semantic, level (e.g. Troyer et al., 2006). However the results are inconclusive as to whether older adults display a greater deficit for recalling unpopular names versus popular names (e.g. Jones & Rabbitt, 1994).

4.1.4 Aims and Objectives

The aim of Study Seven was to produce an analogy of the use-dependency theory using a within-subjects technique. The stimulus characteristics were first names and were manipulated on the basis of popularity (i.e. the number of babies registered with a specific name in a specific year). First names were chosen due to the fact that older adults appear to show a greater deficit in recall for first names, compared to surnames, than younger adults (Jones & Rabbitt, 1994).

An analogy of the use-dependency theory dictates that cognitive representations (e.g. first names) that have been activated more often in later life will show less cognitive atrophy than cognitive representations that have been activated to a lesser degree in later life (even though both were activated to the same high level earlier in life). For this reason a free recall task must be used, therefore the study utilised a list of names as

[19] However, the results indicated that the intentional learning technique had a greater affect on younger adults compared to older adults when studying lists of surnames.

opposed to face-name learning. This is because the use-dependency theory predicts that representations which are activated more often (e.g. the first name Thomas) will have more interconnected cognitive/neuronal networks than representations that have been activated less frequently (e.g. the first name Nigel). Therefore, face-name associations were not used due to the fact that the popular cognitive representation of names should activate similar representations which are more closely associated with one another compared to less popular cognitive representations. To clarify, if participants were presented with the name Thomas, according to the NST, all cognitive representations associated with that first name should be activated. Thus, when encountering a popular name (e.g. Thomas) there should be a greater degree of activation across cognitive/neuronal networks than when a less popular name is encountered (e.g. Cohen & Burke, 1993).

Semenza et al. (1996) showed that age-related deficits in recalling proper names have a greater impact on episodic memory than working memory; that is, older adults compared to younger adults, showed a greater primacy than recency deficit. However, no research has investigated whether the recall advantage of popular over unpopular names relies on an encoding or a consolidation difference between the names. Therefore, the study used a multi-trial technique which investigated whether the hypothesised age-related deficit in name recall was due to an encoding, consolidation or retrieval (measured by saving scores) deficit in older adults. Finally, it was theorised that, based on the NST, older adults should show a greater degree of difficulty (in terms of recall, encoding, consolidation and/or retrieval) for relearning unpopular names versus popular names compared to younger adults.

4.2 Method

4.2.1 Participants

Two groups of participants were tested separated on the basis of age. The younger group consisted of 22 participants with a mean age of 21.68 (SD = 4.13). The older sample consisted of 27 participants with a mean age of 72 (SD = 6.51). The younger sample population had a mean number of years in full time education of 15.18 (SD = 1.71) compared to the older adults with a mean number of years education of 14.63 (SD = 4.38). There was no significant difference in terms of total number of years in education between the two groups ($t = 0.557$). All older adults undertook the mini-mental state examination (Folstein, Folstein & McHugh, 1975); all scored over 27/30 indicating absence of cognitive impairment. All participants were native to England or Wales and gave informed consent.

4.2.2 Stimuli

Stimulus names were taken from Merry (1997) who provided the top 100 names in England and Wales between 1944 and 1994 in ranked order. Two pure-lists of 30 first names were created on the basis of popularity (popular versus unpopular). The popular name list consisted of first names which were ranked in the top 100 in both 1944 and 1994 (e.g. *Thomas, Catherine*). The list of unpopular names consisted of first names which were ranked in the top 100 in 1944 but not in 1994 (e.g. *Nigel, Veronica*). Any name ranked outside of the top 100 in 1994 was assigned a ranking of 101 as actual rankings for these names were not available (see Appendix 8 for full stimuli lists). A third list of 30 names was used as a practise list.

As ranked values were used in selection of stimuli the Wilcoxon rank sum nonparametric test was used. The results satisfied the analogy of the use-dependency theory, that is there was no significant difference between the popularity of names in both lists according to the 1944 data ($W = 891.50$). However there was a significant difference between the popular and unpopular names in terms of ranked popularity in 1994 ($W (1) = 465$, $Z = -7.112$, $p < 0.001$). The names were matched on length (syllables) and there was no significant difference between the popular and unpopular lists ($t = 0.417$). Both experimental name lists contain an equal number of male ($N = 21$) and female ($N = 9$) names. The name lists were presented on one sheet in size 24 Arial font. Participants were required to rate each name on a scale of 1-7 for pleasantness. This was to ensure that participants pay attention to each study item (Feigenbaum & Simon, 1962).

4.2.3 Design and Procedure

The design and procedure was identical to that in Studies Five and Six. Briefly, the study used a mixed design and the dependant variables included in the ANOVAs were intertrial recall, intertrial encoding, intertrial consolidation and retention/retrieval (as measured by saving scores). Older adults received 50% extra study and recall time (e.g. Naveh-Benjamin et al., 2003). All participants were exposed to the popular and unpopular lists of names on five consecutive occasions. After completing the rating of the name list the participants received a standard five figure distracter task before a free recall task. Participants were contacted one week later for the delayed recall task. Presentation of popular and unpopular names were counterbalanced and separated by one week.

4.3 Results

In brief, the aims of the study were threefold; first, to replicate previous research (e.g. James, 2004) which showed a recall advantage of popular over unpopular names. Second, to investigate whether this recall advantage was due to superior encoding, consolidation and/or retrieval of popular compared to unpopular names. Finally, to investigate the relationship between aging and the recall, encoding, consolidation and retrieval of names which differ in popularity. The third aim was also to produce use-dependency-like results and show a dissociation for recall of popular compared to unpopular names between younger and older participants. As in Studies Five and Six, mixed ANOVAs were used to investigate the impact of age, name popularity and number of trials on recall, encoding, consolidation and retrieval.

4.3.1 Intertrial Recall (ITR)

A 2 X 5 X 2 (Age Group x Trial x Stimulus Characteristic i.e. name popularity) mixed ANOVA was used to investigate the impact of age, number of trials and name popularity on overall intertrial recall (ITR). As Figure 4.1 illustrates recall of names increased across the five immediate recall trials, this increase was confirmed to be significant (F (4, 188) = 81.470, $p < 0.001$, $\eta^2 = 0.634$). There was also a significant main effect of name popularity on ITR (F (1, 47) = 13.659, p = 0.001, $\eta^2 = 0.225$). As apparent in Figure 4.1 there is a recall advantage for popular names over unpopular names. The marginal means show that participants recalled 12.68% more popular than unpopular names. However there was no significant main effect of age group on ITR (F = 0.184). Unlike previous research (e.g. Jones & Rabbitt, 1994) there was no evidence of an age-related recall deficit for first names when comparing older adults to younger adults (see Figure 4.1). The results also showed no age difference between incidental recall (from the results of the practise list when participants were not aware of the recall task which followed) due to the fact that there was no significant difference between younger and older adults for name recall on the practise list (t = 1.779).

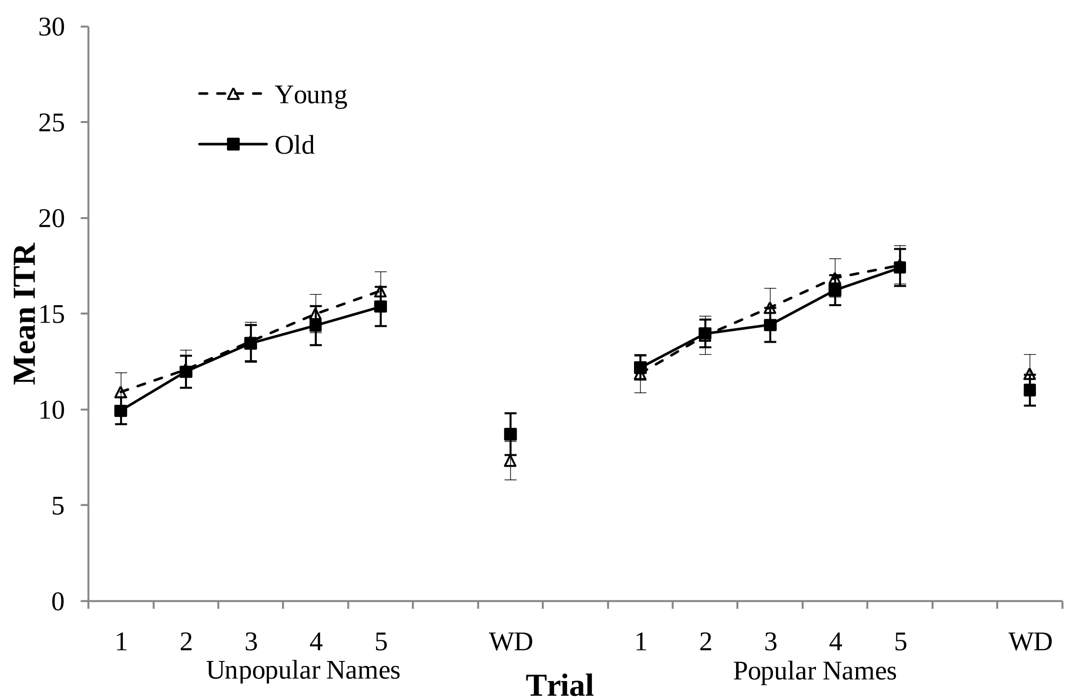

Figure 4.1. Mean Intertrial Recall (ITR) for younger and older participants studying popular and unpopular names.

In line with previous research (e.g. James & Fogler, 2007, Jones & Rabbitt, 1994) there was no significant interaction between age group and name popularity on ITR (F = 0.092). Furthermore there was no significant two-way interaction between trial and age group (F = 0.250) nor name popularity and trial (F = 0.317) on ITR. Furthermore there was no significant three-way interaction between age group, name popularity and trial on ITR ($F = 1.108$).

In summary, the results showed no significant difference in terms of recall between younger and older adults, which does not support the results of Studies Five and Six. In line with Studies Five and Six, there was a significant main effect of stimulus characteristics on recall but no two-way interaction between age and stimulus characteristics. Supporting Study Six's results, there was no three-way interaction between all factors on recall, which was evident in Study Five.

4.3.2 Intertrial encoding (ITE)

Analysis for ITE used a 2 X 5 X 2 (Age Group X Trial X Stimulus Characteristic i.e. name popularity) ANOVA, as noted in Chapter Three an encoding score was calculated for the first trial. The results showed a significant main effect of trial on ITE ($F (4, 188) = 8.085$, $p < 0.001$, $\eta^2 = 0.147$). Figure 4.2 confirms that ITE increases across trials with exception of trials 1-2. There was a main effect of name popularity on ITE ($F (1, 47) = 7.504$, $p = 0.01$, $\eta^2 = 0.134$). The marginal means show that ITE is 12.34% higher for popular compared to unpopular names. There was no significant main effect of age group on ITE ($F = 0.056$).

There was no significant two-way interaction between either name popularity and age group ($F = 0.69$), age group and trial ($F = 0.231$) or name popularity and trial ($F = 0.426$) on ITE. Furthermore there was no significant three-way interaction between all three factors on this dependent variable ($F = 1.434$).

To summarise, the results showed no significant main effects of age group on encoding. This supports the results of Study Six but not those of Study Five which showed that older adults had a significant deficit in encoding. Similar to Studies Five and Six, the present Study showed a significant effect of stimulus characteristics on encoding, but no two-way interaction with age. Mirroring the results of Study Five but not Study Six, there was no significant three-way interaction on encoding.

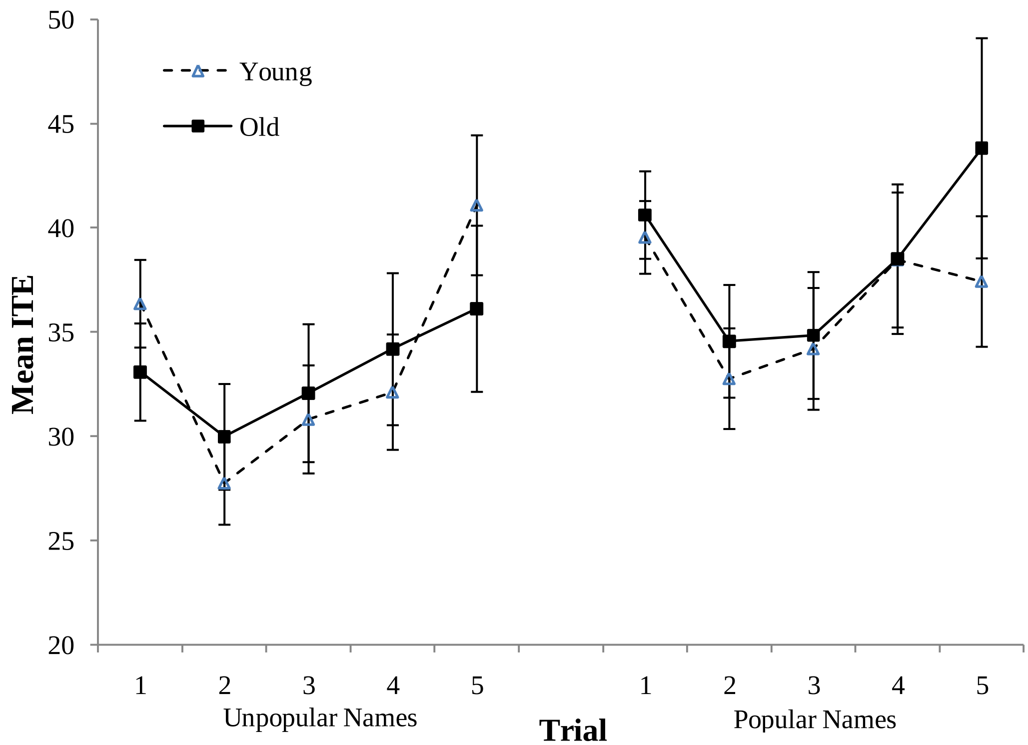

Figure 4.2. Mean Intertrial Encoding (ITE) for younger and older participants studying popular and unpopular names.

4.3.3 Intertrial Consolidation (ITC)

ITC analysis used a 2 X 4 X 2 (Age Group X Trial X Stimulus Characteristics i.e. name popularity) ANOVA. The results showed a significant main effect of name popularity on ITC ($F(1, 47) = 4.778$, $p < 0.05$, $\eta^2 = 0.092$). The marginal means indicate that popular names had a 5.67% higher consolidation score than unpopular names. There was also a significant main effect of trial on ITC ($F(3, 141) = 6.123$, $p = 0.001$, $\eta^2 = 0.115$). As illustrated in Figure 4.3 ITC increased across trials. Once again there was no significant main effect of age group, younger adults did not show a significant higher ITC than older adults ($F = 0.119$). There was no significant two-way interaction between either name popularity and age group ($F = 0.088$), trial and age group ($F = 0.162$) or name popularity and trial ($F = 0.569$) on ITC. Finally, there was no significant three-way interaction between all three factors on ITC ($F = 0.459$).

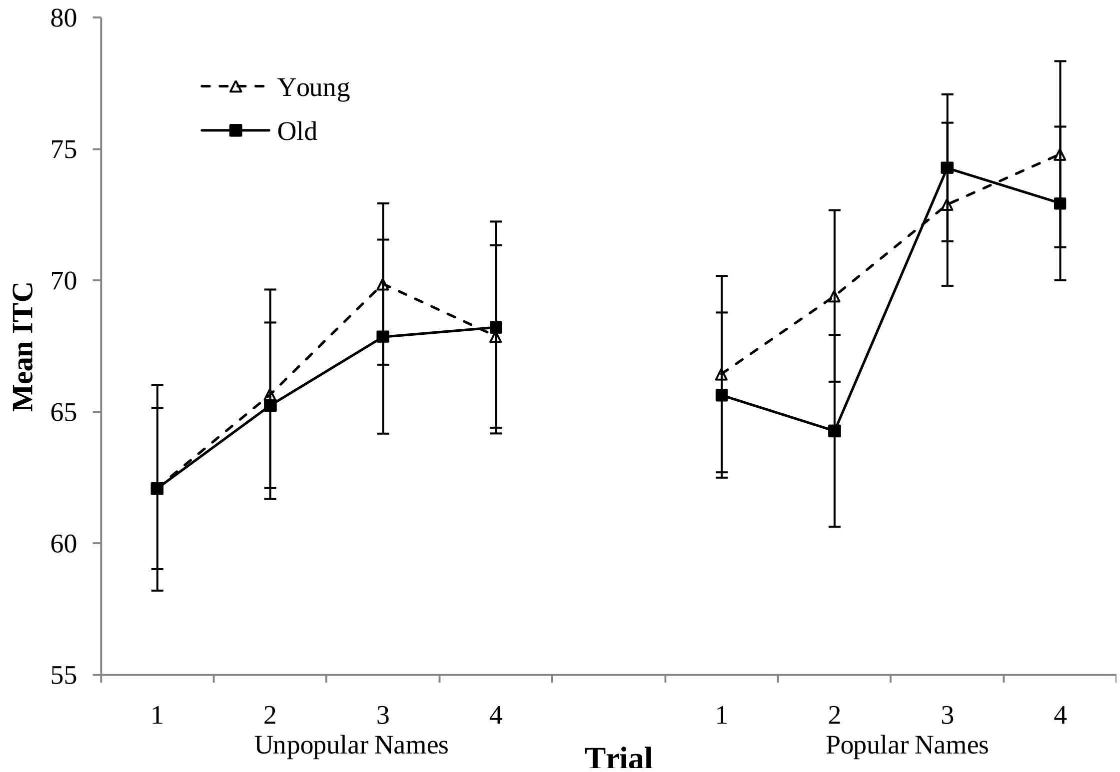

Figure 4.3. Mean Intertrial Consolidation (ITC) for younger and older participants studying popular and unpopular names.

In summary, the results do not support those of Studies Five and Six, in that younger participants did not show a significantly higher consolidation score than older participants. Furthermore, unlike Studies Five and Six, the results showed a significant main effect of stimulus characteristics on consolidation. There was neither a significant two-way interaction between age group and stimulus characteristics nor a significant three-way interaction between all factors on consolidation, which mirrors the results of Studies Five and Six.

4.3.4 Saving Scores

In line with previous research (e.g. Dunlosky & Salthouse, 1996; Chapter Three) saving scored were calculated as a measure of retrieval using a 2 X 2 X 2 (Age Group X Trial X Stimulus Characteristics i.e. name popularity) ANOVA. The results show a significant main effect of name popularity on saving scores (F (1, 47) = 7.304, $p < 0.001$, $\eta^2 = 0.134$). Marginal means confirm that there was a retrieval advantage of

17.71% for popular over unpopular names. There was also a significant main effect on trial on saving scores ($F(1, 47) = 184.064$, $p < 0.001$, $\eta^2 = 0.797$). Participants recalled more names on the final trial compared to the delayed recall trial. There was no significant main effect of age group on saving scores ($F = 0.013$). Finally there were no significant two-way or three-way interactions between all factors on saving scores. Overall, the results mirror those of Studies Five and Six with the exception that a main effect of stimulus characteristics on saving scores was found in the present study.

4.4 Discussion

The aim of Study Seven was to produce an analogy of the use-dependency theory while using a within-subjects design. The study investigated recall, encoding, consolidation and retrieval/retention of popular and unpopular first names in younger and older adults. Previous studies have shown that older adults have a significant age-related deficit in recalling proper names (e.g. James 2004). This age-related deficit appears to be greater for first names as opposed to surnames (e.g. Jones & Rabbitt, 1994) and more apparent for episodic memory rather than working memory (e.g. Semenza et al., 1996). Support for the use-dependency theory requires a dissociation between younger and older adults for recall, encoding, consolidation or retrieval/retention of popular compared to unpopular names. Previous research has not produced a great deal of support for this; however this could be due to methodological techniques or sample populations used in previous research (e.g. James & Fogler, 2007; Jones & Rabbitt, 1994). A summary of the results are shown in Table 4.1.

There was no indication that older adults showed a deficit in either recall, encoding, consolidation or retrieval/retention for first names. This does not support the majority of previous research which has shown that older adults are significantly poorer at recalling names than younger adults (e.g. James & Fogler, 2007; Troyer et al., 2006; James, 2004; Jones & Rabbitt, 1994; Cohen & Faulkner, 1986). James & Fogler (2007) and Yesavage et al. (1983) suggested that name recall can be increased when participants use a deeper LOP. Although James & Fogler (2007) did not show that older adults benefit more from a deeper LOP it is possible that the rating technique used in the current study reduced age differences in recall of names. Anecdotally older adults reported using more semantic association techniques when studying the words than younger adults (e.g. older participants reported using organisational techniques such as names of Royals to aid recall). It is also possible that the extra study and recall time that older adults received reduced the age-related deficit across all dependent variables. Although James & Fogler (2007) increased study and recall time for older adults, this was only the case during the face-name task and not the free recall task. Therefore as shown by Naveh-Benjamin, Hussain, Guez & Bar-On (2003) it is possible that age-related deficits in episodic memory recall are due to effects of processing speed rather than deficits in encoding, consolidation or retrieval.

Table 4.1 Summary of results of Study Seven

	Recall	Consolidation	Encoding	Savings Score
Age main effect	No	No	No	No
Name popularity main effect	Yes	Yes	Yes	Yes
Age X name popularity interaction	No	No	No	No
Age X name popularity X trial interaction	No	No	No	No

The results from James & Fogler (2007) also showed that there was an age difference for intentional compared to incidental learning of proper names. James & Fogler (2007) reported that younger adults appeared to recall more names when using intentional learning versus incidental learning compared to older adults. The results from Study Seven did not show any age deficit when participants were using incidental learning (i.e. on the practise list, when participants were not aware of the free recall test which followed). Therefore the results suggest that there is no age-related difference for intentional or incidental learning of first names and that age-related deficits in proper name recall evident in previous research may have been due to the fact that studies did not control for older adults decrease in processing speed. Finally the results also do not show that age-related deficits in name recall are apparent in first names or episodic memory as suggested by Jones & Rabbitt (1994) and Semenza et al. (1996).

As shown in Table 4.1 the results confirm a recall advantage of popular over unpopular proper names, which supports previous research (e.g. James & Fogler, 2007; Valentine & Moore, 1995). As suggested by the Node Structure Theory (NST; e.g. Cohen & Burke, 1993; MacKay, 1987) the results suggest that the increase activation of popular compared to unpopular names makes it easier for individuals to relearn popular names as opposed to unpopular names. Similar to the inter-item association theory of the recall advantage of high-frequency over low-frequency words (e.g. Watkins et al., 2003; Tan & Ward, 2000) it is likely that cognitive representations/neuronal networks of popular names are more closely associated with one another than representation of unpopular names. Furthermore due to the fact that cognitive representations of unpopular names, by definition, are not activated as frequently as those of popular names it is logical to assume that popular names will be easier to recall when relearned. No previous research has investigated whether this recall advantage is due to an encoding, consolidation or retrieval/retention benefit of the popular names. The results of Study Seven indicate that the effect of name popularity influences all three cognitive constructs; even though there are suggestions that popularity has a larger impact on encoding compared to consolidation (see Sections 4.3.2 and 4.3.3).

The results from the present study casts doubt on previous studies which have shown an age deficit in name recall (e.g. Semenza et al., 1996; Jones & Rabbitt, 1994). Studies which have investigated the relationship between age and facial recognition have indicated that older adults are poor at recognising younger faces, however this age-related deficit is not apparent when the age of the participants matches that of the stimulus face to-be-recognised (e.g. Wright et al., 2008; Wright & Stroud, 2002). Therefore, taking into account research such as Piolino (2002) and Rubin, Rahhal & Poon (1998) it is possible that research which has shown age-related deficits in name recall and face-name recognition (e.g. Firestone, Turk-Browne & Ryan, 2007) may have been due to the stimulus characteristics used (i.e. the names attached to the faces). That is, results such as those found by Firestone et al. (2007), Semenza et al. (1996) and

Jones & Rabbitt (1994) may have been caused by the fact that the names used were more popular for younger adults than the older adults.

Finally, opposing both the NST and use-dependency theory there was no evidence that older adults show a recall advantage of popular over unpopular names to a greater degree than younger adults (supporting James & Fogler, 2007; Jones & Rabbitt, 1994). This was also the case for the other three cognitive constructs measured (i.e. encoding, consolidation and retrieval/retention; see Table 4.1). The use-dependency theory would predict that cognitive atrophy associated with healthy aging would take a larger toll on cognitive representations which are activated less frequently (i.e. unpopular names) than those representation activated more frequently (i.e. popular names). The recall, encoding, consolidation and retrieval/retention deficits of popular versus unpopular names were not greater for older adults compared to younger adults. Due to the fact that name popularity was matched for older adults at a younger age, the use-dependency theory would predict that the decreased activation of cognitive networks representing unpopular names in later life would result in a larger impact on healthy aging on such names compared to popular names. The results show that this was not the case, however this may be due to a lack of an over all age effect on name recall, encoding, consolidation and retrieval/retention.

In conclusion, the result confirms that popular proper names were recalled better than unpopular names supporting previous research (e.g. James & Fogler, 2007; Valentine, Brennen & Brédart, 1996). However there was no evidence of an age-related deficit in overall proper name recall which is conversed to previous research (e.g. James & Fogler, 2007; Troyer et al., 2006; Jones & Rabbitt, 1994; Cohen & Faulkner, 1986). The use of a multi-trial technique has suggested that the recall advantage is arguably due to an encoding advantage of popular names, however there is evidence that compared to unpopular names, popular names are consolidated and retrieved easier. Furthermore the results did not show supporting evidence for the use-dependency theory or NST, in that, older adults did not show superior recall, encoding, consolidation and/or retrieval/retention for popular over unpopular names compared to younger adults. Therefore using a within-subjects technique suggests that there is a lack evidence for the use-dependency theory and that it is possible that previous evidence for the use-dependency theory can be attributed to methodological techniques or mediating demographic factors.

CHAPTER FIVE

CRYPTIC CROSSWORD INTERVENTION

5.1 Background

5.1.1 Introduction

Previous research has indicated that an increase in cognitive activity in later life can attenuate or reverse cognitive decline, which is a hallmark of healthy aging (see Chapter One for a review). Verghese et al. (2003) is one of a number of studies which have indicated that taking part in crosswords, amongst other cognitive activities, can attenuate decline in cognitive functioning (e.g. Salthouse, 2006; Wilson et al., 2002; Hultsch et al., 1999). Chapter Two has indicated through questionnaire techniques that there is a greater impact of cryptic crossword participation, compared to quick and in some cases general knowledge crossword participation, on self-report measures of memory functioning and cognitive awareness. Study One, in particular, indicated that attempting cryptic crosswords frequently can enable older adults to maintain a constant awareness of their cognitive functioning. Studies Two, Three, Four and Four (a) have also indicated that undertaking cryptic crosswords on a regular basis can promote metacognitive awareness and memory self-efficacy (MemSE) in adults throughout the lifespan (see Chapter Two). This is not supportive of Jopp & Hertzog (2007) who found no direct relationship between activities including doing crosswords and either self-reported memory functioning or objective measures of cognitive functioning.

Chapter Two has shown how demographic variables can mediate the impact of cryptic crosswords on perceived cognitive functioning. Previous research has not always confirmed the association between cognitive activity and cognitive decline across the whole sample population, for example, Christensen & Mackinnon (1993) showed that cognitive activity (including attempting crosswords) had a larger impact on cognitive function in adults with fewer years in full time education. The studies in Chapter Two also demonstrate that factors such as the ability to complete cryptic crosswords can impact on perceived cognitive functioning.

Interestingly, psychologists have attempted to use intervention techniques to promote cognitive functioning in older adults (see Chapter One for a comprehensive review). Some of these techniques have been based on the use-dependency theory (e.g. Tranter & Koutstaal, 2008), while others have focused on utilising mnemonic techniques to surpass the natural decline in cognitive functioning (e.g. Karbach & Kray, 2009; Draganski et al., 2006). The majority of these intervention studies have shown that training or an increase in cognitive stimulation can promote a variety of cognitive functioning in later life.

Taking into account the findings of Chapter Two and previous research such as Karbach & Kray (2009) and Tranter & Koutstaal (2008) it would be of interest to investigate whether an increase in attempting cryptic crosswords would produce a change in cognitive functioning. Previous research has suggested that cryptic crosswords require people to utilise abstract thinking and certain problem solving techniques which have been used in cognitive training programmes (Forshaw, unpublished.; Cavallini et al., 2003; Ball et al., 2002).

Furthermore, previous research (e.g. Dunlosky et al., 2007; Dunlosky et al., 2003) has shown that the process of self-testing can promote memory functioning in older adults as well as metacognitive awareness. Cryptic crossword solving requires a form of self-testing due to the fact that a standard cryptic clue has two components which need to match in order to produce the solution (e.g. Hambrick et al., 1999; Nickerson, 1977; Foreshaw, unpublished). As cryptic crosswords appear to encourage self-testing and also appear to promote cognitive awareness through the monitoring pathway of metacognition (see Chapter Two) it is therefore a natural continuation of this line of research to use cryptic crosswords in an intervention-style study. Therefore an intervention technique was used to assess the impact of regularly attempting cryptic crosswords, on various cognitive functions.

5.1.2 Addressing issues of previous research

Although many different cognitive functions show age-related decline research which has used an intervention technique has only focused on one or two specific dependent variables (e.g. Rebok & Balcerak, 1989). However recent research has indicated that an increase in cognitive activity can affect all age-related cognitive function (e.g. Tranter & Koutstaal, 2008; Willis et al., 2006; Ball et al., 2002), therefore this study took into account dependent variables which included MemSE, metacognition, verbal memory and episodic memory (recall, encoding and consolidation).

There is an issue within the field of the cognitive reserve and use-dependency theories, which questions whether an intervention technique can be effective when implemented with older adults. For example, research has provided evidence that an increase in activity is required at a relatively early age if age-related cognitive decline is to be combated (e.g. Bruandet et al., 2008; Barnes et al., 2006; Hensch, 2005; Hensch, 2002; Mortimer et al., 2003; Friedland et al., 2001). However more recent evidence supports the view that an increase in current cognitive activity throughout the later years in life can be sufficient to attenuate or reverse decline in several age-related cognitive functions (e.g. Karbach & Kray, 2009; Tranter & Koutstaal, 2008; Sturman et al., 2005). Therefore there is adequate evidence that intervention techniques aimed at older adults can have benefits in terms of cognitive functioning (e.g. Glisky & Glisky, 1999).

A further issue which needs to be addressed concerns the measures used in studies which investigate the use-dependency theory and which use intervention techniques. The relationship between cognitive activity and cognitive decline has been investigated by using self-report measures of both activity and cognitive functioning (e.g. Wilson et al., 2005; Verghese et al., 2003). However, a number of researchers have shown that self-report measures can be unreliable, especially when the sample population is restricted to older adults (e.g. Rabbitt et al., 1995; Sunderland et al., 1986). Therefore one aim of this study was to investigate whether there are similarities between objective and subjective measurements of cognitive functioning.

Jopp & Hertzog (2007) have conducted cross-sectional research and used structural equation modelling to investigate the relationship between self-reported beliefs, measures of activity and cognitive functioning. Their conclusion acknowledged that cross-sectional methodologies could not determine causation, but activities have a direct effect on objective cognitive functioning and not on MemSE. The analysis was also in recognition that some older adults will attempt certain activities which they believe will promote cognitive functioning. Therefore Jopp & Hertzog (2007) suggested that an increase in cognitive activity should not affect self-reported cognitive functioning unless the activity has a beneficial effect on actual cognitive functioning. However, this is not in support of Berry (1999) and the results of Study Four (a); that is, the results of studies in Chapter Two suggest that under taking certain cognitive activities promotes the monitoring feedback in the metacognition model of Nelson & Narens (1990). In turn, this suggests that attempting cryptic crosswords (specifically for older adults) forces the meta-level of metacognition to be reassessed, potentially independently of current cognitive functioning.

One possibility of the results obtained by Jopp & Hertzog (2007) was the categorisation of activity measures in their study. That is, as with other studies (e.g. Hultsch et al., 1999) there was no dissociation between different types of crosswords. Furthermore, the activity questionnaire took into account physical activities as well as self maintenance and cognitive activities associated with education (e.g. undertaking university classes). Although the distinction of activities were conducted with factor analysis it is likely that the paring of certain activities (e.g. attempting crosswords under the category of playing games) was inappropriate. The fact that Jopp & Hertzog (2007) used structural equation modelling but did not include the number of years in education as a potential mediating factor is also questionable, especially when they included activities such as attempting university courses as cognitive activities. Thus, it could be argued that the measures of activity (specifically cognitive activity) are unrepresentative in Jopp & Hertzog (2007) study, this is especially the case when taking into account measures of cognitive activity reported by Salthouse (2006). Salthouse (2006; Salthouse et al., 2002) have shown how attempting crosswords has been rated as one of the most cognitively intensive activities and therefore arguably cryptic crosswords should not have been categorised in the factor that Jopp & Hertzog (2007) defined as 'games'.

Furthermore the current study will take into account the actual completion rates of each cryptic crossword a participant attempts and ensure that the participants attempt cryptic crosswords for one hour per day. This will reduce the unreliability of self-report measures of cognitive activity. Even though previous research has attempted to measure the participation in activities such as crosswords (e.g. Barnes et al., 2006) there has not been an independent measure of crossword completion over a longitudinal period. Chapter Two has indicated that cryptic crossword completion ability can have an affect on self-reported memory functioning, however this needs to be verified by objective measures of completion rates.

Previous research has been relatively inconclusive as to whether an intervention has a larger impact on either subjective or objective measurements of cognitive functioning. For example, in a meta-analysis of memory training interventions Floyd & Scogin (1997) concluded that interventions have a significantly larger effect on objective rather than subjective measurements of memory functioning. However, other research has shown a significant change in subjective measurements of memory without any evidence for a change in objective memory measurements (e.g. Rapp et al., 2002). Therefore this study will examine whether the current intervention technique produced a change in subjective and objective measures of cognitive functioning or showed a dissociation between the two dependent variable outcomes.

The relationship between cognitive activity and self-reported or objective measures of cognitive functioning is relatively ambiguous in cross-sectional studies. For example, Jopp & Hertzog (2007) showed correlations between most cognitive activities (e.g. using technology, taking educational classes, playing games) and objective measures of overall cognitive function (e.g. verbal fluency), however only certain cognitive activities were significantly important to cognitive self-reported measures of memory functioning and metacognition. It is also apparent that the relationship between activity, self-referent beliefs and cognition is a complicated relationship. As discussed in Chapter

One and later, it is possible that the relationship between cognitive activity and cognitive functioning is mediated by MemSE, but alternatively it is possible that the relationship between MemSE and cognitive functioning is mediated by cognitive activities (e.g. Jopp & Hertzog, 2007; Hertzog & Hultsch, 2000). Hertzog & Hultsch (2000) argued that current cognitive functioning determined the level of cognitive activity a person is comfortable to undertake. However, they also argue that some older adults will start attempting certain cognitive activities in the hope of maintaining their current level of cognition or attenuating future cognitive decline. Therefore Hertzog & Hultsch (2000) argue that self-reported cognitive functioning is a by-product of the two-way relationship between cognitive activity and current cognitive functioning that is, if an individual is undertaking crosswords for example to enhance their current cognition then their MemSE could be relatively high because they are able to complete the crosswords or relatively low because they become more aware of their current cognitive failures. Conversely a person may have been attempting crosswords for sixty years and feel confident about their cognitive ability (i.e. have a high MemSE) but not realise that their cognitive functioning is deteriorating because they are not doing different cognitive activity which would challenge their cognitive functioning.

The only way to assess the relationship between self-reported and objective measures of cognitive functioning with regard to activity is through a longitudinal intervention. Furthermore, the activity used to increase cognition in the intervention study must be an everyday activity that represents a common activity which all older adults can undertake independently of physical fitness (e.g. Wilson et al., 2007). Carlson et al. (2008) attempted to use an everyday activity in a longitudinal intervention for older adults to investigate the impact on memory and executive functioning. Unfortunately no measures of MemSE were taken which did not allow the analysis of the relationship between self-reported and objective measures of functioning. The results showed that the everyday activity (helping primary school children to read, reduce conflicts and organise a library) was only effective for a sub-sample of participants who had a low executive functioning at baseline. It is questionable how cognitively demanding the intervention was and it must be acknowledged that the activity involved a physical and social component which reduces its relevance to the use-dependency theory. Therefore an intervention was needed which used a more cognitively demanding activity which did not have a physical or social activity component i.e. doing cryptic crosswords.

Following on from Carlson et al. (2008) a further aim of this study is to investigate the influence of demographic variables and whether these mediate the outcome of the intervention activity. For example, Schooler & Mulatu (2001) showed that there is a symbiotic relationship between cognitive activity, leisure activity, social interaction and current cognitive functioning. This research was also supported by Jopp & Hertzog (2007) who used structural equation modelling to show that demographic factors can change the impact of cognitive activity on cognitive functioning. Other studies have also demonstrated how factors such as number of years in education can interact with current cognitive activity (both in cross-sectional/longitudinal demographic research and in intervention studies). For example Christensen & Mackinnon (1993) and van Hooren et al. (2007) showed how the impact of cognitive activity can be affected by the number of years in education that a person has. Jopp & Hertzog (2007) and Hultsch et al. (1999) also showed a direct relationship between novel information processing and cognitive functioning in later life, therefore a further aim of this study is to investigate whether undertaking cryptic crosswords on a frequent basis has a larger impact on participants who are not used to attempting cryptic crosswords and are therefore undertaking a novel information processing activity.

Recent research has attempted to address the relationship between cognitive activity and cognitive decline by using intervention activities which are more closely associated with everyday leisure activities (such as word games and crosswords; e.g. Tranter & Koutstaal, 2008). Indeed, previous intervention studies which have used more laboratory-based activities have failed to show that cognitive benefits of the intervention can be transferred to everyday functioning (e.g. Ball et al., 2002). It is relevant to note that in a follow-up to Ball et al. (2002), Willis et al. (2006) showed that reasoning training had a significant impact on everyday functioning while more laboratory-based training techniques such as mnemonics and speed of processing did not show benefits in everyday functioning. The reasoning based technique had activities which one could draw analogies with completing cryptic crosswords, specifically logic tasks which have been used in other intervention studies and proved successful (e.g. Tranter & Koutstaal, 2008). Therefore an intervention, similar to that of Tranter & Koutstaal (2008) which is based around leisure activities would be a more realistic use-dependency based intervention.

5.1.3 The relationship between cognitive activity and metacognition

Previous research has suggested that MemSE is important in aging due to its role in mediating metacognition. However there is an alternate explanation of the association between cognitive activity and cognitive decline which is centred around the relationship between MemSE and metacognition (see Chapter One for full details; Jopp & Hertzog, 2007). To recap, unlike Bandura (1989) who believed that the promotion of MemSE can be beneficial for cognition (based on the social concept of confidence and memory ability) this thesis postulates that a significant amount of cognitive decline associated with healthy aging is due to overconfidence in cognitive abilities of older adults. Metacognition can only function adequately if one tests one's cognitive functioning regularly. For example, Dunlosky et al. (2003) demonstrated how self-testing can enhance cognitive functioning in older adults. Their results show that memory performance can be enhanced when individuals are taught to self-test during the learning phase of a memory test (see also Dunlosky et al., 2007).

According to the classical theory of metacognition (e.g. Nelson & Narens, 1990) an accurate metacognitive system relies on interactions between the meta- and object-level. In Nelson & Narens' (1990) model this feedback is termed monitoring and control. As covered in Chapter One, the meta-level in Nelson & Narens' (1990) model is one's internal estimation of one's cognitive functioning. The more a person undertakes cognitive tasks the more feedback she/he will receive i.e. monitoring (e.g. Hertzog & Hultsch, 2000). However, monitoring is only valuable when the person decides on how much effort a specific task requires (i.e. control). Research has shown that older adults are significantly impaired at determining the amount of effort required for tasks which increase in difficulty (e.g. Souchay & Isingrini, 2004). There is also evidence that older adults have a deficit in the control aspect of metacognition in terms of selecting the most efficient memory strategy for an episodic memory task. For example, Rabinowitz (1989) showed that age-related deficits in episodic memory tasks can be significantly reduced by encouraging older adults to select more appropriate task-related mnemonic strategies. Furthermore, Brigham & Pressley (1988) showed that older adults, compared to younger adults, were significantly impaired when choosing the most appropriate strategies when the memory task changed. Finally, Dunlosky et al. (2007) showed how on experimenter-paced trials older adults were unable to apply new strategies to aid recall, indicating a deficit in the control pathway of metacognition. This was supported by Brehmer et al. (2008), who showed that older adults did not employ mnemonic strategies, which had been taught eleven months earlier, without being retrained. Therefore, the consensus is that age-related episodic memory deficits are a product of impaired metacognition.

The monitoring process during a cognitive functioning task is also important. For example, Roediger III & Karpicke (2006b) have shown that repeated testing can improve episodic memory performance. This is not due to repeated exposure to the same stimulus due to the fact that participants showed long term memory gains during repeated memory testing which were significantly greater than when participants were shown the stimulus repeatedly without being subjected to repeated memory tests. Furthermore, earlier research has shown that participants do not achieve significantly higher recall on single trial tests when they are allowed unlimited study time. The 'labour in vain' effect demonstrates how individuals require feedback before they can master an episodic memory test (Nelson & Leonesion, 1988). This supports the results of Dunlosky et al. (2007, 2003) that has shown that training individuals in the art of self-testing can promote episodic memory ability.

However, there is clear evidence that older adults have a deficit in monitoring during a learning trial. For example, Dunlosky & Connor (1997) and Souchay & Isingrini (2004) have demonstrated that older adults are significantly poorer at allocating study time on self-paced trials compared to experimenter-paced trials. Indeed, Souchay & Isingrini (2004) show that older adults, compared to younger adults, did not increase study time (or repetitions) during self-paced trials even though they were aware that the task requirements increased in difficulty.

It is possible that cognitive activities can promote metacognition by encouraging individuals to test their cognitive functioning more often. For example, research by Forshaw (unpublished) has shown that attempting to solve cryptic crossword clues requires individuals to repeatedly check their solutions with the clue and other solutions which fit in with certain letters. Furthermore, Forshaw (unpublished) and Nickerson (1977) explained that checking is increased during solving cryptic clues due to the fact that cryptic clues tend to have two components which will produce the same solution.

Research by Tranter & Koutstaal (2008) has used tasks which are similar in origin to cryptic crossword clues and have shown that fluid intelligence can be increased over a period of ten weeks. Previous research has shown that there is a bi-directional relationship between fluid intelligence and metacognition (Veenman & Spaans, 2004). There is also well documented empirical research which has shown that executive functioning determines the efficiency of metacognition in older adults (Souchay & Isingrini, 2004). Furthermore, Karbach & Kray (2009) have shown that training older adults in tasks associated with executive functioning can increase overall cognitive functioning in other domains.

The role of MemSE and metacognition has also been investigated in intervention techniques to examine whether gains produced by laboratory based intervention techniques can be transferred to everyday functioning (e.g. Cavallini et al., 2003). Laboratory based intervention programs have produced little evidence that gains found on tests related to the intervention training could be transferred to other empirical tests of memory (e.g. Carlson et al., 2008) or everyday functioning (e.g. Ball et al., 2002). According to previous studies which have used an increase in MemSE to produce an increase in memory performance (e.g. Rebok & Balcerak, 1989), the ability to transfer this newly developed skill to a different task requires enhanced metacognitive abilities (Kimball & Hollyoak, 2000). Kimball & Hollyoak (2000) also suggest that the ability to transfer the newly acquired skill is also reliant on executive functioning. Therefore it is logical to assume that undertaking cognitive activities stimulates the executive functioning and metacognitive abilities of individuals, and that these systems, in turn, are necessary to be able to transfer any skill (developed through the cognitive activity) to other similar cognitive activities or functions (e.g. a JOL task).

Therefore, it is logical to assume that intervention techniques such as the one employed by Tranter & Koutstaal (2008) show that cognitive activity increases fluid intelligence through mediating executive functioning and MemSE, which in turn mediates metacognition (e.g. Jopp & Hertzog, 2007). However, the results are inconclusive for example Dellenbach & Zimprich (2008) have shown that there is a significant correlation between typical intellectual engagements (TIE) and crystallised intelligence but not fluid intelligence. This is puzzling as Dellenbach & Zimprich (2008) defined TIEs as activities which were very similar to those used in the intervention activities of Tranter & Koutstaal (2008). One explanation could be that there is an interaction with demographic mediating factors which neither Tranter & Koutstaal (2008) nor Dellenbach & Zimprich (2008) took into account (e.g. low previous cognitive activity or low socialisation; Jopp & Hertzog, 2007). Furthermore, it must be acknowledged that Dellenbach & Zimprich (2008) used a cross-sectional design and therefore causation between the relationship of TIEs and fluid or crystallised intelligence cannot be determined.

5.1.4 Aims and Objectives

Thus, the aim of this study is three-fold; firstly, to investigate whether cryptic crosswords change participants' subjective and objective measurements of metacognition, MemSE, verbal learning and/or episodic memory. Secondly, to uncover whether there is a significant difference between the subjective and objective dependant variables when using a within-subjects intervention approach. Finally, to investigate whether demographic variables mediated or influenced the intervention as proposed by Glisky & Glisky (1999).

5.2 Method

5.2.1 Participants

Twenty volunteers were recruited from the local community. Written consent was obtained. One participant left after baseline due to transport problems and two further participants were omitted from the analysis due to non-compliance with the crossword intervention activity. The remaining seventeen participants had a mean age of 70.4 years (SD = 5.54) and a mean number of years in education of 15.74 (SD = 3.98). All participants' mini-mental state examination (Folstein, Folstein & McHugh, 1975) scores were over 28, indicating an absence of cognitive impairment. The mean age, number of years in education, frequency of cognitive activity, final cryptic crossword completion score, socialisation score, MMSE and range of cognitive assessment scores for all participants in the study can be found in Table 5.2. The participants have been separated into two groups based on which intervention activity they completed first.

5.2.2 Materials and activities

This study used a within-subjects technique with two interventions, with each intervention running over a 6 week period (in line with previous cognitive intervention studies such as Cavallini et al., 2003; Ball et al., 2002 and Rasmussen et al., 1999). The experimental intervention investigated the effects of cryptic crossword activity on a number of objective and self-rating tests of memory and metacognition. The control activity was colouring as it was hypothesised that minimal cognitive/executive functions were required for this activity.

The cryptic crossword activity required participants to attempt three cryptic crosswords a week for a minimum of one hour a day for the 6 week period. This resulted in a minimum cognitive stimulation total of 2520 minutes compared to 540 in Ball et al. (2002), 840 in Rasmussen et al. (1999) and 450 on Cavallini et al. (2003). The colouring activity required participants to colour in an assortment of patterns for 20 minutes a day over the 6 week period. During the period of colouring activity participants were asked to refrain from doing any crosswords. The study was counterbalanced by randomly assigning participants to either begin with the crosswords (N = 8) or colouring (N= 9) intervention. Participants had a 4 week rest period before undertaking their second intervention activity.

The proportion of each crossword participants were able to complete was monitored. A cumulative score was calculated for each week then added to make a total for each participant. The study took into account the final crossword completion rate of each participant. This technique of measuring how accomplished participants were at completing the cryptic crosswords has not been taken into account in previous studies. A participant could have a final total crossword completion score ranging from 0- 1800; participants had a percentage score for each crossword they completed, therefore this figure represents the total completion rate over the six week period.

5.2.3 Cognitive assessment

Participants were required to make three visits for assessment of cognitive functioning for each intervention period. A baseline assessment was also executed two weeks prior to starting the initial intervention activity. This resulted in a total of seven visits for cognitive assessment over an eighteen week period. Table 5.1 shows the timetable for the entire intervention period.

Subjective and objective measures were taken for memory awareness, metacognition, verbal memory and episodic memory (including measures of recall, encoding and consolidation). First, regarding subjective measures, four questionnaires were used to assess MemSE (two questionnaires), metacognition and memory strategies used (Troyer & Rich, 2002), and a measure of overall cognitive confidence which is named cognitive strength (Troyer & Rich, 2002). One of the MemSE questionnaires was also taken from Troyer & Rich (2002) and focused on many different types of memory such as working memory, perspective memory, and episodic memory; this was entitled Total MemSE. Another MemSE questionnaire was adapted from Berry, West & Dennehy (1989) and specifically focused on episodic memory confidence; this was entitled Episodic MemSE

Table 5.1. Timescale of Intervention Period

Testing period	Rest	Testing period	Rest	Testing period
Baseline. One testing session	Two weeks	Intervention period one. Three testing sessions totalling six-weeks	Four weeks	Intervention period two. Three testing sessions totalling six-weeks

Regarding objective measurements of cognitive functioning there were two measurements of metacognition which both utilised judgement of learning (JOL) ratings. The first technique calculated JOL magnitude and the second rating calculated JOL gamma correlation (Goodman & Kruskal, 1954). Recall and recognition of verbal memory was measured with an adapted form of the Hopkins Verbal Learning Test (Brandt, 1991), however these results will not be presented due to no significant findings. Episodic memory was assessed by using an intertrial learning technique, adapted from Dunlosky & Salthouse (1996). Measurements of recall, encoding and consolidation were taken (see Chapter Three for full details).

5.3 Results

5.3.1 Overview

The aim of this section is to present the baseline data first, then the results of the intervention period will be presented for each cognitive assessment measured (outlined in section 6.2.3), covariate analyses will then follow each cognitive assessment section. As mentioned earlier previous studies have indicated that certain demographic factors may mediate the impact of an intervention technique, therefore this will be included in the analysis in two ways; firstly through correlational analysis to investigate any direct impact of the covariate on the specific cognitive assessment, and secondly through the use of ANCOVAs to ascertain whether the covariate mediates the impact of cryptic crosswords on the specific cognitive functioning variables. Covariates which were taken into account when conducting analysis were: number of years in education, previous total crossword activity, previous total cognitive activity, socialisation score and cryptic crossword completion rate.

5.3.2 Baseline results

Table 5.2. Demographic and cognitive assessment means scores (standard deviations) separated by order of intervention activity

	First Intervention Activity	
Mean Demographic and Cognitive Assessment scores	Crosswords	Colouring
Age	73.13 (5.72)	68.00(4.33)
Education	15.75(3.37)	15.72(4.66)
Mini-Mental State Examination	29.63(0.52)	29.67(0.50)
Socialisation	9.13(4.49)	5.78(4.02)
Total Crossword Frequency	3.5 (3.02)	2.56 (2.13)
Total Cognitive Activity	11.75(4.43)	10.89(4.51)
Final Crossword Completion Score	862.54(772.79)	742.67(609.61)
JOL correct proportion	5.22(1.10)	4.17(0.97)
JOL incorrect proportion	4.27(0.93)	3.52(0.74)
JOL Gamma correlations	0.44(0.57)	0.55(0.29)
Episodic MemSE	46.88(9.25)*	55.11(6.62)*
Total MemSE	44.25(18.10)	49.11(4.29)
Memory strategy	42.63(9.94)	37.22(13.48)
Cognitive strength	47.63(8.80)	50.33(10.56)
Intertrial recall trial 1	7.00(2.00)	8.44(1.81)
Intertrial recall trial 2	9.38(1.92)	10.11(1.45)
Intertrial recall trial 3	10.88(2.75)	11.22(1.72)
Intertrial recall trial 4	12.13(2.36)	12.11(2.15)
Intertrial recall trial 5	13.50(3.12)	12.89(2.03)
Intertrial consolidation 1	79.68(15.23)	69.95(16.71)
Intertrial consolidation 2	64.72(21.00)	66.73(13.62)
Intertrial consolidation 3	74.27(18.94)	68.77(13.62)
Intertrial consolidation 4	76.26(14.71)	73.56(7.19)
Intertrial encoding 1	35.00 (10.00)	42.22(9.05)
Intertrial encoding 2	29.95(8.54)	37.27(5.10)
Intertrial encoding 3	44.06(16.73)	45.17(10.01)
Intertrial encoding 4	40.77(11.48)	49.71(14.82)
Intertrial encoding 5	53.17(17.88)	50.31(24.19)

* Significant to 0.05 level (2-tailed)

Table 5.2 shows the demographic, covariates and cognitive assessments for individuals who were separated on the basis of first task. As demonstrated in the table the results show no significant difference in terms of age, mini-mental state assessment or any of the cognitive assessment measures with the exception of Episodic MemSE. This t-test shows that individuals who undertook the colouring intervention activity first had a significantly higher Episodic MemSE than those who did the crossword activity first ($t_{(1, 15)} = 2.13$, $p = 0.05$). Statistical analysis was needed to ensure that the typical results of metacognitive assessments and episodic memory assessment were evident in this sample population.

5.3.2.1 JOL magnitude

Table 5.2 indicates that participants gave higher Judgements of Learning values to words which they recall compared to words that they forgot (status: recalled versus non-recalled). The results of the baseline JOL magnitude test showed a significant main effect of status i.e. the JOL for correctly recalled words was significantly higher than those for incorrectly recalled words ($F_{(1, 16)} = 9.106$, $p<0.05$, $\eta^2=0.363$). Therefore it can be concluded from the JOL magnitude results that the participants display the appropriate level of metacognitive functioning.

5.3.2.2 JOL gamma correlations

As shown in Table 5.2 JOL gamma correlations are positive, this indicates that metacognitive functioning is appropriate. There was no significant difference between JOL gamma correlations for individuals who undertook the crossword or colouring intervention first ($t = 0.439$).

5.3.2.3 Intertrial learning

Table 5.2 shows the mean intertrial recall (ITR), intertrial consolidation (ITC), and intertrial encoding (ITE) for individuals who undertook the crossword or colouring intervention first. In line with Dunlosky & Salthouse (1996) ITR significantly increased across trials ($F_{(4, 60)} = 28.993$, $p<0.001$, $\eta^2 = 0.659$). There was a borderline main effect of trial on ITC ($F_{(3, 45)} = 2.718$, $p = 0.056$, $\eta^2 = 0.153$). There was also a significant main effect of trial on ITE ($F_{(4, 60)} =3.957$, $p<0.05$, $\eta^2 = 0.209$). As shown in Table 5.2 both ITC and ITE increased across trials. Furthermore, there was no significant difference of ITR, ITC or ITE between the two groups of participants.

5.3.2.4 Covariates

As mentioned earlier a number of covariates were taken into account throughout the analysis and the means can be found in Table 5.1. As the table shows, there was no significant difference of any covariate on the basis of which intervention activity participants began the study with.

Between-subjects groups were created based around the median for each covariate. These were included in the ANOVAs for each dependant variable and will be reported if they change the significance of the interactions between any of the original factors or the main effects of the intervention activity. It was important to take into account whether there was any significant difference at baseline between the between-subjects covariate groups for each dependant variable, therefore t-tests (or ANOVAs) were used to investigate this.

When participants were split on the basis of final cryptic crossword completion there was no significant difference between the two groups on the basis of the episodic MemSE questionnaire ($t = 1.935$), the total MemSE questionnaire ($t = 0.885$), memory strategies ($t = -0.564$), cognitive strength ($t = -1.212$), JOL magnitude ($t = 0.837$), JOL gamma correlations ($t = -0.067$) or intervention activity order ($t = -0.215$). However the results did show that there was a significant difference between the final cryptic crossword completion groups in the basis of intertrial recall ($F\ (1,\ 15) = 19.183$, $p = 0.001$, $\eta^2 = 0.561$), intertrial encoding ($F\ (1,\ 15) = 4.633$, $p<0.05$, $\eta^2 = 0.236$) and intertrial consolidation ($F\ (1,\ 15) = 13.575$, $p<0.005$, $\eta^2 = 0.475$). Participants who completed more of the cryptic crosswords intervention had a mean recall 23.7% higher than those who completed less of the cryptic crossword intervention. The results also show that mean encoding and consolidation was 13.88% and 25.62% higher for those who completed a greater proportion of the cryptic crosswords during the intervention period compared to those who completed a smaller proportion. This indicates that the cognitive ability associated with being able to complete cryptic crosswords is also associated with recall, encoding and consolidation in episodic memory when using an intertrial task.

5.3.3 Intervention period results

With the exception of the intertrial measures of recall, encoding and consolidation the analysis used an intervention activity (2 levels) X visit (3 levels) X first intervention activity (2 levels) ANOVA initially. Covariates were then added when deemed appropriate. Further analysis using covariates included a further between-subjects factor which always had 2 levels. The results of the subjective dependent variables will be presented first followed by the results of the objective dependent variables.

5.3.3.1 Episodic MemSE results

Figure 5.1 shows the mean episodic MemSE results. The data has been separated on the basis of first intervention activity. The figure shows that episodic MemSE appears to be lower when participants are undertaking the cryptic crossword activity compared to the colouring activity; this appears to be the case regardless as to which intervention participants began with. There also does not seem to be a large fluctuation in terms of episodic MemSE over the three visits for either intervention activity.

There was no significant main effects of either visit ($F = 1.590$) or first intervention activity ($F = 0.438$) on episodic MemSE. There was a significant main effect of intervention activity on episodic MemSE ($F (1, 15) = 5.465$, $p<0.05$, $\eta^2= 0.267$). The marginal means indicate that when participants undertook the colouring intervention activity they had a mean episodic MemSE which was 5.06% higher than when they were attempting the crossword intervention. None of the three factors produced a significant two-way or three-way interaction with one another.

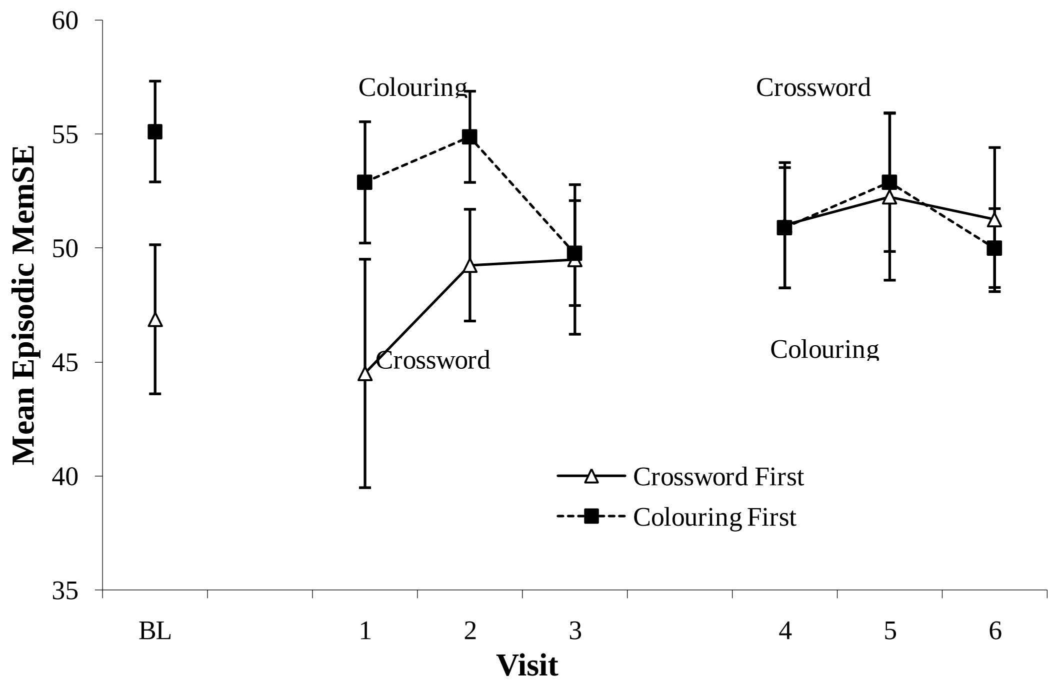

Figure 5.1 Mean episodic MemSE for individuals undertaking the crossword or colouring intervention first

To analyse whether any of the covariates have a direct impact on episodic MemSE correlations were used across all visits. The results showed none of the covariates mentioned above had a significant direct impact on episodic MemSE. ANCOVAs were used to investigate any interaction between the covariates and the original factors on episodic MemSE. The results indicated a two-way interaction between number of years in education and visit on episodic MemSE. Therefore the between-subjects factor of number of years in education was included in the original ANOVA. No notable results were found.

An ANCOVA also showed that controlling for previous total crossword activity produced a significant three-way interaction between the original three factors on episodic MemSE ($F\ (2, 28) = 5.395$, $p=0.01$, $\eta^2=0.278$). The marginal means indicate that participants who began with the crossword intervention show an increase in episodic MemSE over the six intervention visits while those who started with the colouring show a drop in episodic MemSE over the visits. Furthermore, the difference between the two groups appears greater during the earlier visits. The pattern is eventually reversed on the final visit when individuals who started with the crossword intervention report a higher episodic MemSE than those who began with colouring.

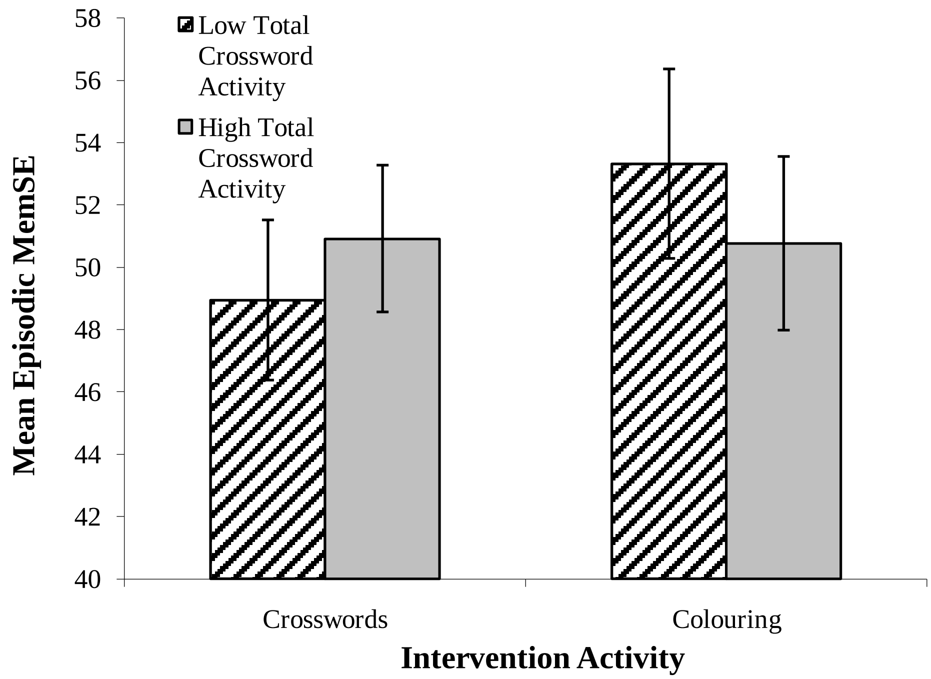

Figure 5.2 Significant two-way interaction between intervention activity and previous total crossword activity on Episodic MemSE

The between-subjects factor of previous total crossword activity was included in the original ANOVA. The factor of previous total crossword frequency interacted significantly with intervention activity ($F (1, 13) = 5.088$, $p<0.05$, $\eta^2 = 0.281$), this was the only significant interaction on Episodic MemSE. The interaction between intervention activity and previous total crossword frequency shows that individuals who regularly completed crosswords in the past did not show a great deal of variation on memory self-efficacy ratings while undertaking either cryptic crosswords or colouring. Conversely participants who reported a lower past total crossword frequency score had a lower memory self-efficacy rating while undertaking crosswords compared to when completing colouring (see Figure 5.2). These results suggest that individuals who regularly attempt crosswords have a relatively fixed memory self-efficacy (perhaps due to the theory that completing crosswords acts as a feedback around individuals to monitor their cognitive functioning). However, for those who do not complete crosswords on a regular basis it is possible that the crossword intervention enables them to gain more insight into their cognitive functioning and specifically those cognitive abilities that decline with age.

Total cognitive activity, socialisation score and final cryptic completion rate were all included in ANCOVAs separately. The results did not show any significant changes to the original main effects or interactions. This was also the case when the between-subject factors for each covariate were added to the original ANOVA. Therefore these results will not be discussed here

5.3.3.2 Total MemSE results

Figure 5.3 shows the mean total MemSE for individuals who started with either the crosswords or colouring intervention activity. The figure does not suggest that mean total MemSE changes over either intervention period for participants who attempt either the crossword or colouring intervention first. Statistical analysis was repeated for this dependent variable. The results showed no significant main effect of intervention activity ($F = 0.352$), visit ($F = 0.227$) or first intervention activity ($F = 3.224$) on total MemSE. Furthermore, there were no significant two-way or three-way interactions between any of the factors.

Correlational analysis showed that none of the covariates, with the exception of final cryptic crossword completion rate, had a significant direct impact on total MemSE. Final cryptic crossword completion rate had a significant negative correlation with total MemSE at baseline and when participants were undertaking their final measurements during the colouring intervention ($r = -0.523$, $p<0.05$, and $r = -0.531$, $p<0.05$ respectively). The correlation suggests that being unable to complete cryptic crosswords reduces participants' confidence in their overall memory ability[20]. With the exception of socialisation score none of the covariates affected the main effects or interactions of the original ANOVA when included in an ANCOVA or as between-subjects factors.

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[20] However, it must be noted that final cryptic crossword completion rate did not have a significant main effect when entered as a covariate or a between-subject factor.

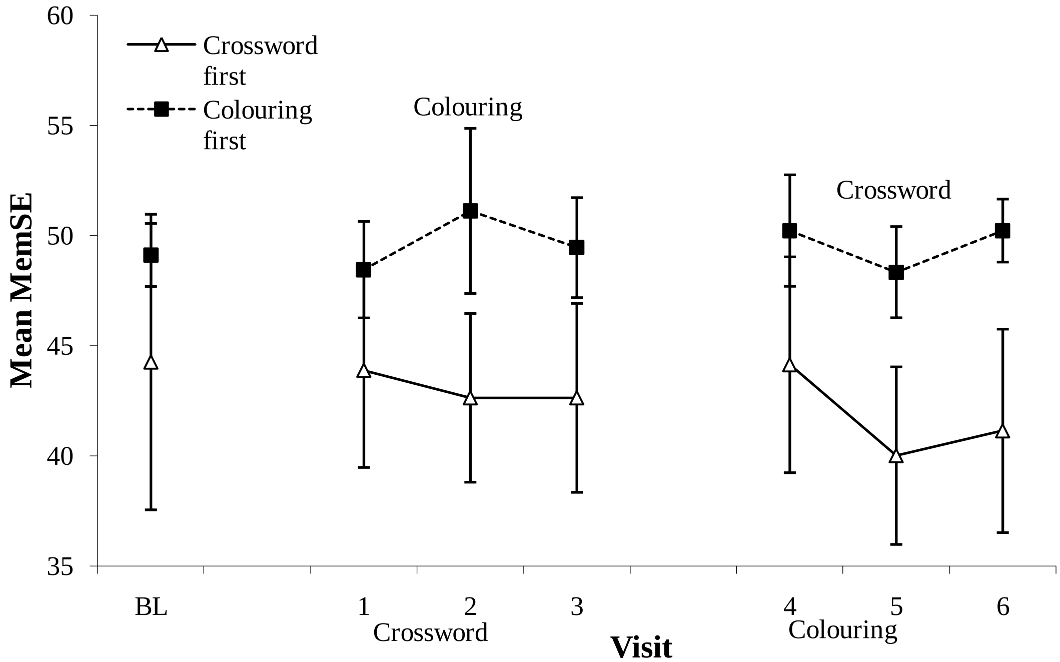

Figure 5.3. Mean MemSE for individuals undertaking the crossword or colouring intervention first

When ANCOVA analysis included socialisation score the results showed a significant main effect of first intervention activity on total MemSE ($F (1, 14) = 4.96, p<0.05, \eta^2 = 0.262$). Marginal means confirmed that participants who undertook colouring first had a Total MemSE score which was 22.96% higher on average than those who started with the crossword intervention.

The between-subjects factor of socialisation was therefore included with the original factors. The results confirmed a significant main effect of first intervention activity ($F (1, 13) = 9.393, p<0.01, \eta^2 = 0.419$). There was also a significant main effect of socialisation score on Total MemSE ($F (1, 13) = 8.999, p = 0.01, \eta^2 = 0.409$). The marginal means show that individuals with a higher socialisation score report a MemSE which is 23.52% higher than individuals with a lower socialisation score. No other noteworthy results were found.

5.3.3.3 Memory strategy results

The results showed no significant main effects of memory strategies for intervention activity (F = 0.876), visit (F = 0.892) or first intervention activity (F = 0.85). The two-way interactions between intervention activity and first intervention activity (F = 0.881), intervention activity and visit (F = 0.881), and visit and first intervention activity (F = 0.883) on memory strategies were all non-significant. Also, the three-way interaction between all three factors on memory strategies was non-significant (F = 0.883). Correlational analysis indicated that number of years in education was significantly related with a higher use of memory strategies (e.g. $r=0.527$, $p<0.05$ on the final visit during the colouring intervention). However when this covariate was included in an ANCOVA and as a between-subjects factor no notable results were found. None of the other covariates had significant correlations or change the results of the original ANOVA when entered in ANCOVAs or as between-subjects factors.

5.3.3.4 Cognitive strength results

There was no significant main effect of either intervention activity (F = 0.220) or visit (F = 2.661) on the cognitive strength dependent variable. Even though baseline results did not show a significant difference in terms of cognitive strength between those who undertook either crosswords or colouring first the intervention period showed that those who completed the colouring intervention first had a significantly higher cognitive strength throughout the whole intervention period compared to those who attempted the crossword intervention first ($F (1, 15) = 4. 830$, $p<0.05$, $\eta^2 = 0.244$). There were no significant two-way or three-way interactions between the factors on cognitive strength.

Correlational analysis showed that none of the covariates had a significant direct impact on cognitive strength. Number of years in education, previous crossword activity and total cognitive activity were included in ANCOVAs and as between-subjects factors in ANOVAs. None of these covariates changed the outcome of the original ANOVA. However, when socialisation score was entered in an ANCOVA the results showed a significant main effect of intervention activity on cognitive strength ($F (1, 14) = 5.029$,

$p<0.05$, $\eta^2 = 0.264$). The marginal means indicated that participants had a 1.10% higher cognitive strength score when they were undertaking the crossword intervention than when completing the colouring intervention. However, this result was not repeated when social score was added as a between-subjects factor. Final cryptic crossword completion rates did not affect the results when included as a covariate or a between-subjects factor.

5.3.3.5 JOL magnitude results

Tables 5.3 and 5.4 show the JOL magnitude scores for correctly recalled and incorrectly recalled words for individuals who started with the crossword intervention and the colouring intervention respectively. The table shows that JOL magnitude is always higher for correctly recalled words than incorrectly recalled words. The difference between JOL magnitude for correctly and incorrectly recalled words is known as status and is included in the original ANOVA and has two levels.

Table 5.3. Mean JOL magnitude for correctly and incorrectly recalled words (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for individuals who undertook the crossword intervention first.

	BL	V1	V2	V3	V4	V5	V6
Correctly recalled	5.22 (0.39)	4.38 (0.69)	4.37 (0.29)	3.96 (0.42)	4.31 (0.29)	4.12 (0.44)	4.33 (0.31)
Incorrectly recalled	4.27 (0.33)	3.15 (0.34)	3.27 (0.33)	3.28 (0.36)	3.8 (0.29)	3.35 (0.22)	3.74 (0.34)

Table 5.4. Mean JOL magnitude for correctly and incorrectly recalled words (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for individuals who undertook the colouring intervention first.

	BL	V1	V2	V3	V4	V5	V6
Correctly recalled	4.17 (0.32)	3.44 (0.42)	3.53 (0.24)	3.6 (0.4)	3.49 (0.28)	3.5 (0.3)	3.41 (0.25)
Incorrectly recalled	3.52 (0.25)	2.64 (0.3)	2.57 (0.28)	2.85 (0.22)	3.26 (0.5)	3.12 (0.31)	2.8 (0.26)

The results of the ANOVA showed that there was no significant main effect of visit on JOL magnitude ($F = 0.175$). There was also no significant main effect of either intervention activity ($F = 0.032$) or first intervention activity ($F = 3.832$) on JOL magnitude. Status had a significant main effect on JOL magnitude ($F(1, 15) = 57.913$, $p<0.001$, $\eta^2 = 0.794$). The marginal means confirmed that JOL magnitude for words correctly recalled was always higher than JOL magnitude of words forgotten. The results showed no significant two-way, three-way or four-way interactions for this dependant variable.

Correlational analysis did not show a direct impact of previous total crossword activity on JOL magnitude. However, when the covariate was included in an ANCOVA the results showed a significant three-way interaction between first intervention activity, intervention activity and status ($F(1, 14)= 5.364$, $p<0.05$, $\eta^2= 0.277$). The marginal means show that the difference in JOL scores for words which were correctly and incorrectly recalled was larger when participants were undertaking their first intervention activity. This indicates that individuals became over confident during their second intervention regardless of the intervention activity they were undertaking.

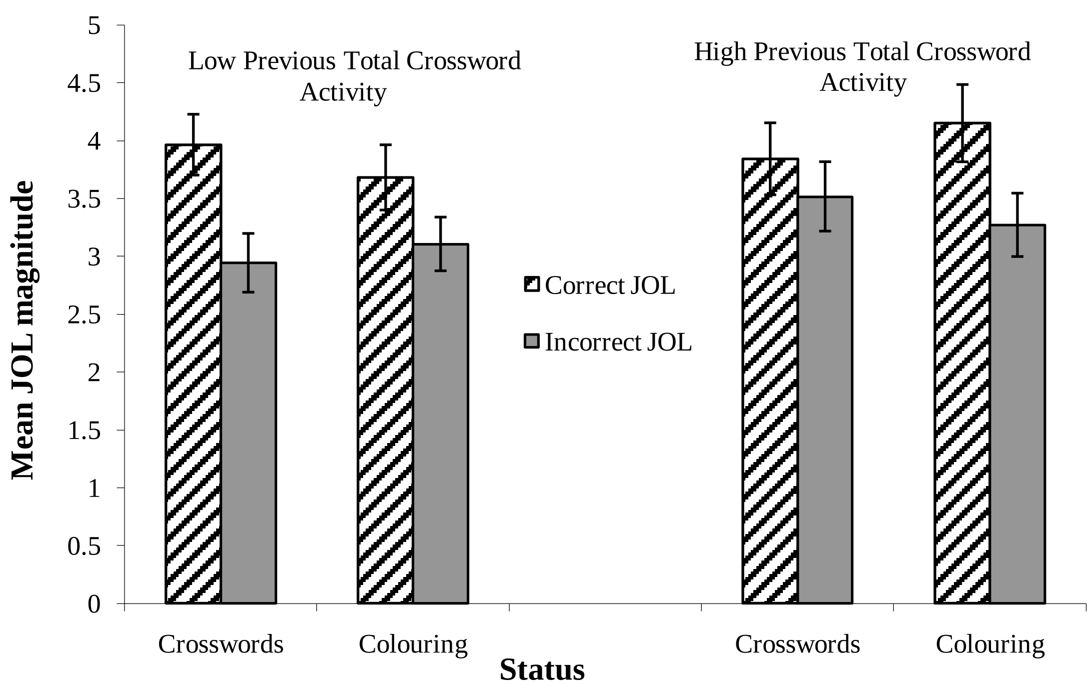

Figure 5.4 Significant three-way interaction between status, intervention activity and previous total crossword activity on JOL magnitude

As the factor of status indicates the accuracy of the JOL, only findings which include this factor will be discussed in terms of covariates. Regarding covariates, correlational analysis showed that number of years in education was significantly correlated with JOL magnitude for status on the first visit during the colouring intervention ($r=0.642$, $p<0.05$). Although the results suggest that participants who have a higher number of years in education show superior metacognition compared to those with fewer years in education this was only apparent on one visit, therefore it is questionable whether this relationship is reliable. Furthermore, there was no relationship, in terms of JOL magnitude and intervention activity, so it is possible that the correlation is unreliable. None of the other covariates showed a significant direct correlation with JOL magnitude. Both ANCOVA analysis and entering number of years in education as a between-subjects factor did not change any of the original main effects or interactions.

Previous total crossword activity was included as a between-subjects factor and the ANOVA was repeated. There was a significant three-way interaction between intervention activity, previous total crossword activity and status on JOL magnitude ($F(1, 13) = 6.489$, $p<0.05$, $\eta^2 = 0.333$). The marginal means indicate that individuals who had a low previous total crossword activity had a more accurate metacognition when they were attempting the crossword intervention activity as opposed to the colouring intervention activity. However this relationship appears to be reversed for individuals classed as having a high previous total crossword activity, that is, their metacognitive functioning appeared to be more accurate during the colouring intervention activity compared to the crossword activity. The results also suggest that the overall magnitude for words which were recalled correctly was higher for the low previous total crossword activity group when they were attempting their cryptic crossword intervention compared to the colouring intervention. This was reversed but to a smaller degree in the higher previous total crossword activity group. The results also confirm those found in the ANCOVA, that is, a significant three-way interaction between first intervention activity, intervention activity and status on JOL magnitude ($F(1, 13) = 4.864$, $p<0.05$, $\eta^2= 0.272$).

The covariate of total cognitive activity did not show a direct relationship with JOL magnitude when correlational analysis was used. Furthermore there were no noteworthy results when the covariate was included in an ANOVA or as a between-subjects factor.

This was also the case for the covariate of socialisation score and final cryptic crossword completion rate.

5.3.3.6 JOL gamma correlation results

Table 5.5 shows the mean gamma correlations across baseline and the two intervention periods for participants who started with either the crossword or the colouring intervention activity. The results show no significant main effects on JOL gamma correlations of intervention activity (F = 0.190), visit (F = 1.162) or first intervention activity (F = 0.297). There were also no significant two-way or three-way interactions for this dependent variable.

Correlational analysis shows a significant relationship between number of years in education and JOL gamma correlations when participants were undertaking the second visit during the colouring intervention ($r = 0.648$, $p = 0.005$). This indicates that participants who have a higher number of years in education display superior metacognitive abilities, however this was only apparent on one visit. The covariate was included in an ANCOVA. It yielded a significant main effect of intervention activity on JOL gamma correlations ($F(1, 14) = 6.92$, $p<0.05$, $\eta^2 = 0.331$). The marginal means show that on average participants had a JOL gamma correlation that was 9.81% higher when they were completing crosswords compared to when they were completing the colouring intervention activity.

Table 5.5 Mean gamma correlations (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for individuals who either started with the crossword or the colouring intervention

	BL	V1	V2	V3	V4	V5	V6
Crosswords	0.44 (0.22)	0.45 (0.14)	0.43 (0.11)	0.37 (0.14)	0.20 (0.12)	0.48 (0.14)	0.22 (0.08)
Colouring	0.55 (0.11)	0.39 (0.06)	0.42 (0.12)	0.20 (0.16)	0.18 (0.09)	0.30 (0.14)	0.35 (0.13)

Number of years in education was entered as a between-subjects factor. The results showed a significant two-way interaction between intervention activity and education group (F (1, 13) =11.308, $p<0.01$, $\eta^2 = 0.465$). The marginal means showed that participants who were classed as having a higher number of years in education had a mean gamma correlation which was 21.29% higher when they were attempting the colouring intervention activity compare to the crossword activity. However, individuals who were classed as having a lower number of years in education had a mean gamma correlation which was 128.1% higher when they were doing the cryptic crossword intervention activity compared to the colouring activity. This indicates that cryptic crosswords promote metacognition in individuals who have a relatively low number of years in education.

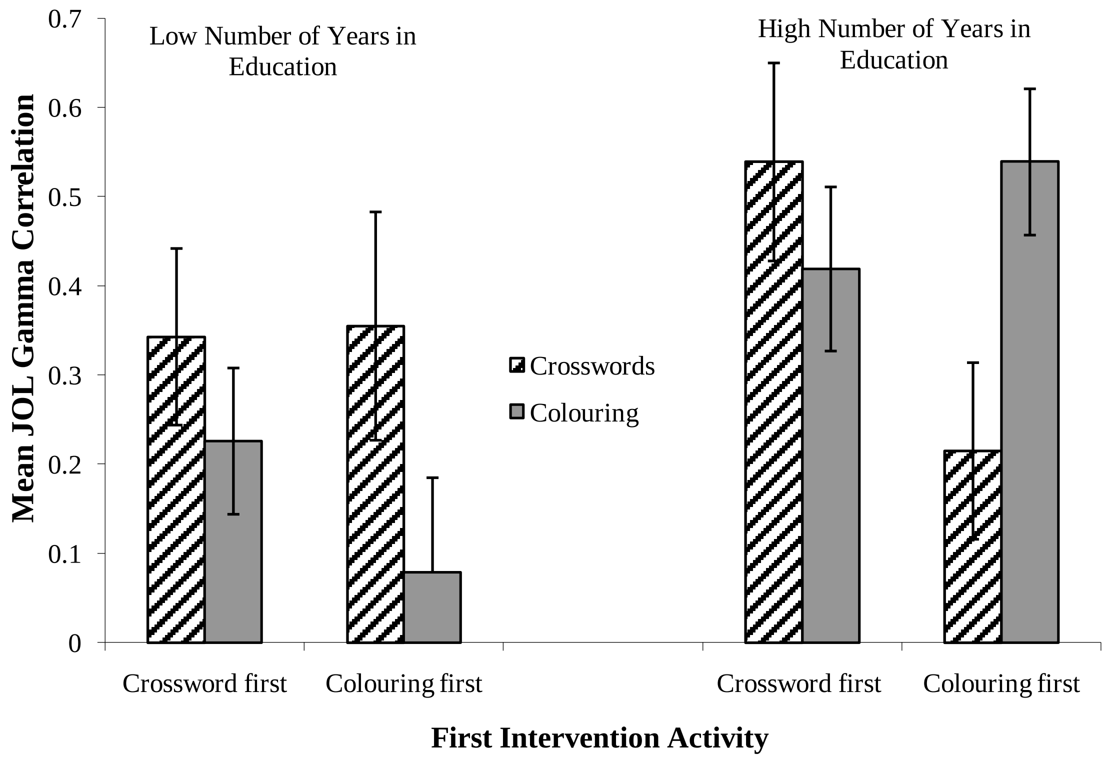

Figure 5.5. Significant three-way intervention between number of years in education, intervention activity and first intervention activity on JOL gamma correlation

There was also a significant three-way interaction between first intervention activity, number of years in education and intervention activity on JOL gamma correlations (F (1, 13) = 11.504, $p<0.01$, $\eta^2 = 0.469$). The marginal means indicate that while individuals with a low number of years in education always have a higher gamma correlation when they are doing crosswords the individuals with a higher number of years in education always have a higher gamma correlation on during their first intervention activity regardless of the intervention activity. Furthermore the results show that individuals who have a lower number of years in education tend to be less confident at predicting overall recall (for recalled and forgotten items) than those with a higher number of years in education (see Figure 5.5). Correlational analyses showed that none of the other covariates had a significant direct relationship with JOL gamma correlations. When each covariate was included in ANCOVAs and as between-subjects factors in ANOVAs separately no noteworthy results were found.

5.3.3.7 Intertrial recall (ITR) results

Table 5.6 and 5.7 show the mean ITR for participants who either started with the crossword or colouring intervention first. The within-subjects factor of trial was included in the analysis to produce a 2 x 3 x 5 x 2 ANOVA. The results showed a significant main effect of trial on ITR ($F (4, 60) = 99.126$, $p<0.001$, $\eta^2 = 0.869$). The marginal means confirmed that recall was on average 59.29% higher on the fifth trial compared to the first trial. None of the other factors produced significant main effects on ITR. There were two significant two-way interactions; firstly, between trial and visit ($F (8, 120) = 2.435$, $p<0.05$, $\eta^2 = 0.140$), and secondly, between first intervention activity and intervention activity ($F (1, 15) = 33.863$, $p<0.001$, $\eta^2 = 0.693$). The first interaction does not shed any light on the impact of either activity on ITR and the second interaction simply indicates that participants, on average, recall 12.25% more words during their second intervention period compare to their first, regardless of specific activity. There were no three-way or four-way significant interactions on ITR.

Correlation analysis showed that while participants were on their last visit during the colouring intervention there was a significant relationship between the higher number of years in education and mean ITR ($r = 0.487$, $p<0.05$). However this was not found on any other visit. The covariate was included in an ANCOVA and as a between-subjects factor in an ANOVA and no noteworthy results were found. Correlational analysis showed that neither previous total crossword activity nor total cognitive activity was significantly associated with ITR. When these covariates were included in ANCOVAs and as between-subjects factors the original ANOVA results were repeated and neither factors produced a significant interaction with the original factors.

Table 5.6 Mean ITR (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for participants who began with the crossword intervention activity

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
BL	7.00 (0.71)	9.38 (0.68)	10.88 (0.97)	12.13 (0.83)	13.50 (1.10)
V1	7.50 (1.09)	10.63 (1.08)	11.38 (0.98)	12.88 (1.41)	12.63 (1.28)
V2	8.13 (1.49)	10.63 (1.08)	12.13 (1.19)	13.63 (0.94)	13.63 (1.12)
V3	7.75 (1.03)	10.50 (0.73)	12.50 (1.02)	13.25 (0.92)	14.50 (0.68)
V4	8.75 (1.08)	12.63 (1.03)	12.88 (1.13)	15.25 (0.84)	15.13 (1.09)
V5	8.75 (0.45)	12.50 (1.48)	15.50 (0.85)	15.63 (1.13)	16.00 (0.89)
V6	10.25 (1.11)	12.88 (1.52)	13.88 (1.87)	14.50 (1.43)	16.38 (1.28)

Table 5.7 Mean ITR (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for participants who began with the colouring intervention activity

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
BL	8.44 (0.60)	10.11 (0.48)	11.22 (0.57)	12.11 (0.72)	12.89 (0.68)
V1	9.11 (0.65)	10.13 (0.88)	12.56 (0.73)	13.11 (0.81)	14.33 (1.14)
V2	8.89 (0.63)	11.44 (0.75)	14.11 (0.84)	14.56 (0.58)	15.44 (0.84)
V3	8.67 (0.53)	11.44 (0.41)	12.11 (0.93)	13.67 (0.67)	15.44 (1.00)
V4	9.89 (0.92)	12.56 (0.82)	13.33 (0.76)	14.78 (0.91)	16.22 (1.04)
V5	11.11 (0.75)	13.78 (1.06)	14.89 (0.86)	16.11 (0.95)	15.89 (1.22)
V6	9.44 (0.84)	11.89 (0.87)	13.89 (0.70)	15.00 (0.78)	17.00 (0.75)

There was a significant negative correlation between socialisation score and mean ITR during the first and second visit of the crossword intervention period ($r = -0.614$, $p<0.01$ and $r = -0.515$, $p=0.01$ respectively) and on the first visit of the colouring intervention period ($r = -0.551$, $p<0.05$).These results suggest that individuals who have a higher socialisation score recall significantly fewer words on average during the intertrial tasks. Socialisation score was entered as a covariate and as a between-subjects factor but no notable results were found.

Correlational analysis confirmed the baseline findings that final cryptic completion rate was significantly related to mean ITR ($r = 0.734$, $p = 0.001$). The analysis also shows a positive relationship between final cryptic crossword completion rate and mean ITR for participants who were on their final visit during the colouring intervention ($r = 0.518$, p<0.05). These results suggest that the ability to complete cryptic crosswords is linked to superior ITR. No noteworthy were found when this covariate was included in an ANCOVA or as a between-subjects factor in an ANOVA.

5.3.3.8 Intertrial consolidation (ITC) results

Table 5.8 and 5.9 show the ITC for individuals who started with the crossword intervention activity and colouring activity. Unlike ITR there was only four levels for the factor of trial because ITC could not be calculated for the last trial, therefore a 2 x 3 x 4 x 2 ANOVA was used (see Chapter Three for explanation). There were no significant main effects of either intervention activity (F = 0.102), visit (F = 1.574) or first intervention activity (F = 0.21) on ITC. There was, however, a significant main effect of trial on ITC ($F (3, 45) = 7.336$, $p<0.001$, $\eta^2 =0.328$). Mean consolidation was 10.44% higher on the last trial compared to the first trial. Once again there was a significant two-way interaction between first intervention activity and intervention activity ($F (1, 15) = 10.192$, $p<0.01$, $\eta^2 = 0.405$). Mean consolidation was 6.93% higher during the second intervention activity. There were no other significant two-way, three-way or four-way interactions for ITC.

Table 5.8 Mean ITC (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for participants who began with the crossword intervention activity

	Trial 1	Trial 2	Trial 3	Trial 4
BL	79.68 (5.39)	64.72 (7.42)	74.27 (6.70)	76.26 (5.20)
V1	73.32 (7.38)	77.32 (4.21)	80.57 (7.59)	80.70 (5.11)
V2	78.90 (5.04)	79.02 (7.08)	85.75 (3.13)	79.90 (4.06)
V3	69.24 (6.30)	69.82 (10.86)	79.12 (5.44)	84.06 (3.82)
V4	87.40 (5.56)	76.46 (5.09)	86.34 (3.51)	84.10 (3.53)
V5	77.83 (6.01)	84.64 (4.35)	80.47 (5.26)	84.88 (4.55)
V6	69.92 (9.16)	85.43 (5.68)	84.84 (3.44)	94.49 (1.81)

Correlational analysis showed that there was no direct relationship between number of years and education and ITC. The covariate was included in an ANOVA and as a between subjects factor, but no notable results were found. The results show that previous total crossword activity was significantly inversely related to ITC when participants were undertaking the first and last visit in the crossword intervention period ($r = -0.558$, $p<0.05$ and $r = -0.571$, $p<0.05$, respectively). When the covariate was included in an ANCOVA and as a between-subjects factor in an ANOVA there was no evidence to support these correlations which indicate that participants who were more accustomed to attempting crosswords had a lower ITC when undertaking the crossword intervention activity. There was also no change to the results of the original ANOVA when this covariate was included.

There was no evidence of a direct relationship between ITC and total cognitive activity when using correlational analysis. When this covariate was included in an ANCOVA the results showed a significant interaction between intervention activity and visit ($F(2, 28) = 4.150$, $p<0.05$, $\eta^2 = 0.229$). The marginal means suggest that ITC increased across the colouring intervention period but not the crossword intervention period. However it must be acknowledged that ITC peaks during the second visit for each intervention period, therefore the results are likely to be an anomaly. The results of the ANCOVA suggested two significant three-way interactions between intervention activity, visit and total cognitive activity ($F(2, 28) = 4.446$, $p<0.05$, $\eta^2 = 0.241$) and visit, trial and total cognitive activity ($F(6, 84) = 2.315$, $p<0.05$, $\eta^2 = 0.142$). However, when total cognitive activity was entered as a between-subjects factor none of these interactions were significant. Correlational analysis did not show a direct relationship between socialisation score and ITC. Furthermore this covariate did not change the results of the original ANOVA and there were no noteworthy results when the covariate was included as a between-subjects factor.

Table 5.9 Mean ITC (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for participants who began with the colouring intervention activity

	Trial 1	Trial 2	Trial 3	Trial 4
BL	69.95 (5.57)	66.73 (4.38)	68.77 (4.54)	73.56 (2.40)
V1	62.78 (7.52)	66.38 (5.72)	78.20 (4.85)	78.68 (5.22)
V2	76.79 (4.87)	76.45 (3.58)	82.07 (2.05)	83.94 (4.74)
V3	77.16 (4.97)	70.65 (6.46)	75.67 (2.55)	81.86 (4.08)
V4	74.18 (5.75)	82.16 (3.40)	81.11 (3.99)	83.02 (5.50)
V5	81.03 (3.67)	83.66 (3.01)	87.49 (4.29)	79.98 (5.84)
V6	80.13 (4.35)	77.43 (2.04)	83.80 (3.42)	88.80 (3.44)

The correlation results confirm the positive relationship between final cryptic crossword completion rate and mean ITC, however this was only evident at baseline ($r = 0.746$, $p=0.001$). It is unclear why this relationship was not apparent across the entire intervention period since final cryptic crossword completion was a post-hoc calculation. However, the results of the ANCOVA also suggested that final crossword completion rate had a significant main effect on ITC ($F (1, 14) = 4.788$, $p<0.05$, $\eta^2 = 0.255$). Controlling for final cryptic completion rates did not any results of note. This was also true when the covariate was included as a between-subjects factor in an ANOVA.

5.3.3.9 Intertrial Encoding (ITE) results

The mean ITE for participants who started with the crossword or colouring intervention activity are illustrated in Tables 5.10 and 5.11 respectively. A 2 x 3 x 5 x 2 ANOVA included the within-subjects factor of trial to analyse the ITE results (see chapter 2 for justification). There was a significant main effect of trial on ITE ($F (4, 52) = 10.062$, $p<0.001$, $\eta^2 = 0.436$). The marginal means show mean ITE was 17.58% higher on the last trial compared to the first trial. There were no other significant main effects on this dependent variable. The only significant two-way interaction on ITE was between the factors of intervention activity and first intervention activity ($F (1, 13) = 6.664$, $p<0.05$, $\eta^2 = 0.339$). On average ITE was 9.48% higher during the second intervention period compared to the first. There were no other significant three-way or four-way interactions.

On the last visit for the colouring intervention correlational analysis indicated that there was a positive relationship between number of years in education and ITE ($r = 0.612$, $p<0.01$), however this was not apparent over any other visit. The ANCOVA which included the covariate of number of years in education showed no noteworthy results. This was also the case when number of years in education was included as a between-subjects factor and added to the original ANOVA

Table 5.10 Mean ITE (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for participants who began with the crossword intervention activity

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
BL	35.00 (3.54)	29.95 (3.02)	44.05 (5.92)	40.77 (4.06)	53.17 (6.32)
V1	37.50 (5.43)	41.86 (5.78)	37.11 (7.92)	43.21 (7.97)	44.07 (13.97)
V2	40.63 (7.47)	37.21 (5.58)	41.06 (7.38)	52.19 (12.10)	47.92 (10.75)
V3	38.75 (5.15)	46.27 (5.70)	50.28 (4.34)	45.15 (7.18)	47.88 (9.96)
V4	43.75 (5.41)	46.02 (4.23)	42.74 (8.43)	64.86 (11.71)	58.19 (12.81)
V5	43.75 (2.27)	52.65 (10.26)	61.63 (7.04)	61.90 (16.08)	66.67 (10.29)
V6	51.25 (5.57)	55.55 (7.77)	43.68 (8.38)	52.68 (11.33)	62.02 (10.63)

Figure 5.6 shows that the pattern in terms of mean ITE is relatively similar between individuals classed as having a high or low number of years in education when they are undertaking each activity for the first two visits. However individuals with a high number of years in education show a drop in mean encoding when they are attempting the crossword intervention and an increase in mean encoding when they are doing the colouring intervention on their final visit. Individuals who were classed as having a lower number of years in education show the opposite relationship, that is a mean drop in ITE when they are attempting the colouring intervention and a slight increase in mean ITE when they are doing the crossword intervention (on the final visit).

Table 5.11 Mean ITE (standard error) for baseline (BL) and visits (V) 1-6 of the intervention period for participants who began with the colouring intervention activity

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
BL	42.22 (3.02)	37.47 (2.00)	45.17 (3.34)	49.71 (4.94)	50.31 (8.06)
V1	45.56 (3.27)	39.35 (5.23)	59.39 (4.96)	49.20 (10.17)	63.89 (8.83)
V2	44.44 (3.17)	41.58 (3.57)	63.98 (6.01)	54.44 (7.72)	63.00 (10.25)
V3	43.33 (2.64)	44.40 (4.94)	46.03 (5.13)	58.97 (7.19)	69.09 (9.26)
V4	49.44 (4.60)	53.41 (8.18)	43.58 (6.64)	61.64 (7.07)	65.74 (12.49)
V5	55.56 (3.77)	57.35 (7.94)	66.54 (6.83)	65.83 (8.46)	71.11 (13.60)
V6	47.22 (4.18)	42.52 (6.66)	62.08 (9.64)	57.90 (11.98)	78.84 (7.57)

Correlational analysis did not show any direct relationship between previous total crossword activity and ITE. The covariate did not change the original results when it was included in an ANCOVA or in an ANOVA as a between-subjects factor. There was also no direct relationship between total cognitive activity and ITE when using correlational analysis. The ANCOVA showed a significant main effect of intervention activity on ITE (F (1, 12) = 5.355, $p<0.05$, $\eta^2 = 0.309$). The marginal means showed a 2.67% higher ITE when participants undertook the colouring intervention compared to the crossword intervention. The results also indicated a significant interaction between intervention activity and total cognitive activity on ITE (F (1, 12) = 4.771, $p<0.05$, $\eta^2 = 0.284$).

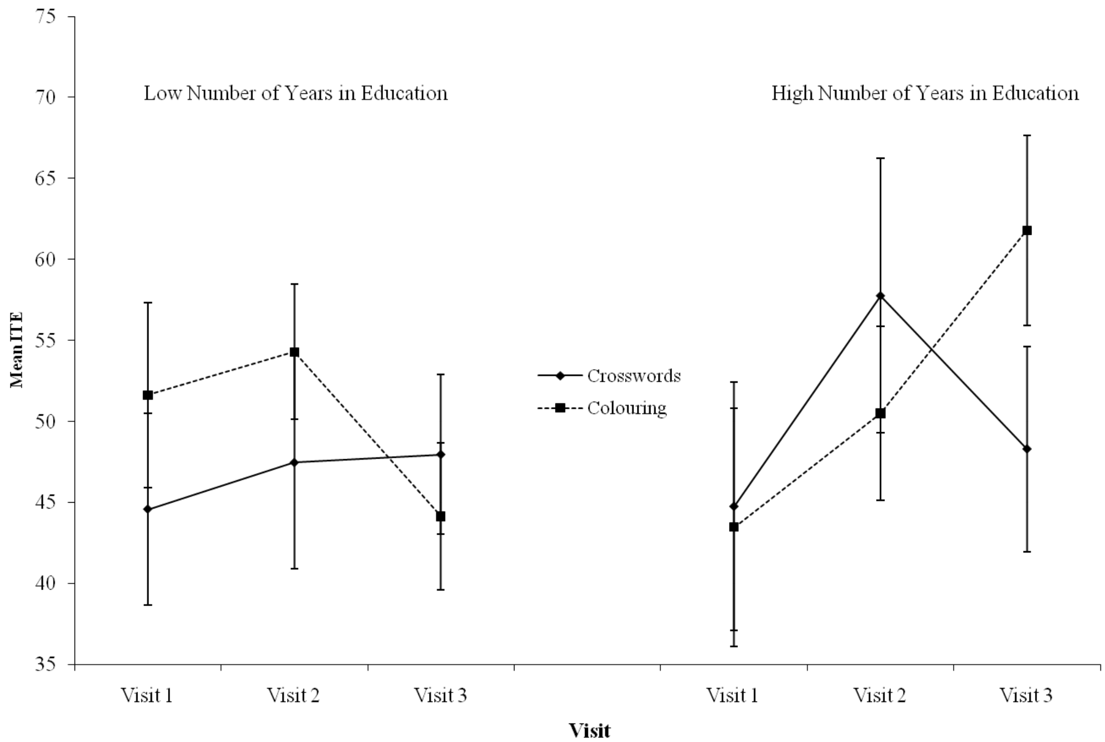

Figure 5.6. Significant three-way interaction between number of years in education, intervention activity and visit on ITE.

When total cognitive activity was included as a between-subjects factor the results confirm the significant two-way interaction between intervention activity and total cognitive activity (F (1, 11) = 7.429, $p<0.05$, $\eta^2 = 0.403$). The marginal means showed that for individuals classed as having a high previous total cognitive activity mean ITE during the crossword intervention were 24.29% higher than individuals classed as having a low previous total cognitive activity. Whereas during the colouring intervention individuals with lower previous total cognitive activity encoded on average 2.42% more during the colouring intervention than those in the high total cognitive activity group.

There was a significant three-way interaction between first intervention activity, trial and intervention activity on ITE ($F (4, 44) = 3.440$, $p<0.05$, $\eta^2 = 0.238$). The marginal means showed that encoding across trials was always higher for participant's second activity. The results also show the highest ITE was gained on trials 4 and 5 for individuals who started with the colouring intervention but while they were undertaking the crossword intervention. There was also a significant three-way interaction between intervention activity, trial and total cognitive activity on ITE ($F (4, 44) = 3.275$, $p<0.05$, $\eta^2 = 0.229$). The marginal means indicate that individuals who are classed as having a high total cognitive activity have a higher mean ITE across all trials for both intervention activities. However the results also indicate that participants who have a lower total cognitive activity show a greater ITE while undertaking the colouring intervention compared to the crossword intervention. This pattern is reversed for individuals with a higher total cognitive activity; ITE, on average, is higher when they are attempting the crossword intervention activity as opposed to the colouring activity.

There was no evidence of a direct relationship between socialisation score and ITE with correlational analysis. The ANCOVA which included socialisation score showed no notable results. When the covariate was included as a between-subjects factor there was a significant three-way interaction between socialisation score, first intervention activity and intervention activity on ITE ($F (1, 11) = 5.682$, $p<0.05$, $\eta^2 = 0.341$). Figure 5.7 shows that participants who are classed as having a low socialisation score have a higher mean overall ITE when they attempt the crossword intervention activity first, compared to the colouring activity, even though they achieve a slightly higher mean ITE while attempting the cryptic crossword intervention activity. For the high socialisation participants, mean ITE is higher when they are taking part in their second intervention, regardless of the specific activity. Furthermore this group showed a higher overall mean ITE when they start with the colouring activity compared to the crossword intervention activity.

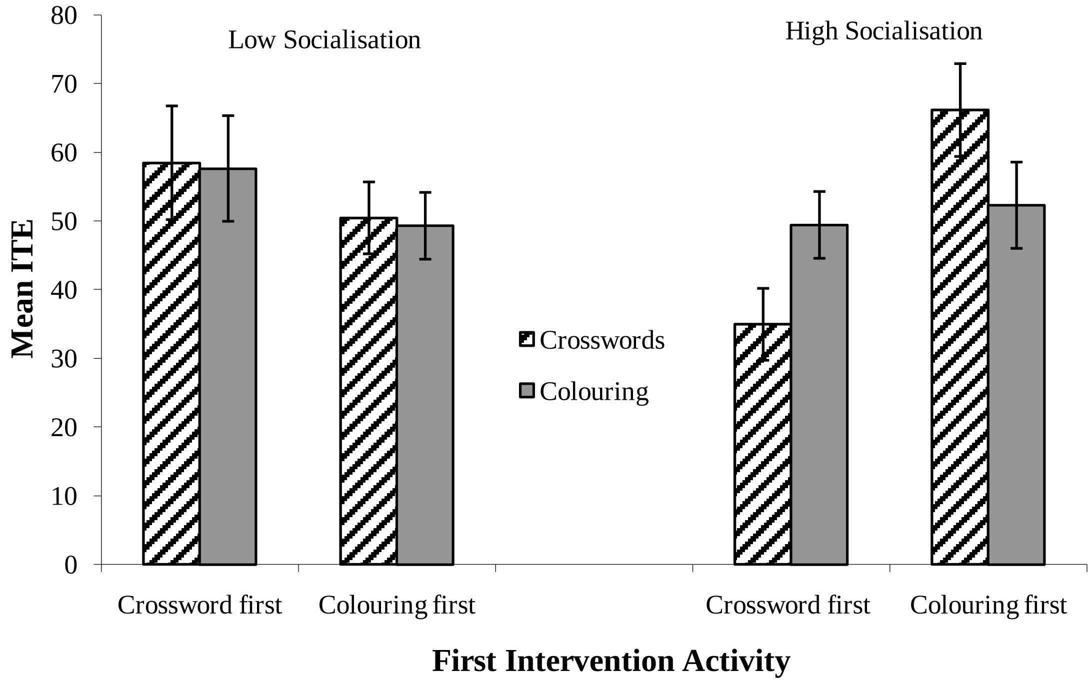

Figure 5.7. Significant three-way interaction between socialisation score, intervention activity and first intervention activity on ITE.

Socialisation, intervention activity and trial significantly interacted on ITE (F (4, 44) = 3.539, $p<0.05$, $\eta^2 = 0.243$). The marginal means suggested that for overall encoding there was almost no difference between individuals classed as having a high or low socialisation score. However ITE increased at a greater rate across trials for individuals with a higher socialisation score when they were attempting the crossword intervention activity compared to the colouring activity. For individuals with a low socialisation score the pattern was reversed but to a lesser degree; encoding across trials was slightly greater when these participants were undertaking the colouring intervention activity compared to the crossword intervention activity.

There was also a significant three-way interaction between trial, visit and intervention activity on ITE (F (8, 88) = 2.281, $p<0.05$, $\eta^2 = 0.172$). The marginal means indicate that ITE across later trials is greater on visits 1 and 2 for people who are attempting the crossword intervention activity than for individuals who are undertaking the colouring intervention activity. However, for those who are attempting the cryptic crosswords mean encoding across later trials is lower on the final visit compared to the first two visits and the last two visits for individuals who are undertaking the colouring intervention activity. There was an apparent direct relationship between final cryptic crossword completion rate and ITE for participants who were on their last visit of the colouring intervention activity ($r = 0.715$, $p = 0.001$). This covariate did not produce any results of note when included in an ANCOVA or as a between-subjects factor.

5.4 Discussion

This study aimed to investigate whether attempting cryptic crosswords on a regular basis altered cognitive performance. This study also examined whether there was a difference in terms of subjective and objective measures of cognition. Throughout the analysis demographic variables were taken into account to explore whether these variables mediated the effects of the intervention activity. Table 5.12 summarises the key findings of the results.

Table 5.12. Overview of significant main effects of cryptic crossword intervention, significant interactions between the crossword intervention and visit, and the influence of demographic variables (covariates).

	Crossword Intervention activity	Intervention activity X visit	Effects of covariates
Episodic MemSE	Yes	No	Controlling for previous total cognitive activity produced a significant interaction between visit, intervention activity and first intervention activity (see section 6.3.3.1). Significant interaction between previous total crossword activity and intervention activity (see Figure 5.2).
Total MemSE	No	No	Direct effect of socialisation score indicating a higher socialisation score associated with a higher total MemSE.
Memory Strategy	No	No	None
Cognitive Strength	No	No	Small effect of crossword intervention activity when controlling for socialisation score (see section 6.3.3.4).

JOL Magnitude	No	No	Controlling for previous total crossword activity produced a significant interaction (Figure 5.4). Also significant interaction between intervention activity, status and previous total crossword activity.
JOL Gamma correlations	No	No	Significantly higher JOL gamma correlation when controlling for number of years in education. Significant interaction between number of years in education, intervention activity and first intervention activity (see Figure 5.5). Significant interaction between number of years in education and intervention activity (see section 6.3.3.6)
ITR	No	No	Direct negative association with socialisation score. Direct positive association with final cryptic crossword completion rate.
ITC	No	No	Direct negative association with previous total crossword activity. Controlling for total cognitive activity produced significant interaction between intervention activity and visit (see section 6.3.3.8). Direct positive association with final cryptic crossword completion rate.
ITE	No	No	Significant interaction between number of years in education, visit and intervention (see Figure 5.6). Significant interaction between total cognitive activity and intervention activity. Significant interaction between socialisation score, intervention activity and first intervention (see Figure 5.7).

5.4.1 Subjective Measures

Previous research has shown that cognitive training can significantly improve subjective measures of memory and cognitive functioning (e.g. West et al., 2008; Rapp et al., 2002). Furthermore, there has shown to be a direct link between cognitive activity and self-reported cognitive functioning (e.g. Wilson et al., 2005). This study did not show a significant relationship between reported total cognitive activity, as measured by using a similar questionnaire to Wilson et al. (2005) and self-reported cognitive functioning at baseline. This is interesting as four self-report measures were used which covered episodic MemSE, global MemSE, confidence in one's own cognitive ability and the use of memory strategies. Therefore, the baseline results do not show support for either the use-dependency theory or cognitive reserve hypothesis when using self-reported cognitive activity and functioning measures. This is supportive of Jopp & Hertzog (2007) who showed no relationship between attempting activities such as cryptic crosswords and self-reported cognitive functioning when studying a cross-sectional sample population.

The intervention period also showed a lack of support for the use-dependency theory. The crossword intervention did not produce an increase or decrease in reported total MemSE, cognitive strength or the use of memory strategies. This was true when a mean was calculated over the two intervention periods for each dependent variable or when the results took into account the potential interaction with visit across each intervention period (see Table 5.12). These results do not show that interventions, training or an increase in cognitive activity is associated to an increase in overall MemSE as reported by previous researchers such as Rebok & Balcerak (1989).

However, the results do show support for the view that undertaking cryptic crosswords increases monitoring during episodic memory tasks. Table 5.12 shows that participants re-evaluate their episodic memory abilities when undertaking the crossword intervention. This supports research by Dunlosky et al. (2007, 2003) who demonstrated that self-testing (in this case undertaking cryptic crosswords) can encourage participants to reappraise their episodic memory abilities. This result is also supportive of Cavallini et al. (2003) who showed that specific cognitive intervention techniques can be more effective for one's cognitive functioning compared to another. For example, they found that different intervention techniques can have a larger impact on episodic memory ability or awareness and not affect everyday memory awareness or overall metacognition. There are two reasons why the current results show a dissociation between total MemSE and episodic MemSE; first, the intervention period is too short for any gains to be transferred to other, more general aspects of MemSE. Second, certain cognitive interventions only promote awareness of episodic memory. The second possibility is most likely because Cavallini et al. (2003) demonstrated that abilities promoted by certain cognitive interventions can be transferred to objective measures of everyday memory functioning even if participants are unaware of it. Brehmer et al (2008) also showed that in comparison to younger participants, older participants need to be encouraged to use mnemonic strategies, which had been learnt effectively eleven months earlier. This indicates that although older adults are able to improve their memory with certain strategies they are unable to initiate the strategies without environmental supports. Furthermore, older adults who develop strategies through training to develop their cognitive functioning appear to be unable to transfer the new techniques to different cognitive tasks (e.g. Ball et al., 2002).

If one assumes that the results support the view that undertaking regular cognitive activity promotes the monitoring aspect of Nelson & Narens' (1990) model, then the results indicate that older adults also have a deficit in the control aspect of the metacognition model. Specifically, there was no evidence that participants reported using more mnemonic strategies as measured by the memory strategy questionnaire (see Table 5.12). This supports the research of Brigham & Pressley (1988), which shows that older adults are significantly impaired when choosing the most appropriate memory strategy for an episodic memory task. This is also supportive of Souchay & Isingrini (2004) who demonstrated that older adults do not adjust the amount of effort they put into cognitive tasks even though they are aware that the task has increased in difficulty. Furthermore Rabinowitz (1989) had confirmed a deficit in strategy selection by showing that age-related memory deficits can be significantly reduced by encouraging older adults to choose more appropriate mnemonic strategies. The results presented in Chapter Two also support the theory that all the adults do not apply strategies, which have been developed through attempting cryptic crosswords, to other aspects of cognitive functioning.

Overall, the subject measures results show that reasonable doubt must be cast over research which has used self-report measures of cognitive activity or cognitive functioning. Unlike Bandura (1989) the results do not support the view that under taking cognitively stimulating activities promote confidence in ones cognitive abilities (e.g. MemSE). Furthermore, the results support the research of Sunderland et al. (1986)

who showed that self-report and subjective measures of cognitive appraisal can be unreliable. Hence, the current results must raise questions over the validity of previous research which has indicated a link between previous and/or current cognitive activities and cognitive functioning when using self-report measures of either variable (e.g. Wilson et al., 2005; Friedland et al., 2001; Christensen & MacKinnon, 1993). However it is important to take into account the mediating effects of demographic variables, which have been shown to influence the impact of both cognitive activity and cognitive interventions (e.g. Glisky & Glisky, 1999; Kondo et al., 1994). This is covered in Section 5.4.3.

According to Berry (1999) the relationship between cognitive activity and cognitive functioning is mediated by MemSE. However, Jopp & Hertzog (2007) have provided evidence that MemSE is a product of the interaction of cognitive activity and current cognitive functioning. Using structural equation modelling Jopp & Hertzog (2007) demonstrated that the relationship between cognitive activity and cognitive functioning is independent of beliefs about current memory ability, whereas the relationship between cognitive activity and MemSE is dependent on current cognitive functioning and the level of current cognitive activity. As testified in the next section even though older adults became more aware of their episodic memory functioning, there is no evidence that they used this increase in awareness to modify their episodic memory functioning. Due to the longitudinal nature of this study, the results suggest that the relationship between cognitive activities and cognitive functioning is not mediated by MemSE which is in support of the results of Studies Four and Four (a).

5.4.2 Objective Measures

Research has suggested that cognitively stimulating activities can produce observable change in objective measures of cognition when controlled intervention studies are conducted (e.g. Tranter & Koutstaal, 2008; Carlson et al., 2008). However the results of the current study provided no evidence to support the view that a prolonged cognitive intervention produces a significant increase in objective measures of metacognition, recall, consolidation or encoding of episodic or verbal memory. This was the case when comparing the overall means for each intervention period and when the factor of visit was taken into account.

As demonstrated in Table 5.12 there is no evidence of an improvement in cognitive functioning during the intervention period. This is not supportive of the use-dependency theory, and does not support previous research which has shown that an increase in cognitive activity through an intervention is also associated with an increase in memory functioning (e.g. Tranter & Koutstaal, 2008; Carlson et al., 2008; Willis et al., 2006; Cavallini et al., 2003; Ball et al., 2002). Furthermore, there is a lack of support for the cognitive reserve hypothesis from the baseline results. For example, there is no evidence that participants who have a higher number of years in education or who undertake more cognitive activities demonstrate superior metacognition or episodic memory abilities. This is not supportive of previous research such as van Hooren et al. (2007) or Wilson et al. (2005), which has shown that participants who report undertaking more cognitive activities and who have a greater number of years in education display improved cognitive functioning.

The results also raise questions about the link between executive functioning, metacognition and cognitive functioning. Ball et al. (2002) and Willis et al. (2006) showed how a strategic cognitive intervention promoted objective measures of episodic memory and memory awareness. According to Kimball & Hollyoak (2000) there is a link between metacognition, executive functioning and the ability to transfer newly acquired skills to other cognitive tasks (see also Karbach & Kray, 2009). Furthermore if the view is accepted that undertaking cognitive activities promotes the monitoring component of Nelson & Narens' (1990) model the results should demonstrate that undertaking cryptic crosswords on a regular basis promotes metacognition, however this was not the case (see Chapter Two). Forshaw (unpublished) shows that cryptic crossword solving involves strategic cognitive functions which can be viewed as similar to the strategic training which was effective in Ball et al. (2002) and Willis et al. (2006), but the current study has not shown that these strategic tasks (associated with attempting cryptic crosswords) are transferred and improved objective measures of metacognition or episodic memory. Once again, the results support those of Brehmer et al. (2008) who show that older adults are impaired at initiating memory strategies which they have been taught or have developed through training.

Even though the subjective measures suggest that participants became more aware of their deficits in episodic memory there was no evidence that they used this awareness to enhance their episodic memory functioning. This is not supportive of Dunlosky et al. (2007, 2003) who showed that teaching participants to self-test can counteract the age deficits in episodic memory. It is possible however, that the participants were not aware that their specific objective metacognition or recall tasks were similar to the functioning which they appeared to become aware of lacking on the episodic MemSE questionnaire. Therefore the results support the view that older adults have difficulties transferring newly acquired memory strategies or metacognitive skills to other tasks (e.g. Karbach & Kray, 2009; Brigham & Pressley, 1988).

The subjective measures of MemSE and the objective measures of metacognition support the results of Chapter Two, that is, that attempting cryptic crosswords promotes the monitoring pathways in older adults. Chapter Two suggests that older adults did not believe that attempting cryptic crosswords would be of an advantage for actual memory functioning which appears to have been supported with the objective measures of both episodic and verbal memory in this study. However, one possibility where older adults did not show an increase in memory functioning while doing the cryptic crossword intervention could be because the memory tests were experimenter-paced and not self-paced. Dunlosky et al. (2007) provided convincing evidence that self-testing (presumed to have been increased by attempting the cryptic crosswords) only enhanced memory functioning when the participants had time to self-test during the learning task. Therefore, it is not inconceivable that cryptic crosswords can increase episodic memory functioning, but only under self-paced learning conditions.

The results demonstrate the inconsistencies that have been apparent in previous research which has investigated the use-dependency theory. For example Floyd & Scogin (1997) concluded that an intervention activity is likely to have a larger impact on objective rather than subjective measures of cognition, whereas Rapp et al. (2002) concluded that it is easier to alter participants subjective views of their cognitive abilities compared to actual objective measures when conducting an intervention study. This current study supports the results of Rapp et al. (2002) with regards to the larger impact on subjective compared to objective measures of memory and cognition. Once again, in line with Jopp & Hertzog (2007) their results suggest that the relationship between cognitive activity and actual cognitive functioning is not mediated by subjective opinions of cognitive functioning as suggested by Berry (1999). In fact, the results suggest that the relationship between cognitive activity and self reported cognitive functioning is independent of actual cognitive functioning, especially with regard to episodic memory.

Overall the results from the objective measures do not show that a cognitive intervention which is based on an everyday cognitive activity (i.e. cryptic crosswords) can improve objective measures of either metacognition or episodic memory. This does not support previous research by Tranter & Koutstaal (2008) who showed that undertaking problem solving and word game activities promoted objective measures of cognition. The results support those of Rapp et al. (2002) who suggested that it is more likely to find a subjective rather than an objective change in cognitive functioning following an intervention activity. Finally the results support the view that evidence which has been provided for support of the cognitive reserve hypothesis or use-dependency theory may be due to the use of a between-subjects technique and not a direct relationship between cognitive activity and cognitive functioning/decline. Hence, supporting Jopp & Hertzog (2007) the results suggest that there is a different relationship between cognitive activity and both self-reported and objective cognitive functioning. However, unlike Jopp & Hertzog (2007) the results suggest that cognitive activity does not have a significant influence on objective measures of cognitive functioning. Therefore, in line with the conclusions of Chapter Two, the results indicate that cognitive activity promotes the awareness of cognitive functioning in older adults, these individuals do not utilise this awareness to modify their cognitive functioning.

5.4.3 Demographic Mediating Factors

Table 5.12 illustrates how demographic factors can mediate the effectiveness of a cognitive intervention. Of interest is that the results show that there is a difference in terms of the effectiveness of the crossword intervention between participants who differ on the basis of total cognitive activity or number of years in education. This is apparent on the episodic MemSE and the two objective measures of metacognition. The results show that individuals who can be classed as having a low cognitive reserve (i.e. who have fewer number of years in education or report a lower participation in cognitive activities) appear to show a significant increase in cognitive awareness when undertaking the crossword intervention activity.

In fact, the results show that both objective and subjective measures of memory awareness (particularly episodic memory awareness) are significantly improved for individuals who can be classed as having a low cognitive reserve. This supports the research by Christensen & Mackinnon (1993) which showed that cognitive decline was significantly lower in individuals who were highly cognitively active but who had a relatively low number of years in education compared to those who were both cognitively inactive and had a low number of years in education. The results also support those of Carlson et al. (2008) who showed that an everyday cognitive intervention had a significant impact on participants who have been classed as being at risk of cognitive decline due to demographic factors (e.g. Van der Bij et al., 2002).

There is also some evidence that the crossword intervention can be beneficial for objective measures of encoding for participants classed as having a low cognitive reserve. For example Figure 5.6 shows that over the intervention period ITE increased for participants who had fewer years in education when they were attempting the crossword intervention and ITE decreased for these participants when they were attempting the colouring intervention. This pattern was reversed for individuals who had a higher number of years in education.

However, the results did not demonstrate that the crossword intervention promoted objective measures of episodic memory functioning in individuals who could be classed as having a low cognitive reserve. In fact, the results showed that individuals who reported a higher total cognitive activity showed a significant increase in ITE while undertaking the crossword intervention, which was not evident for participants who reported a lower total cognitive activity. This pattern is reversed for the colouring activity, that is, participants who are classed as having a lower total cognitive activity show a higher ITE than those who have a higher total cognitive activity classification. This is supportive of Bissig & Lustig (2007) who demonstrated that intervention techniques appear to be more effective for individuals who display a higher level of cognitive functioning[21].

Although the majority of the sample population had not undertaken cryptic crosswords before the intervention activity, the results suggested a link between the ability to complete cryptic crosswords and objective measures of episodic memory. The baseline results illustrated that the ability to undertake cryptic crossword (measured post-hoc when participants attempted the crosswords) was directly associated with both episodic memory recall and consolidation. Unfortunately it is not possible to determine the causal relationship but it is likely that the ability to solve cryptic crosswords and to complete the episodic memory tests have a number of abilities in common. Furthermore the results support the idea that processes which are required to complete cryptic crosswords are also associated with improving one's own memory abilities. It is unclear what these specific functions might be, however based on the research of Forshaw (unpublished) and Dunlosky et al. (2003; 2007) it is likely that the ability to complete cryptic crosswords involves both metacognition and executive functioning. Both metacognition and executive functioning have been shown to be critical for the transfer of cognitive training to other cognitive abilities (e.g. Kimball & Hollyoak, 2000).

However, there was no evidence to support Hultsch et al. (1999) who showed that novel information processing activities (i.e. attempting cryptic crosswords) was associated

[21] Although it must be noted that ITE is higher across both intervention periods for participants who report a higher total cognitive activity compared to those who report a lower total cognitive activity.

with higher objective measures of cognitive functioning. This does not support Park et al. (2007) who suggested that a novel activity is a more effective cognitive intervention as novel activities tend to stimulate neurogenesis more than well practised activities (e.g. Grabner, Neubauer & Stern, 2006). Furthermore, the results also showed that there is no apparent difference between those who are able to complete the cryptic crosswords and those who are less able to do so, on subjective or objective measures of cognition.

In conclusion, the results demonstrate how a within-subjects technique can be used to assess a cognitive intervention by removing demographic mediating factors. The design has also demonstrated how mediating factors which have been implicated as being almost impossible to control for (e.g. Hertzog, 2009; Jopp & Hertzog, 2007) can be analysed in the second phase of analysis. Unlike Park et al. (2007) the results suggest that individuals who have the hallmarks of a lower cognitive reserve benefit more from a realistic cognitive intervention which supports Karbach & Kray (2009). This design supports the view of Salthouse (2006; 2007) in that when mediating factors are all controlled for (i.e. using a within-subjects design) there is a distinct lack of support for the use-dependency theory. However, the results do support those of Glisky & Glisky (1999) in that an intervention could benefit a certain subgroup of older adult.

5.4.4 Conclusions

In conclusion, the baseline results do not provide any support for either the cognitive reserve hypothesis or the use-dependency theory. This is not supportive of the results of studies covered in Chapter Two of this thesis. For the entire sample population there is also no evidence for the use-dependency theory from the intervention period results. This is true for subjective and objective measures of cognition with the exception of subjective measures of episodic MemSE. The results from the episodic MemSE analysis indicate that undertaking cognitive activities, specifically cryptic crosswords, promote cognitive awareness in later life. This finding supports the view that attempting a cognitive activity on a regular basis can reinforce the monitoring component of the metacognition model proposed by Nelson & Narens (1990). However, the results also show that older adults have a deficit in the control function of this model because there is no evidence that the participants are able to use this increase in awareness to enhance their metacognitive or episodic memory abilities.

There is a disparity between subjective and objective measures of cognition. This is magnified when mediating demographic factors are included in the analysis. These results support the view of Glisky & Glisky (1999) who highlighted the fact that certain cognitive interventions will only be beneficial for individuals with specific demographic factors, for example people who have been relatively cognitively inactive or who have a lower number of years in education. This does not support Park et al. (2007) who suggested that cognitive interventions are more effective of individuals who have higher levels of cognitive functioning (e.g. those who have a greater number of years in education), however the results are in line with Karbach & Kray (2009) in that an everyday cognitive intervention appears to benefit all the adults who can be identified as at risk of low functioning. Finally, the results show the importance of not relying on self-report measures of either cognitive activity or cognitive functioning which has been the case in previous research. The results show that there is a need to use a within-subjects design and take objective measures of both cognitive activity and functioning when investigating the use-dependency theory.

CHAPTER SIX
GENERAL DISCUSSION

6.1 Overview of thesis aims

The majority of research has shown a positive correlation between cognitive activity and cognitive functioning throughout the lifespan and particularly in later life. This gave rise to the cognitive reserve hypothesis and use-dependency theory. However, it is in no way conclusive that an increase in cognitive activity (throughout life or in later life) will attenuate the cognitive decline associated with healthy or pathological aging. Methodological issues have meant that the interpretation of previous research (e.g. Jopp & Hertzog, 2007; Barnes et al., 2006; Verghese et al., 2003) is difficult. That is, further research was (and still is) needed to understand whether an increase in cognitive activity at any stage in life can reverse or slow the cognitive aging process. With regards to methodology of previous research, this thesis addressed four specific topics. These are specifically: the use of a between- versus within-subjects design, the measures of cognitive activity, the assessment of cognitive functioning and the use of questionnaire compared to intervention techniques.

6.1.1 Between-subject versus within-subject techniques

First, whether the use of a within-subjects design would provide different evidence for either the use-dependency theory or cognitive reserve hypothesis. The majority of previous research has compared two groups of participants; one who has been categorised as being active and another who has been categorised as relatively inactive (in terms of cognitive activity, in particular, but also social and physical activity). Elias & Wagster (2007) are amongst a number of researchers who have indicated that demographic factors can directly and indirectly affect the course of cognitive decline throughout the lifespan. Furthermore, certain cognitive factors (e.g. MemSE and cognitive functioning) can mediate the relationship between cognitive activity and cognitive decline, potentially in combination with mediating demographic factors. Hertzog (2009) acknowledged that it was impossible to control for every potential mediating or confounding variable when using a between-subjects technique. Therefore this thesis compared the use of a between- and within-subjects technique when investigating both the cognitive reserve and use-dependency theories.

6.1.2 Measures of cognitive activity

The second issue addressed by this thesis is related to the measure of cognitive activity. The measures of cognitive activity have varied greatly over the 30 years of investigation into the use-it-or-lose-it theory. Salthouse (2007) suggested that there is no consensus as to what constitutes a cognitive activity when investigating the relationship between cognitive activity and cognitive decline. Typically, research has used self-reported measures of cognitive activity. Not only has the type of activity varied between studies, but also the time period of undertaking the activity being measured has also varied. For example Barnes et al. (2006) investigated self-reported cognitive activity throughout the entire lifespan (starting in early childhood), whereas Dellenbach & Zimprich (2008) focussed on current cognitive activity. Furthermore, some research has taken self-reported retrospective activity measures from family members/friends of patients with dementia (e.g. Friedland et al., 2001; Kondo et al., 1995).

Both Sunderland et al. (1986) and Memon et al. (2003) have argued that older adults are less reliable with reporting facts which have occurred previously compared to younger adults. Furthermore, activity can be directly affected by preclinical dementia and other psychological disorders such as depression (e.g. Zelinski & Gilewski, 2004; Verghese et al., 2003). Salthouse (2006) has also shown how different cognitive activities require a different amount of cognitive effort, therefore it is potentially invalid to produce a composite of total cognitive activity based on self-reported measures. This is especially the case when the activity questionnaires have been developed by younger adults who may not be aware of leisure activities undertaken by older adults (Salthouse, 2007).

A further issue with a number of activity measures used to investigate the use-dependency theory is that they have either grouped cognitive activities differently (e.g. Jopp & Hertzog, 2007; Hultsch et al., 1999) or not discriminated between specific types of cognitive activity (e.g. types of crosswords). Hambrick et al. (1999) and Forshaw (unpublished) have demonstrated that the cognitive skills required to complete a cryptic crossword are different to those required to solve a general knowledge or quick crossword; and it is possible that these different skills may have a different effect on cognitive decline associated with healthy aging.

This thesis used two different measures of cognitive activity: the standard self-report technique (but separating reported frequency of different crossword types) and a manipulation of stimulus characteristics. As covered in Chapter One, Three and Four, it is likely that differences within a specific cognitive domain (i.e. language) can be used as an analogy of either the cognitive reserve hypothesis or use-dependency theory. The benefit of this is that cognitive activities (i.e. stimulus characteristic) are measured objectively and therefore removes possible confounds. An objective measurement of cognitive activity was also provided in the intervention study (Chapter Five). Participants were required to attempt cryptic crosswords on a regular basis, and an objective measure of crossword completion rate was taken. Both these methods removed the potential problem of using self-report techniques when measuring cognitive activity.

6.1.3 Assessing cognitive functioning

The third aim of this thesis was to investigate whether the use-dependency theory and/or the cognitive reserve hypothesis was more evident when using subjective or objective measures. Similar to the second aim, previous research has shown that an increase in cognitive activity has a larger impact on objective measures of cognitive functioning (e.g. Rapp et al., 2002) whereas other research has found an increase in subjective, but not objective, measures of cognitive functioning when using cognitive intervention techniques (e.g. Rebok et al., 2007; Floyd & Scogin, 1997).

If an increase in cognitive activity attenuates cognitive decline in later life, it is important to understand how this association is brought about. Berry (1999) has argued that the relationship between cognitive activity and objective measures of cognitive functioning is mediated by MemSE (subjective memory awareness). Berry (1999) states that an increase in MemSE will encourage older adults to undertake more cognitive activities and be more confident in their cognitive functioning. This is believed to be a reciprocal relationship. However, Jopp & Hertzog (2007) argued that subjective ratings of MemSE are a by-product of current cognitive functioning. They argue that as functioning declines with age, people feel less confident (i.e. have a drop in MemSE) and therefore attempt fewer cognitive activities. Jopp & Hertzog (2007) also believe that this relationship is reciprocal and has demonstrated that the relationship between cognitive activity and objective measures of cognitive functioning is independent of MemSE. Furthermore, Jopp & Hertzog (2007) showed that the relationship between MemSE and cognitive activity is mediated by current cognitive functioning.

This thesis postulates that the metacognition system is vital to understanding how cognitive activity influences cognitive functioning. Through questionnaire technique, laboratory studies and intervention technique, it was possible to investigate the relationship between different measures of cognitive activity and the relationship with both subjective and objective measures of cognitive functioning.

6.1.4 Questionnaire versus intervention techniques

Finally, previous studies have used questionnaires to identify potential cognitive activities which are negatively associated with cognitive decline in later life (e.g. Jopp & Hertzog, 2007). However, cognitive intervention studies have tended not to use these activities when formulating interventions (e.g. Smith et al., 2009). The majority of cognitive interventions appear to only be effective for the cognitive domain which has been targeted by the intervention activity (e.g. Willis et al., 2006); that is they appear to be non-transferrable to everyday functioning.

Hertzog (2009) is one of a number of researchers who have argued that there is a need to develop cost effective interventions which are based on an everyday cognitive activity. By doing this, the intervention will not require a large investment with regards to training participants and will be widely available. This thesis used questionnaire studies to identify a particular everyday activity which appeared to increase cognitive awareness in older adults. This activity (taking part in cryptic crosswords) was then used in an intervention technique using a within-subjects design (see above and Chapter Five). This enabled a comparison of subjective and objective measures of both undertaking cryptic crosswords and cognitive functioning in a number of cognitive domains.

6.2 Summary of thesis findings

Table 6.1 shows the key findings from each study which constitutes this thesis. Each study provides information which has focussed on one or more of the specific aims outlined in Section 6.1. Discussion of the key findings will follow in subsequent sections.

Table 6.1. Summary of key findings.

Study	Design	Key Findings
One	Questionnaire: Between-subjects	▪ Subjective ratings of one's own memory decline with age. ▪ Cryptic crossword frequency had a larger impact than quick or general knowledge crosswords on subjective measures of cognition (especially in older adults compared to younger adults).
Two	Questionnaire: Between-subjects	▪ Significant negative correlation between age and both MemSE and self-reported metacognition. ▪ Cryptic crosswords, in particular, positively associated with increase in cognitive awareness but not the use of cognitive strategies. ▪ When controlling for crossword completion rate, older adults who attempted more cryptic crosswords appeared to have a more realistic view of their cognitive abilities than those who attempted fewer such crosswords.

Three	Questionnaire: Between-subjects	▪ MemSE decreases with age. ▪ Cryptic crosswords promote self-reported cognitive awareness and MemSE in the whole sample population. ▪ Compared to the younger adults, older adults who attempt more cryptic crosswords believe that such crosswords promote cognitive awareness, which is not the case for general knowledge crossword frequency.
Four	Questionnaire: Between-subjects	▪ Older adults reported giving up attempting cryptic crosswords more than younger adults. ▪ Proportion of one's life spent attempting cryptic crosswords and perceived ease of cryptic clues were positively associated with episodic MemSE in older but not younger adults. ▪ Participants who had given up cryptic crosswords had a significantly lower episodic MemSE than those who still attempted cryptic crosswords. This was more evident in older than younger adults. ▪ Reading cryptic clues appeared to cause older adults to re-evaluate their memory functioning.
Four (a)	Questionnaire: Between-subjects	▪ For older adults, attempting cryptic clues before taking an episodic MemSE test resulted in significantly lower MemSE compared to the opposite (i.e. doing the MemSE test before attempting cryptic clues). ▪ This relationship became more apparent when taking into account participants' abilities to solve the clues, but only when participants attempted the clues before the MemSE test. ▪ The results support the theory that attempting cryptic crosswords promotes the monitoring facet in metacognition.

Five	Experimental: Mixed (between-subjects for age groups and within-subjects for stimulus characteristics/cognitive activity, specifically high- versus low-frequency words)	▪ Older adults showed significantly poorer recall, encoding and consolidation (but not retention/retrieval) than younger adults. ▪ High-frequency words were recalled and encoded significantly better than lower-frequency words for the whole sample population. However there was no significant difference for consolidation or retention/retrieval of high- or low-frequency words. ▪ Recall, encoding, consolidation and retention/retrieval of low-frequency words did not occur at a different rate across trial for younger and older participants. However, older adults showed a significantly greater recall of high-frequency words, across the five trials, than younger adults. This was not the case for consolidation, encoding or retention/retrieval. ▪ The conclusion was that the increased activation of high- compared to low-frequency words, across the lifespan, protected the high-frequency words from cognitive atrophy associated with healthy aging. This supports the cognitive reserve hypothesis.
Six	Experimental: Mixed (between-subjects for age groups and within-subjects for stimulus characteristics/cognitive activity, specifically early- versus later-acquired words)	▪ Overall, older adults showed deficits in recall and encoding but not consolidation and retention/retrieval compared to younger adults. ▪ Early-acquired words were significantly better recalled, consolidated and retained/retrieved (but not encoded) than later acquired words. ▪ There was no dissociation in the rates that younger compared to older adults recalled, consolidated and encoded and retained/retrieved early- and later-acquired words. ▪ These results suggest that age-related decline has significant deficits for consolidation, whereas manipulation of stimulus characteristics appear to affect encoding; even though there is an overall effect of both factors. ▪ In conclusion, there is little evidence for the cognitive reserve hypothesis.

Seven	Experimental: Mixed (between-subjects for age groups and within-subjects for stimulus characteristics/cognitive activity, specifically popular versus unpopular proper names)	▪ Overall, there was no evidence that older adults recalled, encoded, consolidated or retained/retrieved fewer first names than younger adults. ▪ Compared to names which had become less popular, names which had remained popular were significantly better recalled, encoded, consolidated and retained/retrieved across the whole sample population. ▪ Between younger and older adults, there was no dissociation between the rate at which they recalled, encoded, consolidated and retained/retrieved popular compared to unpopular names. ▪ In conclusion, there is no support for the use-dependency theory when using stimulus characteristics compared to self-reported cognitive activity.
Eight	Intervention: Within-subjects	▪ Significant impact of intervention activity on subjective, but not objective, measures of episodic memory functioning. ▪ Significant impact of cognitive intervention on metacognition when taking into account possible mediating factors. This indicated that participants who can be regarded as at risk benefitted from cognitive intervention. ▪ On objective measures of episodic memory functioning certain sub-samples of participants (e.g. who differed in socialisation score, crossword completion rate, previous history of crossword activity) benefitted more from the cryptic crossword intervention.

This thesis has used both between- and within-subjects designs when investigating both the cognitive reserve hypothesis and use-dependency theory. For the whole sample population there is strong support for the cognitive reserve hypothesis when using a between-subjects technique, and some support for the use-dependency theory when using the same type of design. For example, Studies One through Four (a) showed that participants who report taking part in more cognitive activities show a greater awareness of their cognitive functioning. This has complemented the majority of previous research into both theories (e.g. Dellenbach & Zimprich, 2008; Barnes et al., 2006; Verghese et al., 2003).

However, when using a within-subjects design the results of studies in this thesis have shown no evidence for the use-dependency theory for the whole sample population. Furthermore, there is only a modicum of evidence for the cognitive reserve hypothesis when using this type of technique. However, the results of Study Eight have provided support for the use-dependency theory when comparing older adults who are regarded to be at-risk or at a higher rate of cognitive decline. Therefore, it can be concluded that evidence for the use-dependency theory, in particular, is only apparent in certain sample populations and the proposed association between cognitive activity and functioning in the general elderly population may not be as clear as previous research has suggested (e.g. Hertzog et al., 2009).

6.3 Methodological Issues

6.3.1 Between-subjects versus within-subjects techniques

When using a between-subjects design it is arguably impossible to identify a causal relationship between two factors and consider or control for every possible mediating factor or confounding variable. Thus it is very difficult to confirm a direct causal relationship between cognitive activity and cognitive decline when using a between-subjects design (Hertzog, 2009). Elias & Wagster (2007) along with King & Suzman (2009) reiterate the fact that many known (and possibly unknown) factors influence cognitive functioning in later life. Furthermore, many of these factors (e.g. education, diet, genetic makeup, stress) affect the potential impact of cognitive activity on cognitive functioning throughout life. Even though a between-subjects design can have the benefits of identifying potential factors which affect cognitive decline, a within-subjects approach would be needed to identify the causal relationship between overall or specific cognitive activity and cognitive functioning.

It is not surprising that when using a between-subjects design research has confirmed a positive relationship between cognitive activity and cognitive functioning. To recapitulate the findings from this thesis and other research (e.g. Jopp & Hertzog, 2007), many factors which are positively related to a decrease in cognitive decline in later life are also positively related to cognitive activity or education. This is the case for demographic factors (e.g. healthcare, ability to cope with stress, socioeconomic status) and other cognitive measures which are also related to objective measures of cognitive functioning (e.g. MemSE, psychological wellbeing, cerebral blood flow). To include all these factors as covariates in analysis would decrease the significance of the variance associated with cognitive activity with regards to cognitive functioning (e.g. Hertzog, 2009).

Studies Five through Eight used a within-subjects design to investigate the effect of cognitive activity on cognitive functioning in later life. For the whole sample population, there was no evidence to support the use-dependency theory and only a modicum of support for the cognitive reserve hypothesis. The key fact here is that other factors, apart from cognitive activity, appear to influence the cause of cognitive decline in healthy aging. This was also the case when considering the effects of manipulating stimulus characteristics, for example, Studies Five, Six and Seven suggested that the cognitive stimulation (associated with the comparison of recall for stimulus which varies in either frequency, AoA or popularity) was insufficient to account for the deficits in episodic memory which are empirically supported in the cognitive aging literature (e.g. Dunlosky & Salthouse, 1996).

Study Eight, in particular, demonstrated how a cognitive intervention could use a within-subjects counterbalanced design which would automatically only identify the direct relationship between the cognitive intervention activity and the cognitive functions which are measured[22]. Although the sample population was relatively small in this intervention and therefore the effect of the intervention may be more detectable when using a larger sample population, Basak et al. (2008) used a similar size experimental group and found significant effects of an everyday cognitive

[22] Assuming that demographic/mediating factors remain constant throughout the study period.

activity/intervention. It is possible that Basak et al.'s (2008) use of a between-subjects approach may have contributed to an apparent effect the intervention activity compared to the control group. However, it is also possible that either the intervention in their study was more cognitively stimulating, or that the cognitive functioning measures were easier (or less stressful) for the intervention sample to complete as they were presented via a computer, similar to the intervention activity. It is well documented that older adults are less confident at using information technology than younger adults (e.g. Salthouse, 2006).

The results of Study Eight support the findings of the questionnaire studies in that attempting cryptic crosswords increased cognitive awareness in older adults. This pattern of results was repeatedly found in Studies One through Four (a). The suggestion that cryptic crosswords could increase cognitive awareness could not be regarded as causal from the questionnaire studies due to both the between-subjects design and the cross-sectional nature, however Study Eight provided strong evidence of this causal relationship. Study Eight also confirms the result of Study Seven and provided no clear support of the use-dependency theory when using objective measures of cognitive activity and functioning (see Sections 6.3.2, 6.3.3, 6.3.4 and 6.4 for further discussion).

Studies Five, Six and Seven used a within-subjects technique and demonstrated how an analogy of the cognitive reserve hypothesis and use-dependency theory could be produced by manipulating stimulus characteristics. Although these are discussed in the next section, it is important to point out that the use of a within-subjects design has produced different results for word frequency, AoA and name popularity on recall. Specifically with regards to AoA and name popularity, the results suggest that heterogeneity between sample populations when using a between-subjects technique appear to have produced artificial effects of stimulus characteristics on recall (further discussion Sections 6.3.2 and 6.4). To clarify, when using the same multi-trial technique, the effect of age on cognitive decline has differed when measuring the effects of recall, encoding, consolidation and retrieval/retention, when different stimulus is used. There are suggestions that the variance associated with age-related cognitive decline may be shared by or even a consequence of stimulus characteristics. For example, Studies Five and Six both showed a significant effect of age on recall, however this was not evident in Study Seven even though an identical design was used. Thus, it must be concluded that the stimulus characteristics of Studies Five through Seven had a significantly different impact on younger compared to older adults.

In conclusion, between-subjects techniques have the benefit of comparing groups of participants which differ on a number of factors which appear to impact on cognitive functioning/decline. Previous research which has used techniques to compare groups of people who are classed as relatively cognitively active or inactive has indicated that cognitive activity can attenuate cognitive decline in aging. However the within-subjects technique used in this thesis has demonstrated that a difference in cognitive activity alone is insufficient to change objective measures of cognitive functioning in later life. Between-subjects designs are useful for comparing different subsamples which may represent at-risk groups. For example, participants with fewer numbers of years in education appear to benefit more from attempting cryptic crosswords. However, when investigating the effect of an intervention on the whole sample population it is necessary to use a within-subjects technique to control for mediating factors and component variables which may influence the effectiveness of the intervention. It is entirely possible that a cognitive intervention will not have a significant effect on participants who are relatively cognitively active and who have a high level of educational achievement (Hertzog, 2009), but the cognitive intervention may be very effective for individuals who are at-risk who have started to display significant cognitive decline.

6.3.2 Cognitive activity measures versus stimulus characteristics

Almost all previous research investigating the use-dependency theory and arguably the cognitive reserve hypothesis have taken a measure of cognitive, social and/or physical activity (e.g. Hertzog et al., 2009; Jopp & Hertzog, 2007; Barnes et al., 2006; Verghese et al., 2003; Wilson et al., 2002). Many of these measures are subjective and cannot be confirmed by objective measures (e.g. self-report activity questionnaires). In brief, using self-report measures of cognitive activity can be regarded as unreliable and invalid, especially in older adults (Sunderland et al., 1986). However, questionnaires and self-report techniques are critical at uncovering the relationship between specific cognitive activities and perceived cognitive functioning. For example throughout Studies One to Four, there were significantly higher correlations between cryptic crossword participation and measures of cognitive awareness, which was not the case for quick or general knowledge crosswords (see below for further discussion).

There has also been a disagreement about what constitutes a cognitive activity (Salthouse, 2006) and how cognitive activities are combined to form constructs of different forms of total cognitive activity. For example, Jopp & Hertzog (2007) included crossword participation as a game compared to Hultsch et al. (1999) who included crossword participation as a novel information processing activity, whereas Parslow et al. (2006) did not include a measure of crossword participation in their inventory. Furthermore, to date, no cognitive activities measure has separated the assessment of crossword frequency by specific crossword type. This is important as cryptic crosswords appear to require a unique type of processing compared to quick and general knowledge crosswords (e.g. Hambrick et al., 1999; Forshaw, unpublished).

The questionnaire studies in this thesis indicate that cryptic crosswords have a different effect on the metacognition system of older adults compared to younger adults, which was not the case for quick or general knowledge crosswords. Self-report techniques were imperative for uncovering differences in participants who did or did not attempt cryptic crosswords regularly; that is, comparing those who have given up attempting such crosswords to those who never attempted or still attempted such crosswords. However, the self-report technique in Study Four (a) demonstrated how the formulation of questionnaires can have a significant effect on the cognitive awareness of participants completing the questionnaire. These are discussed further in Section 6.3.3, but the key aspect here is that subjective measures of cognitive activity can have a direct impact on subjective measures of cognitive functioning.

Hertzog & Nesselroade (2003) commented on the fact that self-report cognitive activity measures may be determined, at least in part, by current cognitive functioning. That is, a number of researchers have hypothesised that the relationship between cognitive activity and cognitive functioning in later life may be symbiotic (e.g. Hertzog, 2009; Hertzog & Nesselroade, 2003; Schooler & Mulatu, 2001). This is critical because any subjective measure of cognitive activity would be positively correlated with measures of cognitive functioning (e.g. Wilson et al., 2007). This is also the case for longitudinal research such as Hultsch et al. (1999), because it is possible that preclinical dementia or cognitive decline has a negative impact on cognitive activity frequency from mid-life (e.g. Friedland et al., 2001). Therefore, an objective measure of cognitive activity/stimulation is required to investigate both the cognitive reserve hypothesis and use-dependency theory; this technique was used in Studies Five, Six and Seven.

Studies Five through Seven produced analogies of the cognitive reserve hypothesis and use-dependency theory by manipulating stimulus characteristics of the to-be-remembered words. Ellis & Lambon-Ralph (2000) and Li (2009) proposed that high-frequency and early-acquired words would be stored in more interconnected neuronal/cognitive networks than low-frequency and later-acquired words respectively. Therefore, according to the cognitive reserve hypothesis, high-frequency and early-acquired words should show less of an effect of cognitive aging than low-frequency and later-acquired words. In older adults, high-frequency words were recalled at a greater rate across trials than low-frequency words; however this dissociation was not evident in younger adults. Conversely, there was no dissociation in terms of recall (and all other measures of memory) of words which differed in terms of AoA between younger and older adults.

The results from Study Five support the cognitive reserve hypothesis, that is, a constant higher level of stimulation/activation of certain cognitive networks (i.e. high-frequency words) appears to protect such networks from cognitive activity, which appears to take a larger toll on cognitive networks which are activated less frequently (i.e. low-frequency words). One implication of this is that it suggests that the cognitive decline seen in healthy aging is akin to the cognitive decline seen in dementia. For example, Taylor (1998) showed that in dementia patients high-frequency objects were identified significantly faster than low-frequency objects, which suggests that the repeated activity of the high- compared to the low-frequency cognitive representations reduced the impact of the cognitive/neuronal atrophy of the dementia. This pattern of being able to name high-frequency objects faster than low-frequency objects is also evident in participants who do not show cognitive impairment (e.g. Carroll & White, 1973), suggesting a similar form of protection (from cognitive/neuronal atrophy associated with healthy aging) of high- compared to low-frequency words through an increase in activation of such words.

Study Six did not support the cognitive reserve hypothesis, that is, early-acquired words were not recalled significantly better than later-acquired words by older adults compared to younger adults. To provide support for the cognitive reserve hypothesis, the result must show that the impact of stimulus characteristics, representing life-long activation, is greater in older than younger adults. This is due to the fact that episodic memory deteriorates with age, therefore the hypothesised protection of the increase activation of early- over later-acquired words should be more evident older adults. However, for the whole sample population, the results of this study show early-acquired words were significantly better consolidated and retained/retrieved than later-acquired words. This resulted in a recall benefit of early- over later-acquired words, however there was no evidence that early-acquired words were encoded better than later-acquired words. The opposite was the case when considering the significant effect of the age of the participants on recall; to clarify, older adults showed an encoding deficit but not a consolidation and/or retrieval/retention deficit compared to younger adults.

It is important to consider this result in relation to previous research which has investigated either the effects of AoA on recall (e.g. Dewhurst et al., 1998) or investigations into the effects of chronological age on recall (e.g. Dunlosky & Salthouse, 1996). First, the effects of AoA on recall have typically shown that the later-acquired words are recalled significantly better than earlier-acquired words. The results of Study Five and previous research (e.g. Morrison & Ellis, 2000) suggest that earlier-acquired words are accessed and thus encoded faster than later-acquired words. As covered in Chapter Three, this result may indicate that later-acquired words received a greater amount of processing time/resources, when using mixed-lists, than early-acquired words and therefore were encoded to the same degree (or better than). Study Six showed that when participants spent an equal amount of time studying each type of word, early-acquired words are encoded more effectively than later-acquired words. Therefore it is important to match study time when comparing words which differ on specific stimulus characteristics.

Second, with regards to studies which have investigated the age-related effects of cognitive functioning on recall it is important to consider the stimulus characteristics of the to-be-remembered words. For example, many studies control word frequency when comparing metacognition or memory in younger and older adults (e.g. Dunlosky et al., 2007; Dunlosky & Salthouse, 1996), however many do not report whether or not the AoA of the to-be-remembered words is also matched. Even though both stimulus characteristics are highly correlated (e.g. Morrison et al., 1997) the results of Studies Five and Six demonstrate that word frequency and AoA have a different impact on memory function. It is arguably possible that results which have demonstrated an encoded/recall deficit of older over younger adults may be detected and effects of stimulus characteristics and not age (especially since age does not appear to significantly affect encoding; Study Six). Equally, it is possible that word frequency may be the underlying cause of some research which has investigated the age-related effects of repeated exposure to stimulus as Study Five has indicated that older adults show a dissociation between learning high- compared to low-frequency words, which was not the case for younger adults. It is important to consider whether the effects of stimulus characteristics may have had an impact on recall, which had not been acknowledged, when studying other sample populations (e.g. patients with brain damage or other conditions which have been assumed to affect memory).

Forbes-McKay et al. (2005) argued that the results of their study showed that the protection of words with an earlier AoA (or higher word frequency) meant that such words were accessed faster than later-acquired (or low-frequency) words in patients with dementia compared to healthy controls. If dementia is an accelerated version of normal/healthy aging then it would be interesting to investigate whether the dissociation between high- and low-frequency words, with regards to recall, is evident when comparing patients with dementia to either healthy older adults or younger adults. Furthermore, Forbes-McKay et al. (2005) argued that AoA had a larger impact on verbal fluency in dementia than word frequency; therefore it would be of interest to investigate whether this transferred to a recall, encoding, consolidation and/or retention/retrieval benefit of early- or later-acquired words to a greater degree in participants with dementia compared to controls. If this is the case, then it may be possible to incorporate this intervention/rehabilitation technique targeted at dementia.

The majority of previous research has shown that names which are popular are easier to learn and recall than names which are less popular (e.g. James & Fogler, 2007). Research has also shown that older adults show significant deficits in name recall compared to younger adults (e.g. James, 2004), especially in terms of episodic memory (Semenza et al., 1996). Study Seven confirmed the recall advantage of popular over unpopular names, however there was no evidence of an age-related deficit in name-recall. This was the case when considering overall recall as well as encoding, consolidation and retention/retrieval. According to previous research (e.g. Jones & Rabbitt, 1994) the use of pure-lists of names and the focus on episodic memory should have provided strong evidence of the deficit in name recall for older compared to younger adults. However, this was not the case and thus there was no evidence for the use-dependency theory when using objective measures of cognitive activity/stimulation and cognitive functioning. Methodological issues of previous research are discussed in Section 6.5.

Finally, Study Eight suggested that self-reported questionnaires of cognitive activity may reflect more than just the frequency of taking part in certain cognitive activities. In line with the results from Studies One through Four (a), Study Eight showed that the ability to complete a cognitive activity (specifically cryptic crosswords) appeared to be as, if not more important, than simply attempting the activity. Therefore it is important for future questionnaire studies to investigate the competency of doing cognitive activities as well as the frequency (as commented on by Salthouse, 2006). This is discussed further in Section 6.4, but it can be argued that frequency questionnaires reflect a combination of participants' competency and accessibility to take part in cognitive activities and not simply the frequency of doing so. Using more objective measures of cognitive activity (e.g. using intervention techniques or manipulating stimulus characteristics) is arguably a more objective way of investigating the relationship between cognitive stimulation/activity and cognitive functioning.

In conclusion, cognitive activity measures can be unreliable and may be influenced by a number of mediating/demographic factors. By manipulating stimulus characteristics Studies Five through Seven were able to investigate the direct relationship between cognitive activity/stimulation and cognitive functioning. Not only did these studies produce a lack of support for the use-dependency theory they also showed how methodological designs can produce findings which are incorrectly attributed to differences between participants or stimulus characteristics (e.g. age of the sample population or frequency of cognitive activity). Future research is needed to investigate whether manipulating stimulus characteristics affects other domains such as metacognition and whether the results observed in this thesis are evident in different sample populations.

6.3.3 Subjective versus objective dependent variables

The research literature has provided inconclusive evidence as to whether cognitive activity or cognitive interventions have a larger impact on subjective or objective measures of cognitive functioning (e.g. Rebok et al., 2007; Rapp et al., 2002; Floyd & Scogin, 1997). This has had a large implication on the understanding of how cognitive activity may influence objective measures of cognitive functioning. For example, Berry (1999) has argued that MemSE is the critical factor in determining whether older adults undertake cognitive activity regularly, whereas Jopp & Hertzog (2007) have demonstrated that the relationship between cognitive activity and actual/objective cognitive functioning determines whether an individual feels confident enough to continue undertaking certain cognitive activities.

Studies One through Four (a) showed how subjective dependent variables are highly correlated with self-reported activity. However, Studies Four and Four (a) showed how subjective dependent variables can be influenced directly from the order of the questionnaire or design used. Conversely, Studies Five to Seven showed that objective measures of memory functioning reduced the variance between younger and older adults, in response to manipulations of stimulus characteristics. Finally, Study Eight showed how, for the whole sample population, cognitive activity appeared to have a larger impact on subjective rather than objective measures of cognitive functioning.

There are critical implications of the results from Studies Four and Four (a) when considering the results of previous research. For example, Cavallini et al. (2003) showed that a metacognitive and mnemonic training intervention promoted cognitive awareness and MemSE. However it is unclear as to whether participants completed the subjective dependent variables before or after attempting the objective cognitive functioning tasks (e.g. episodic memory recall tests). Furthermore, longitudinal intervention studies have used MemSE training to promote objective measures of cognitive functioning (e.g. West et al., 2008). It is possible that participants in the experimental group received MemSE training before completing the cognitive measures for each visit. If this is the case, it is possible that the effects of the MemSE training were relatively short-term as demonstrated in Study Four (a).

The relationship between subjective and objective cognitive functioning is the basis of theories of metacognition (e.g. Nelson & Narens, 1990). As metacognition declines with age, one important question is whether the decline is due to a deficit in cognitive awareness (i.e. the monitoring pathway) or a decrease in the ability to change ones' behaviour (i.e. the control pathway). This is discussed at length in Section 6.4 and in previous chapters. However, this quandary lies at the heart of the question as to whether studies which investigate the use-dependency theory and/or cognitive reserve hypothesis should monitor/investigate subjective or objective measures of cognitive functioning. As discussed in Section 6.4 it is likely that subjective awareness of current cognitive functioning is a critical component of the use-dependency theory. Undertaking cognitively stimulating activities appears to promote older adults' awareness of the current cognitive functioning. Thus subjective feedback during cognitively demanding tasks may illuminate the metacognitive processes of older adults (e.g. Dunlosky et al., 2007).

Salthouse (2007; 2006) has argued that evidence for the use-dependency theory must be produced by providing an objective difference in cognitive functioning of older adults who are either relatively cognitively active or inactive. This thesis supports that view because there is clear evidence from subjective measures of cognitive functioning that participants who are more cognitively active (or undertake a cognitive intervention) show changes in subjective measures of cognitive functioning; whereas there is relatively no evidence that objective measures of cognitive functioning are changed by (self-reported or objectively manipulated) variations in cognitive activities. This is definitely the case for the whole sample population of various studies, but as discussed in Section 6.4 various sub-samples do show changes in objective measures of functioning in response to variation in cognitive activity.

The results of the thesis show support for Rebok et al. (2007) and Floyd & Scogin (1997) in that an increase in cognitive activity appeared to have a larger effect on subjective measures of cognitive functioning and did not appear to affect objective measures of functioning. One reason for this could be that older adults have a deficit in metacognitive control (e.g. Brehmer et al., 2008). Even when asking older adults directly, as in Study Three, the results show that older adults believe they become more aware of their cognitive frailties when undertaking certain cognitive activities (e.g. cryptic crosswords). However, these individuals appeared to believe that they were unable to use the increase in cognitive awareness to modify current cognitive functioning. This was also apparent in the intervention study (Study Eight) whereby older adults showed an increase in metacognition and episodic memory awareness but did not use this awareness to improve their actual memory ability (see Section 6.4 for further discussion). Finally, it is important to quantify the difference between self-reported cognitive functioning and self-reported beliefs about cognitive functioning. For example, the results of Study Three suggested that older adults believe that cryptic crosswords promoted cognitive awareness to a greater degree than younger adults. This was specifically the case when comparing those participants who attempted such crosswords to those who did not. These results are solely about the beliefs of participants and further research is needed to investigate whether these beliefs are based on participants' experiences or information taken from the media or other sources (e.g. advertisements about Nintendo Brain Training).

6.3.4 Questionnaire versus intervention results

On the whole, the results from the questionnaire studies support those from Study Eight (the intervention). The majority of the results from Studies One through Four (a) indicate that attempting cryptic crosswords promotes cognitive awareness in older adults to a greater degree than younger adults. The intervention (Study Eight) also showed that attempting cryptic crosswords on a regular basis increased cognitive awareness, especially with regards to episodic memory functioning. The benefits of an intervention technique is that findings from questionnaire studies can attempt to be reproduced under tightly controlled conditions. Furthermore, intervention techniques can take into account objective measurements of the ability to complete cognitive activities and objective measures of cognitive functioning. As discussed in Section 6.3.1, there is a need to use a similar intervention technique as that of Study Eight and investigate the effect of other cognitive activities, particularly those which are commercially available (e.g. Nintendo Brain Training).

6.4 Theoretical issues and implications

6.4.1 A proposed model of the cognitive reserve hypothesis and use-dependency theory

As discussed in Chapter One, the cognitive reserve hypothesis and use-dependency theory are not mutually exclusive and it is likely that individuals who are cognitively stimulated at an earlier age continue to seek out and undertake cognitively stimulating activities throughout the lifespan (e.g. Dellenbach and Zimprich, 2008). Thus a model of how cognitive activity affects cognitive functioning in later life must consider the effects of cognitive activity/stimulation in early life. Furthermore, as discussed by Jopp

& Hertzog (2007) and Berry (1999), it is important to consider the relationship between actual objective measures of cognitive functioning and subjective measures of cognitive awareness or MemSE when investigating the impact of current cognitive activity (especially in later life).

Figure 6.1 illustrates the proposed model which encompasses both the cognitive reserve hypothesis and the use-dependency theory. This model is based on the results of this thesis as well as other results from empirical research, including animal research (e.g. Held, 1965). The arrows depict the effect of the four different components on each other, while the dashed arrow represents a pathway which appears to be less efficient in older adults.

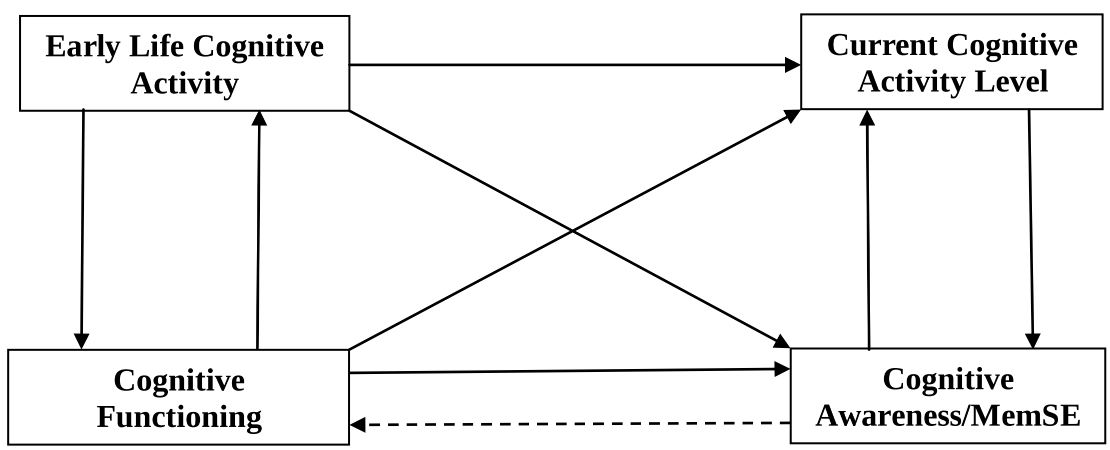

Figure 6.1. A model of the effects of cognitive activity on subjective and objective measures of cognitive functioning (see text for full explanation).

In Figure 6.1, Early Life Cognitive Activity represents all cognitive stimulation and activity (including education) before the age of around twenty-five. Current Cognitive Activity Level represents the frequency that an individual undertakes cognitively stimulating leisure and work activities as well as further educational or self-enhancing training activities (e.g. learning a foreign language). The Current Cognitive Activity Level represents the level of activity of an individual at any stage of mid-life onwards. The Cognitive Functioning component represents the actual level of cognitive functioning which includes episodic memory, executive functioning and some aspects of working memory (e.g. attention). The component of Cognitive Awareness/MemSE represents the metacognition system as well as overall self-efficacy relating to overall cognition, not just memory functioning.

Regarding the relationships between the components in Figure 6.1, previous research has shown that Early Life Cognitive Activity can produce neuronal growth in animals (e.g. Held, 1965) and humans (e.g. Mortimer et al., 2003). The results from Studies Five and Six also demonstrate that Early Life Cognitive Activity can have a significant impact on Cognitive Functioning for both younger and older adults. Certain researchers have also suggested that this type of activity (e.g. access to cognitive resources at a very young age, succeeding in education) produces a symbiotic relationship between cognitive functioning and cognitive activity in early life (e.g. Dellenbach & Zimprich, 2008; Barnes et al., 2006). Studies One through Four (a) also suggest that participants with a greater number of years in education take part in more cognitive activity, thus there is a direct impact between Early Life Cognitive Activity and Current Cognitive Activity Level. This is also supported by previous research such as Dellenbach and Zimprich (2008) and Wilson et al. (2007), in that participants who have been cognitively stimulated regularly at an earlier age seek out more intellectual activities in later life. Previous research has shown that participants who have a higher level of education also show superior metacognitive functioning (e.g. Romainville, 1994), which was also confirmed in Studies Two and Three of this thesis, hence the direct link between the Early Life Cognitive Activity and Cognitive Awareness/MemSE components.

For the Current Cognitive Activity Level, this thesis has only shown evidence that this has a direct effect on Cognitive Awareness and MemSE; specifically, Studies One through Four (a) and Study Eight showed a significant impact of specific cognitive activities (e.g. cryptic crosswords) on metacognition and MemSE (specifically relating to episodic memory). This has also been reported in the literature, for example Cavallini et al. (2003) and Rebok & Balcerak (1989) showed how a cognitive intervention could promote MemSE and certain aspects of metacognition. Once again, the relationship between Current Cognitive Activity Levels and Cognitive Awareness/MemSE appears to be symbiotic. Schooler & Mulatu (2001) showed how older adults would retire from work or give up certain leisure activities due to feeling less confident at being able to complete them. This was also proposed by Berry (1999) as one of the main reasons why older adults gave up attempting cognitive activities. This was supported in Study Four, in particular, whereby older adults who had given up attempting cryptic crosswords showed a significantly lower MemSE than those who still attempted cryptic crosswords. This association was not as evident in the younger sample population, indicating a symbiotic relationship between MemSE and cognitive activity, which is enhanced over time.

However, the relationship between Current Cognitive Activity Level and Cognitive Awareness/MemSE is not the only interaction which appears to underpin the use-dependency theory; the relationship of both components to the Cognitive Functioning component appears to be a key factor. Supporting Jopp & Hertzog (2007) the results of Studies Four and Four (a) suggest that older adults have given up attempting certain cognitive activities due to a perceived or actual decrease in Cognitive Functioning. It is possible that this relationship is representing the impact of a decrease in MemSE on Current Cognitive Activity Level, but the results confirm that participants who were less able to complete a cognitive task (solving cryptic crossword clues) reported giving up attempting such cognitive activities but only showed a lower MemSE if they attempted the activity before completing the MemSE test and not if they completed the MemSE test prior to attempting to cognitive activity. Hence there appears to be a direct influence of Cognitive Functioning on Cognitive Awareness/MemSE, but arguably there is also a direct effect of Cognitive Functioning on Current Cognitive Activity Level.

Study Eight has indicated how the Cognitive Functioning, Current Cognitive Activity Level and Cognitive Awareness/MemSE components interact to produce the subjective findings and a lack of significant objective results. Cognitive Functioning, when considered in relation to Study Eight, can include the abilities necessary to complete the cryptic crossword intervention (as well as the objective measures of memory functioning taken). The baseline results showed that post-hoc crossword completion rates were significantly correlated with MemSE, indicating that cognitive functioning had a direct impact on an individual's confidence in their own memory. The results also confirmed the bi-directional relationship between Current Cognitive Activity Level (i.e. doing cryptic crosswords) and the Cognitive Awareness/MemSE component; that is, participants who were attempting cryptic crosswords reported a significantly lower episodic MemSE after controlling for the effects of Early Life Cognitive Activity (e.g. education), but this was more evident for participants who attempted the cryptic crosswords after the placebo/control intervention.

Therefore the ability to complete the cognitive intervention was having a direct and indirect (through the Current Cognitive Activity Level component) effect on the Cognitive Awareness/MemSE component. However, as illustrated by the dashed link in Figure 6.1, the increase in Cognitive Awareness/MemSE did not have significant impact on Cognitive Functioning (e.g. objective measures of episodic memory ability, metacognition control and verbal learning). This proposed model is not supportive of the views of Berry (1999) and West et al. (2008) who proposed that MemSE had a direct effect on Cognitive Functioning and Current Cognitive Activity Level. These researchers did not fully agree that Cognitive Functioning or Current Cognitive Activity Levels influenced MemSE, although they felt that Cognitive Functioning and Current Cognitive Activity Levels had a symbiotic relationship.

Figure 6.1 dictates that Current Cognitive Activity Levels do not have a direct impact on Cognitive Functioning, because this is mediated by Cognitive Awareness/MemSE (i.e. metacognition). This is supportive previous research which has shown that metacognitive training can promote Cognitive Functioning but only if older adults are reminded to use the skills which they had developed in training, that is the Current Cognitive Activity Level and Cognitive Awareness/MemSE components are activated (e.g. Brehmer et al., 2008). The model of showed a supportive view of Bherer, Kramer & Peterson (2008) and Dunlosky et al. (2005), in that the control pathway of metacognition appeared to be impaired in older adults (represented by the dashed link between Cognitive Awareness/MemSE and Cognitive Functioning in Figure 6.1).

This model of the cognitive reserve and use-dependency theory is similar to that of Hertzog (2009) and Jopp & Hertzog (2007). These researchers emphasise how Cognitive Functioning can have a direct impact on Current Cognitive Activity Levels. They also confirmed that this will influence the bi-directional relationship between the components of Current Cognitive Activity Level and Cognitive Awareness/MemSE, alongside the direct impact of Cognitive Functioning on MemSE (although to a lesser degree). However, Jopp & Hertzog (2007) in particular do not consider the effect of Early Life Cognitive Activity on the other three components. Furthermore Jopp & Hertzog (2007) believe that the relationship between Cognitive Awareness/MemSE and Cognitive Functioning is intact, which the results of Study Eight do not support. The results of Studies Four and Four (a) suggest that the impact of Cognitive Functioning on both Current Cognitive Activity Level and Cognitive Awareness/MemSE is significantly larger than what Jopp & Hertzog (2007) or Hertzog (2009) believed. Studies One to Three also suggest that Early Life Cognitive Activity may have a larger impact on both Current Cognitive Activity Level and Cognitive Awareness/MemSE compared to the views of Jopp & Hertzog (2007) or Herzog (2009).

In conclusion, for the general sample population of older adults, Figure 6.1 illustrates that early life experiences can have a significant affect on cognitive functioning throughout the lifespan. This can be directly as a result of the high levels of neuroplasticity evident in early life or indirect through influencing later cognitive activity and cognitive awareness or metacognition. Cognitive activity in later life is directly influenced by the ability to undertake such activities (i.e. cognitive functioning). There is not evidence that cognitive activity in later life has a direct effect on cognitive functioning, but it does appear to have a direct effect on metacognition and cognitive awareness. The only way in which cognitive activity in later life can positively affect cognitive functioning is by modifying behaviour through the metacognition system. Unfortunately, for older adults it appears that the metacognition system has a significantly less effective influence on cognitive functioning compared to younger adults (e.g. Brehmer et al., 2008; Dunlosky et al., 2005; Dunlosky et al., 2003). Therefore, a negative feedback loop is created between the level of current cognitive activity and the individual’s overall cognitive self-efficacy system. This negative feedback discourages participants from undertaking cognitive activities due to the inability to enhance cognitive functioning, and thus complete the cognitive activity and in turn promote self-efficacy.

6.4.2 The effect of mediating demographic/cognitive factors

Figure 6.1 is a proposed model of how the cognitive reserve hypothesis and use-dependency theory operate in the general older adult population. However, throughout this thesis results from certain sub-samples of participants have shown that higher levels of cognitive activity in later life produced a significant improvement in objective measures of cognitive functioning. This is also evident in previous research which has shown strong evidence which supports the use-dependency theory, either in the whole sample population or in specific sample populations (e.g. Carlson et al., 2008; Basak et al., 2008; Stine-Morrow et al., 2007; MacKinnon et al., 2003; Christensen & MacKinnon, 1993).

Glisky & Glisky (1999) are one of a number of research groups who have suggested that cognitive intervention may be more effective on certain groups of older adults than others. To recapitulate, some studies have demonstrated that cognitive interventions appear to be more effective on older adults who show higher levels of functioning at baseline, specifically executive functioning (e.g. Karbach & Kray, 2009), whereas the majority of research has suggested that cognitive interventions are more effective on adults with lower levels of cognitive functioning at baseline (e.g. Carlson et al., 2008).

One possibility for the findings of research such as Carlson et al. (2008) is that higher functioning older adults may show ceiling effects, whereby they are functioning close to their optimum level (e.g. Salthouse, 2006); thus adults with lower levels of cognitive functioning have a greater dimension for improvement. Another explanation (which may act in conjunction to the potential ceiling effects) may depend on the intervention activity used. For example, Carlson et al. (2008) used an everyday cognitive activity which was not based in the laboratory, however Karbach & Kray (2009) used a relatively theoretical training technique. Study Eight demonstrated how an everyday cognitive activity improved cognitive awareness and metacognition of older adults who either had few years in education or reported taking part in few cognitive activities (especially crosswords). For these individuals, who can be regarded as at risk (e.g. Van der Bij et al., 2002), attempting a unique cognitive activity will stimulate the Current Cognitive Activity Level in Figure 6.1, which will then activate the Cognitive Awareness/MemSE component. Both components would not have been activated as much by the Early Life Cognitive Activity component compared to individuals with a greater number of years in education.[23]

These results support the theories of Park et al. (2007) and the research of Noice & Noice (2006) in that older adults appear to show a greater improvement in Cognitive Functioning when the intervention is a novel task, that is an activity which the participants have not attempted before. Park et al. (2007) suggest that this is because attempting novel activities stimulates different neural networks, which then causes an increase in neurogenesis. This is contrary to the view of Cianciolo et al. (2006) who proposed that older adults can build up a level of expertise in one specific domain and transfer this expertise to solve new problems. It is unclear, from the results of Study Eight, whether the novelty of attempting cryptic crosswords or the expertise needed to solve the cryptic crosswords had a larger effect on either subjective or objective measures of Cognitive Functioning. However, the results suggested that for certain individuals, the novelty of attempting cryptic crosswords promoted metacognition functioning and cognitive awareness.

As mentioned throughout this thesis, it is impossible to account for every single potential mediating factor which may affect any of the components of the model in Figure 6.1. However, further research is needed to use a similar technique with a larger sample population to investigate the roles of known mediating factors on the relationship between everyday cognitive activities and cognitive functioning. For example, a difference in socialization score between participants in Study Eight appeared to mediate the relationship between the components of Cognitive

[23] It can also be argued that the Cognitive Functioning component would not have affected either the Cognitive Awareness/MemSE or Current Cognitive Activity Level components as much because of the influence of Early Life Cognitive Activity on Cognitive Functioning.

Awareness/MemSE and Cognitive Functioning, specifically for encoding episodic memories. If future research can identify groups of participants who appear to benefit from certain cognitive activities, then everyday cognitive interventions can target individuals with these specific demographic characteristics to enhance the pathway between Cognitive Awareness/MemSE and Cognitive Functioning.

Intervention techniques did not necessarily have to modify cognitive activities. For example, if it is the case that an increase in socialization can enhance episodic memory encoded in individuals who undertake certain cognitive activities, the result should be to use a social intervention activity (e.g. Stine-Morrow et al., 2007). It is also likely that multi-modal intervention techniques will be more effective than simple cognitive interventions (Rebok et al., 2007). Thus, based on Study Eight, a combination of attempting crosswords while socializing may increase the transfer of the increase in cognitive awareness to actual cognitive functioning. One example of this could be using social crossword clubs as an intervention.

It is also clear that some of the mediating demographic factors represent aspects of components in this model (Figure 6.1), for example, the number of years in education represents a key factor in the Early Life Cognitive Activity component, and previous cognitive/crossword frequency is encapsulated in Current Cognitive Activity Levels. Therefore, it can be argued that to a certain degree mediating factors are taken into consideration in this model of cognitive functioning in later life. However, it is acknowledged that many other mediating factors, such as socialization, ability to cope with stress, personality, need to be represented in this model (e.g. Elias & Wagster, 2007). Further research, perhaps using structural equation modelling, is needed to understand the relative effects of each component on one another and how other mediating factors impact on the components of Figure 6.1.

In conclusion, the results of Studies One through Four (a) and Study Eight have shown how the relationships between the components of the model depicted in Figure 6.1 can be influenced by mediating factors. Many other mediating factors which have been identified by other research (e.g. King & Suzman, 2009; Hertzog et al., 2009; Elias &

Wagster, 2007; Salthouse, 2006) were not measured throughout this thesis due to logistical reasons (e.g. genetic markers of decline, allostatic stress response, diet, physical activity), need to be incorporated into future investigation using a similar design. However the questionnaire studies have highlighted a number of possible mediating factors which have not been taken into account in previous studies which have investigated the use-it-or-lose-it theory or used cognitive interventions (e.g. the order of undertaking tasks, reasons for giving up certain activities, completion rates of activities/intervention). Therefore, the results support the view of Glisky & Glisky (1999) in that certain cognitive interventions will be more effective and appropriate for different groups of older adults. Cognitive interventions should target individuals who are at risk and who have low cognitive functioning. Finally, within-subjects designs are vital when investigating the effectiveness of an intervention or cognitive activity on a whole sample population, because potential mediating factors are controlled for and can be investigated in post-hoc analysis.

6.5 Implications regarding previous research

With regards to the use of cross-sectional questionnaire studies to investigate the use-dependency theory or cognitive reserve hypothesis, there is a very important message from this thesis, which has appeared to be ignored by researchers studying the cognitive reserve hypothesis or use-dependency theory (e.g. Wilson et al., 2007; Barnes et al., 2006; Willis et al., 2006; Wilson et al., 2002; Ball et al., 2002), which is that the relationship between cause and effect with regards to cognitive activity and cognitive functioning must be data driven and not theoretically derived. Chapter One describes the theories of non-linear dynamics in learning and the views of Shadish et al. (2002), which state that the causal relationship between a dependent variable and its antecedents is never as simple as first identified by the pioneers of experimental psychology (e.g. James, 1890). The assumptions of Occam's razor (e.g. Gauch, 2003) have been adopted by researchers such as Wilson et al. (2007) and it was theorised that cognitive activity must be positively correlated with cognitive functioning. Therefore studies which produce evidence to the contrary (i.e. a negative relationship between reported cognitive activity and cognitive functioning) were dismissed as having either inappropriate measures of cognitive activity or cognitive functioning (or both, as well as reportedly weak methodology). This meant that such research would not necessarily be published due to the fact that it did not fit with the theoretical concepts of cognitive reserve or the use-dependency theory.

Chatton's anti-razor fits closely with the non-linear dynamic view of chaos theory (e.g. Harle, 2010; Fromberg, 2010), which dictates that an extreme number of variables impinge on any causal relationship, therefore to exclude any of these variables may adjust the statistical power and/or the understanding of the relationship between one variable and another. Shadish et al. (2002) describes an inus condition where a minimum number of variables must be present in order to elicit the expected causal effect. The studies in this thesis demonstrate that there are multiple factors which can all have an effect on the cognitive functioning of older adults, even though many other factors could not be taken into account (e.g. genetics, personality, stress etc). In line with Glisky & Glisky (1999) the theory of Shadish et al. (2002) dictates that a condition whereby cognitive activity can elicit a decrease in cognitive decline or an increase in cognitive functioning it is determined by a vast number of mediating factors such as previous cognitive activity, the type of activity undertaken, the proportion of life spent attempting specific activities and the ability to use feedback from attempting activities. Only then can the relationship between cognitive activity and cognitive functioning be examined. The next stage in this process would be to identify a condition whereby older adults appear to gain an insight into their current cognitive functioning (e.g. for older adults who have never attempted cryptic crosswords to start attempting them on a regular basis) and to investigate whether this condition produces subjective or objective results in terms of cognitive functioning in different cognitive domains.

With regards to experimental techniques investigating age-related decline in everyday memory functioning, the results of Study Seven suggest that previous research which has shown an age difference in the recall of names may have done so due to stimulus characteristics or the methodology used. For example, older participants reported grouping names on the basis of categories (e.g. the royal family), which was not reported by younger adults during debriefing. Therefore it is possible that previous research (e.g. James, 2004) used names which were less familiar to older adults. Furthermore, some studies have used face recognition to cue recall of the to-be-remembered names (e.g. James, 2004). Studies have shown that older adults are more easily distracted than younger adults (e.g. Hasher & Zacks, 1988) and therefore presenting older adults with a face and a name may reduce the attention/process time of the name in older adults to a greater degree than younger adults. Naveh-Benjamin, Guez, Kilb & Reedy (2004) have demonstrated that older adults show a greater deficit for name-face associative recall than for recalling faces or names alone.

Study Seven presented participants with pure-lists of first names and asked participants to rate the names for liking. Older participants received 50% extra study and recall time, which has not always been the case in previous studies (e.g. James & Fogler, 2007). By rating each name participants have to process each name to a relatively similar degree. Also it is likely that the increase in study and recall time allows older adults to organise names in a specific way which enables them to recall the names successfully. These differences in the methodology of Study Seven compared to previous research shows how older adults can appear to have specific deficits which may have been produced by the design used and not an underlying cognitive deficit.

Finally, the cognitive intervention conducted in Study Eight has highlighted the issue of whether mediating factors should receive greater attention when conducting intervention studies. The revolutionary use of a within-subjects design highlighted the fact that the specific cognitive intervention was not effective with regards to promoting cognitive functioning for the whole population. However, there was clear evidence that subsamples of the sample population benefitted from the intervention. Research which uses standard clinical trials to investigate cognitive inventions need to consider whether mediating demographic factors change the degree of effectiveness of the intervention. Furthermore, Study Eight demonstrated that an everyday cognitive activity could be used as an intervention for certain sample populations, reducing their need for expensive time-consuming training programmes that are not accessible to the general population.

6.6 Future research

Cross-sectional questionnaire studies which investigate use-dependency theory and cognitive reserve hypothesis need to consider whether the order of the questionnaire affects both subjective and objective measures of cognitive functioning. Study Four (a), in particular, demonstrated how the order of a questionnaire can have a significant effect on the outcome of subjective measures of cognitive functioning. It would be of interest to investigate whether this was also the case with regards to objective measures of cognitive ability. Finally, with regards to questionnaire studies, it is necessary to investigate whether a combined measure of frequency of cognitive activity and competency or effort required to undertake the activity provides a different relationship between self-reported cognitive activity and subjective and/or objective measures of cognitive function (e.g. Salthouse, 2006).

Further research is needed to investigate whether word frequency or AoA has effects on other cognitive functions such as metacognition, and longer term delayed recall, when using a similar multi-trial technique to that used in Chapter Three. As discussed in Sections 6.3.3 and 6.4, cognitive activity/stimulation appears to have a significant effect on cognitive awareness/metacognition (see Chapter Two and Five). Therefore it is possible that high-frequency and early-acquired words will show more accurate JOL responses than low-frequency and later-acquired words respectively. If this is the case, then it is necessary to consider stimulus characteristics when investigating the area of metacognition, especially metacognitive intervention studies (e.g. Dunlosky et al., 2007).

The results of Studies Five, Six and Seven also need to be replicated in different sample populations. There is evidence that AoA, word frequency and potentially name popularity all have significantly larger effects in patients who have dementia (e.g. Forbes-McKay et al., 2005; Taylor, 1997), specifically in naming latencies. Thus it would be interesting to investigate whether there is a dissociation in terms of recall, encoding, consolidation and/or retention/retrieval of words which differed in terms of stimulus characteristics between younger adults, healthy older adults and patients with dementia. Once again, this could also investigate the overall recall as well as the JOL abilities.

Finally, it is also the case that Study Eight only investigated the impact of an increase in activity/frequency of one specific activity (cryptic crosswords), therefore future research needs to repeat this type of technique to investigate the impact of other types of cognitive activity on cognitive functioning. The within-subjects intervention design used in Study Eight cannot replace the classic clinical trial technique if researchers want to conduct follow-up investigations[24], however the within-subjects approach should be conducted alongside of standard clinical trial approaches. Due to the recent increase in commercial products, which advertise brain training and cognitive enhancement, it would be prudent to assess the effectiveness of such products while using a within-subject technique (King & Suzman, 2009). It must also be acknowledged that a greater number of cognitive functioning measures are required than those which were used in Study Eight. In particular there is a need to incorporate measures of working memory and executive functioning (e.g. verbal fluency and task-switching).

6.7 Summary

This thesis began with a critical review of the theories and evidence behind the use-it-or-lose-it idea. As discussed in Chapter One, the cognitive reserve hypothesis and use-dependency theory are not mutually exclusive and a combination of the two concepts has been presented throughout this thesis to explain the possibility of cognitive activity (throughout the lifespan) affecting cognitive functioning in later life. It has been argued that differences in methodologies, measures of cognitive activity and cognitive functioning have produced an oversimplified picture of the relationship between cognitive activity and cognitive decline in later life. Many psychologists (e.g. Schooler, 2007) are adamant that an increase in cognitive activity throughout the lifespan will attenuate cognitive decline associated with healthy aging. Numerous cross-sectional and longitudinal techniques have provided evidence in support of this view (e.g. Hertzog et

[24] Although the time period between the intervention activity and start of the placebo/control activity (or vice versa) be lengthened to incorporate a follow-up period.

al., 2009; Smith et al., 2009; Verghese et al., 2003; Wilson et al., 2002; Hultsch et al., 1999).

However, there are a number of discrepancies in the research earlier which calls for clarification as to the type of cognitive activity that would influence cognitive functioning, the age at which an increase in cognitive activity is needed to slow cognitive decline and the types of individuals who would benefit from cognitive interventions. As the majority of research investigating both the cognitive reserve hypothesis and use-dependency theory used a between-subjects design it is arguably impossible to draw a direct causal relationship between cognitive activity and cognitive functioning (Hertzog, 2009). It is clear that other factors (e.g. genetics, diet) have a significant influence on cognitive functioning (particularly in later life) and can mediate the effect of cognitive activity on cognitive functioning/decline in healthy aging (e.g. Elias & Wagster, 2007).

This thesis used a combination of questionnaire studies, experimental studies and intervention techniques to investigate if and how cognitive activity impacted on cognitive functioning in later life. This involved subjective and objective measures of both cognitive activity/stimulation and cognitive functioning. Traditionally self-report/subjective measures of cognitive activity have been used when investigating this research area (e.g. Barnes et al., 2006). Chapter Two describes the questionnaire studies used in this thesis to identify the effects of different cognitive activities on self-reported cognitive functioning. As hypothesised, cryptic crossword frequency appeared to have a significantly greater impact on cognitive awareness of older adults than other types of crosswords. This was critical because previous research had failed to discriminate between the type of crossword being attempted when measuring crossword frequency as a cognitive activity (e.g. Verghese et al., 2003).

The concern about using self-report measures of cognitive activity is that current cognitive functioning may directly influence the level of cognitive activity (e.g. Jopp & Hertzog, 2007) and therefore produce a significant cognitive correlation between activity and functioning which supports the cognitive reserve hypothesis and use-dependency theory (e.g. Wilson et al., 2007). Furthermore, self-report measures of either cognitive activity or cognitive functioning appear to be unreliable, especially in sample populations of older adults (e.g. Sunderland et al., 1986) and when using retrospective accounts of cognitive activity (e.g. Barnes et al., 2006; Kondo et al., 1995). Thus, the experimental studies in this thesis attempted to manipulate stimulus characteristics to produce analogies of the cognitive reserve hypothesis and use-dependency theory when using a within-subjects design to control for possible mediating or external factors which may affect both cognitive activity and cognitive functioning.

Studies Five, Six and Seven manipulated stimulus characteristics of to-be-remembered words to produce analogies of the cognitive reserve hypothesis and use-dependency theory. Of note was the fact that high-frequency words appear to be afforded protection from cognitive atrophy associated with healthy aging to a greater degree than low-frequency words. This finding was only evident for overall recall and not for measures of encoding, consolidation and/or retention/retrieval. There was no evidence of a similar age X stimulus characteristics interaction when manipulating the AoA of the to-be-remembered words. One possibility is that the effect of word frequency on cognitive representations is enforced throughout life which is not necessarily the case for the effect of AoA (e.g. Li, 2009; Ellis & Lambon-Ralph, 2000). Although this provided some evidence for the cognitive reserve hypothesis, Study Seven did not provide any evidence for the use-dependency theory. That is, there was no dissociation, in terms of recall, encoding, consolidation and/or retention/retrieval, of names which had remained popular compared to names which had become unpopular between younger and older participants. Thus, when using objective measures of both cognitive stimulation (or activity) and cognitive functioning there is a modicum of support for the cognitive reserve hypothesis but no support for the use-dependency theory.

Study Eight used a revolutionary within-subjects intervention technique to investigate the impact of an everyday cognitive activity (i.e. attempting cryptic crosswords) on subjective and objective measures of cognitive functioning. The results confirm that older adults report a significant increase in cognitive awareness when undertaking an increase in cognitive activities. However, the older adults apparently are unable to use this increase in cognitive awareness to promote objective measures of cognitive functioning. The results of Study Eight were taken with the results of the previous studies and the model of the use-dependency theory and cognitive reserve hypothesis, illustrated in Figure 6.1, was produced to explain the results.

Overall, the novel model (Figure 6.1) suggests that cognitive functioning can be affected by early life experiences, such as cognitive stimulation and the number of years in education. However, this relationship appears to be bidirectional, in that an increase in cognitive functioning will enable younger adults to undertake more cognitively stimulating activities. Early life experiences also appear to determine the level of cognitive activity in later life. Supporting research by Dellenbach & Zimprich (2008), older adults who have a greater number of years in education also appear to take part in more cognitive activities later in life. Early life experiences, specifically education, also appear to directly and indirectly affect the level of cognitive awareness and MemSE that an older adult possesses. Figure 6.1 shows that contrary to the use-dependency theory there is no direct relationship between current (later life) cognitive activity level and objective/actual levels of cognitive functioning. Supporting the views of Hertzog (2009) and Jopp & Hertzog (2007), the current level of cognitive activity appears to be directly influenced by participants' actual cognitive functioning level, as well as their level of confidence/self-efficacy (which is also directly affected by current cognitive functioning). In this model, the only way cognitive activity in later life can affect cognitive functioning is through the metacognition system. However, unfortunately it appears that older adults have a deficit in the control pathway of metacognition (e.g. Brehmer et al., 2008), in that even if they become aware of a deficit in cognitive functioning and that certain activities promote the awareness of this, they are unable to modify their behaviour to counteract this deficit in cognitive functioning.

Figure 6.1 is a representation of how (earlier and later) cognitive activity affects cognitive functioning for the general population of older adults. However, it is clear through the studies presented in this thesis and previous research (e.g. Carlson et al., 2008) that cognitive interventions and/or a higher level of cognitive activity in later life are beneficial, in terms of cognitive functioning, for certain groups of older adults. This indicates that mediating factors can have a significant impact on the relationships between the components of the model presented in Figure 6.1. This also supports the view of Glisky & Glisky (1999), that cognitive interventions must be tailored to the needs of specific groups of older adults. It is the case that some older adults age successfully (Salthouse, 2007; 2006), thus the direct influence of the components Cognitive Awareness/MemSE and Cognitive Functioning of the model must be intact. Therefore it is necessary to identify how cognitive interventions can be used in at-risk sample populations to enhance the relationship between metacognition and actual cognitive functioning.

In conclusion, this thesis has taken into account the critique of previous research which has investigated the cognitive reserve hypothesis and use-dependency theory (collectively known as the use-it-or-lose-it theory). The types of cognitive activities measured and the cognitive functioning measures are both critical factors when investigating the use-it-or-lose-it theory. However, the methodology used is also important and can have a direct and/or indirect influence on the results of studies. This thesis demonstrated certain cognitive activities (e.g. cryptic crosswords) appear to have a larger impact on cognitive functioning (specifically cognitive awareness and/or metacognition) than other activities (e.g. quick or general knowledge crosswords). However, when using objective measures of cognitive activity/stimulation and cognitive functioning there was no evidence supporting the use-dependency theory and only partial evidence for the cognitive reserve hypothesis. A revolutionary within-subjects intervention technique confirmed the theory that cognitive activity has a significantly greater impact on subjective compared to objective measures of cognitive functioning for the whole sample population. Finally, the results suggest that mediating factors play a significant role in determining whether cognitive activity can modify actual/objective measures of cognitive functioning in later life. It is clear that older adults have a significant deficit in modifying their cognitive functioning even though (through participating in certain cognitive activities) they become aware of cognitive deficits associated with healthy aging. Future intervention techniques need to focus on the metacognition system as it is clear that older adults, compared to younger adults, show a deficit in the control pathway of the classic metacognition model (e.g. Nelson & Narens, 1990). These intervention techniques must be based on everyday activities, which are economical and accessible to all older adults, but especially those who are deemed to be at-risk (e.g. those with fewer years in education and who are or have been relatively cognitively inactive).

CHAPTER SEVEN

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APPENDIX ONE

MEMORY QUESTIONNAIRE

Thank you for showing interest in this study. The following questions are designed to investigate the relationship between intellectual activity levels and memory function. Please type the appropriate response or tick the boxes. These questions are for research purposes only. There are no right or wrong answers to these questions. Your responses and results will be kept anonymous and not passed on to any third party.

Section One

	Please type your responses below
Age	
Sex	
Number of years in formal education	
Occupation or previous occupation	

Section Two

For this section, a rating scale will be used to show how often you do the following things.

	Every day	Several times a week	Several times a month	Less than once a month	Never
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐
Read books or newspaper	☐	☐	☐	☐	☐
Playing cards	☐	☐	☐	☐	☐
Quiz	☐	☐	☐	☐	☐
Board games (eg cluedo, chess etc)	☐	☐	☐	☐	☐

Section Three

For each type of crossword you attempt regularly, please indicate how well you typically complete it:

	Finish it all	Finish more than half	Finish about half	Finish less than half	Fail to finish any of it
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐

Section Four

Do you complete the crossword on your own, with someone else, or with another form of help, for example a dictionary or thesaurus? Please tick all that apply:

	Alone	With a regular partner	With an occasional partner	Other form of help
Quick crossword	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐

Section Five

Please indicate how you consider yourself, compared to your prime.

	Much better	Slightly better	The same	Slightly worse	Much worse
Overall health	☐	☐	☐	☐	☐
Memory	☐	☐	☐	☐	☐
Crossword skills	☐	☐	☐	☐	☐

Section Six

This section will address the frequency in which you make mistakes in everyday activities which everyone makes from time to time.

	Every day	Several times a week	Several times a month	Less than once a month	Never
Forget people's names	☐	☐	☐	☐	☐
Read something again because you have not been concentrating	☐	☐	☐	☐	☐
Forget why you went into a specific area of your house	☐	☐	☐	☐	☐
Forget which turning to take on a familiar road that you rarely use	☐	☐	☐	☐	☐
Forget if you've locked the door or close a window	☐	☐	☐	☐	☐
Struggle to find the correct word to use	☐	☐	☐	☐	☐
Miss certain appointments unintentionally	☐	☐	☐	☐	☐
Forget where you've left your keys	☐	☐	☐	☐	☐
Struggle to remember a word on the tip of your tongue	☐	☐	☐	☐	☐
Forget what you went to the shops to buy	☐	☐	☐	☐	☐
Become easily distracted or confused with a difficult task	☐	☐	☐	☐	☐
Put something in an inappropriate place (e.g. butter in the bread-bin)	☐	☐	☐	☐	☐

Thank you for taking part in this questionnaire. We hope that this research will enable us to better understand changes in memory in older people. If you are interested in taking part in further research focusing on this area, please leave your name and contact details. All details will be treated confidentially and not passed on to any other source

APPENDIX TWO

MEMORY QUESTIONNAIRE

Thank you for showing interest in this study. The following questions are designed to investigate the relationship between intellectual activity levels and memory function. Please type the appropriate response or tick the boxes. These questions are for research purposes only. There are no right or wrong answers to these questions. Your responses and results will be kept anonymous.

Section One

	Please type your responses below
Age	
Sex	
Age you left school / college / university	
Occupation (or previous occupation)	

Section Two

For this section, please rate how often you do the following things on the scale shown.

	Every day	Several times a week	Several times a month	Less than once a month	Never
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐
Read books or newspaper	☐	☐	☐	☐	☐
Playing cards	☐	☐	☐	☐	☐
Quiz	☐	☐	☐	☐	☐
Board games (eg cluedo, chess etc)	☐	☐	☐	☐	☐
Play a musical instrument	☐	☐	☐	☐	☐
Study a foreign language	☐	☐	☐	☐	☐

Section Three

For each type of crossword you attempt regularly, please indicate how well you typically complete it:

	Finish it all	Finish more than half	Finish about half	Finish less than half	Fail to finish any of it	Not applicabl e
Quick crossword	☐	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐	☐

Section Four

Do you complete the crossword on your own, with someone else, or with another form of help, for example a dictionary or thesaurus? Please tick all that apply:

	Alone	With a regular partner	With an occasiona l partner	Other form of help	Not applicabl e
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐

Section Five

Please indicate how you consider yourself, compared to your prime.

	Much better	Slightly better	The same	Slightly worse	Much worse
Overall health	☐	☐	☐	☐	☐
Memory	☐	☐	☐	☐	☐
Crossword skills	☐	☐	☐	☐	☐

Section Six

Below are statements about feelings that people may have about their memory. Read each statement and decide whether you agree. Think about how you have been feeling over the past two weeks. Then, place a tick in the appropriate box.

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
I am generally pleased with my memory ability.	☐	☐	☐	☐	☐
There is something seriously wrong with my memory.	☐	☐	☐	☐	☐
When I forget something, I fear that I may have a serious memory problem.	☐	☐	☐	☐	☐
My memory is worse than most other people my age.	☐	☐	☐	☐	☐
I have confidence in my ability to remember things.	☐	☐	☐	☐	☐
When I have trouble remembering something, I'm not too hard on myself.	☐	☐	☐	☐	☐
I am concerned about my memory.	☐	☐	☐	☐	☐
My memory is really going downhill lately.	☐	☐	☐	☐	☐
I am generally satisfied with my memory ability.	☐	☐	☐	☐	☐

I get annoyed or irritated with myself when I am forgetful.	☐	☐	☐	☐	☐
I worry about my memory ability.	☐	☐	☐	☐	☐

Below is a list of common memory mistakes that people make. Decide how often you have done each one in the *last two weeks*, then place a tick in the appropriate box

	All the time	Often	Sometimes	Rarely	Never
Forget to pay a bill on time.	☐	☐	☐	☐	☐
Misplace something you use daily, like your keys or glasses.	☐	☐	☐	☐	☐
Have trouble remembering a telephone number you just looked up.	☐	☐	☐	☐	☐
Not recall the name of someone you just met.	☐	☐	☐	☐	☐
Leave something behind when you meant to bring it with you.	☐	☐	☐	☐	☐
Forget an appointment.	☐	☐	☐	☐	☐
Forget what you were just about to do; for example, walk into a room and forget what you went there to do.	☐	☐	☐	☐	☐
Forget to run an errand.	☐	☐	☐	☐	☐

In conversation, have difficulty coming up with a specific word that you want.	☐	☐	☐	☐	☐
Have trouble remembering details from a newspaper or magazine article you read earlier that day.	☐	☐	☐	☐	☐
Forget to take medication.	☐	☐	☐	☐	☐
Not recall the name of someone you have known for some time.	☐	☐	☐	☐	☐
Forget to pass on a message.	☐	☐	☐	☐	☐
Forget what you were going to say in conversation.	☐	☐	☐	☐	☐
Forget a birthday or anniversary that you used to know well.	☐	☐	☐	☐	☐
Forget a telephone number you use frequently.	☐	☐	☐	☐	☐
Retell a story or joke to the same person because you forgot that you had already told him or her.	☐	☐	☐	☐	☐
Misplace something that you put away a few	☐	☐	☐	☐	☐

days ago.					
Forget to buy something you intended to buy.	☐	☐	☐	☐	☐
Forget details about a recent conversation.	☐	☐	☐	☐	☐

People often use different tricks or strategies to help them remember things. Several strategies are listed below. Decide how often you used each one in the *last two weeks*. Then, place a tick in the appropriate box.

	All the time	Often	Sometimes	Rarely	Never
Use a timer or alarm to remind you when to do something.	☐	☐	☐	☐	☐
Ask someone to help you remember something or to remind you to do something.	☐	☐	☐	☐	☐
Create a rhyme out of what you want to remember.	☐	☐	☐	☐	☐
In your mind, create a visual image of something you want to remember, like a name and a face.	☐	☐	☐	☐	☐
Write things on a calendar, such as appointments or things you need to do.	☐	☐	☐	☐	☐
Go through the alphabet one letter at a time to see if it sparks a memory for a name or word.	☐	☐	☐	☐	☐
Organise information you want to remember;	☐	☐	☐	☐	☐

for example, organise your grocery list according to food groups.					
Say something out loud in order to remember it, such as a telephone number you just looked up.	☐	☐	☐	☐	☐
Use a routine to remember important things, like checking that you have your wallet and keys when you leave home.	☐	☐	☐	☐	☐
Make a list, such as a grocery list or a list of things to do.	☐	☐	☐	☐	☐
Mentally elaborate on something you want to remember.	☐	☐	☐	☐	☐
Put something in a prominent place to remind you to do something, like putting your umbrella by the front door so that you will remember to take it with you.	☐	☐	☐	☐	☐
Repeat something to yourself at increasingly longer and longer intervals so that you will remember it.	☐	☐	☐	☐	☐
Create a story to link together information you want to remember.	☐	☐	☐	☐	☐
Write down in a notebook things that you want to remember.	☐	☐	☐	☐	☐

Create an acronym out of the first letters in a list of things to remember, such as carrots, apples, and bread (cab).	☐	☐	☐	☐	☐
Intentionally concentrate hard on something so that you will remember it.	☐	☐	☐	☐	☐
Write a note or reminder for yourself (other than on a calendar or in a notebook).	☐	☐	☐	☐	☐
Mentally retrace your steps in order to remember something, such as the location of a misplaced	☐	☐	☐	☐	☐

Thank you for taking part in this questionnaire. We hope that this research will enable us to better understand changes in memory in older people. If you are interested in taking part in further research focusing on this area, please leave your name and contact details. All details will be treated confidentially and not passed on to any other source.

If you have a partner or know someone who may be interested in completing this questionnaire, please ask them to either fill in a blank copy of their own, or to contact us for another one. We are interested in people who do and do not complete crosswords.

APPENDIX THREE

Thank you for showing interest in this study. Some of you may have taken part in a similar questionnaire around 18months ago. If this is the case your answers would still be valuable here. The following questions are designed to investigate the relationship between intellectual activity levels and memory function. Please tick the boxes to indicate the correct response. These questions are for research purposes only. There are no right or wrong answers to these questions. Your responses and results will be kept anonymous.

Section One

	Please type your responses below
Age	
Sex	
Number of years of education (including university etc.)	
Occupation (or previous occupation)	

Section Two

For this section, please rate how often you do the following things on the scale shown.

	Every day	Several times a week	Several times a month	Less than once a month	Never
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐
Read books or newspaper	☐	☐	☐	☐	☐
Playing cards	☐	☐	☐	☐	☐
Quiz	☐	☐	☐	☐	☐
Board games (eg cluedo, chess etc)	☐	☐	☐	☐	☐
Play a musical instrument	☐	☐	☐	☐	☐
Study a foreign language	☐	☐	☐	☐	☐

Please indicate the combination that best describes your crossword participation

I attempt…	
No Crosswords	☐
Only Quick Crosswords	☐
Only Cryptic Crosswords	☐
Only General Knowledge Crosswords	☐
Cryptic and Quick Crosswords	☐
Cryptic and General Knowledge Crosswords	☐
Quick and General Knowledge Crosswords	☐
Cryptic, Quick and General Knowledge	☐

Section Three
Please indicate in the boxes how much you agree with each of the following statements regarding cryptic crosswords.

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable
Doing cryptic crosswords helps to keep my mind sharp	☐	☐	☐	☐	☐	☐
Cryptic crosswords help me with everyday mental challenges	☐	☐	☐	☐	☐	☐
I find cryptic crosswords much more difficult nowadays	☐	☐	☐	☐	☐	☐
I feel I have lost the mental sharpness to do cryptic crosswords	☐	☐	☐	☐	☐	☐
Cryptic crosswords are enjoyable	☐	☐	☐	☐	☐	☐
Doing cryptic crosswords helps me meet people	☐	☐	☐	☐	☐	☐
When I cannot solve a cryptic clue it makes me concerned about my	☐	☐	☐	☐	☐	☐

mental ability						
Finishing a cryptic crossword makes me feel good about my mental abilities	☐	☐	☐	☐	☐	☐
The logic behind cryptic crossword clues has no bearing on everyday reasoning	☐	☐	☐	☐	☐	☐
Doing cryptic crosswords makes me more aware of how my memory has declined with age	☐	☐	☐	☐	☐	☐
Doing cryptic crosswords helps me think of other ways to keep my mind sharp	☐	☐	☐	☐	☐	☐
Doing cryptic crosswords prevents Alzheimer's disease	☐	☐	☐	☐	☐	☐
I've found as I've aged that cryptic crosswords have got easier	☐	☐	☐	☐	☐	☐

Section Four

Please indicate in the boxes how much you agree with each of the following statements regarding general knowledge crosswords.

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Not Applicable
Doing general knowledge crosswords helps to keep my mind sharp	☐	☐	☐	☐	☐	☐
General knowledge crosswords help me with everyday mental challenges	☐	☐	☐	☐	☐	☐
I find general knowledge	☐	☐	☐	☐	☐	☐

crosswords much more difficult nowadays						
I feel I have lost the mental sharpness to do general knowledge crosswords	☐	☐	☐	☐	☐	☐
General knowledge crosswords are enjoyable	☐	☐	☐	☐	☐	☐
Doing general knowledge crosswords helps me meet people	☐	☐	☐	☐	☐	☐
When I cannot solve a general knowledge clue it makes me concerned about my mental ability	☐	☐	☐	☐	☐	☐
Finishing a general knowledge crossword makes me feel good about my mental abilities	☐	☐	☐	☐	☐	☐
Doing general knowledge crosswords makes me more aware of how my memory has declined with age	☐	☐	☐	☐	☐	☐
Doing general knowledge crosswords helps me think of other ways to keep my mind sharp	☐	☐	☐	☐	☐	☐
Doing general knowledge crosswords prevents Alzheimer's disease	☐	☐	☐	☐	☐	☐
General knowledge crossword clues have no bearing on	☐	☐	☐	☐	☐	☐

everyday reasoning						
I've found as I've aged that general knowledge crosswords have got easier	☐	☐	☐	☐	☐	☐

Section Five

Please indicate in the boxes how much you agree with each of the following statements

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
If I was given a list of 10 random words I would be able to remember all of them without noting them down	☐	☐	☐	☐	☐
I am able to devise mental strategies to remember important things (e.g. visualising an item I need to buy)	☐	☐	☐	☐	☐
When information is on the tip of my tongue I can generally retrieve it	☐	☐	☐	☐	☐
I rely on making notes/lists to remember things	☐	☐	☐	☐	☐
I rely on other people to ensure I remember important things	☐	☐	☐	☐	☐

Section Six
Please complete the sentences below by choosing a percentage value

	100%	75%	50%	25%	0%
If I was shown a list of 15 words I would remember ___% of them	☐	☐	☐	☐	☐
In my prime, if I was shown a list of 15 words I would remember ___% of them	☐	☐	☐	☐	☐
If I went grocery shopping without a list I would remember ___% of the items I went to buy	☐	☐	☐	☐	☐
If I was introduced to 10 people I would remember ___% of their names one hour later.	☐	☐	☐	☐	☐

Thank-you very much for taking part in this questionnaire. If you have any queries please feel free to email me at nalmond944@aol.com

APPENDIX FOUR

Although this questionnaire is asking for information about habits regarding crosswords we are extremely interested in individuals who have either never attempted crosswords or have given up attempting crosswords. Please take a few minutes to fill in the questionnaire. Many of the questions only require a tick in the appropriate box. Your responses will be treated anonymously and will not be passed on to any third parties.

Section One

	Please type your responses below
Age	
Sex	
Number of years of education (including university etc.)	
Occupation (or previous occupation)	

Section Two

For this section, please rate how often you do the following things on the scale shown.

	Every day	Several times a week	Several times a month	Less than once a month	Never
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐

If you currently attempt all three crosswords, please move to section 4. Otherwise, please continue with section 3.

Section Three

This section focuses on individuals who do not undertake a specific type of crossword on a regular basis (regular basis indicates more than twice a month), please tick the appropriate description of each activity.

	Used to do but given up	Never attempted on a regular basis	NA
Quick crossword	☐	☐	☐
Cryptic crossword	☐	☐	☐
General knowledge crossword	☐	☐	☐

If you used to attempt any type of crossword please fill in the next four tables. If you have never attempted any crosswords on a regular basis please proceed to section five.

Please indicate what proportion of your life you have attempted each type of crossword on a regular basis.

	0 – 25%	26 – 50%	51 – 75%	76 – 100%	NA
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐

Quick Crosswords

If you have given up quick crosswords please indicate the reason for this. You can tick as many options as you like.

	Agree	NA
Lost interest	☐	☐
No time	☐	☐
Taken up other hobbies	☐	☐
Lost confidence	☐	☐
Found them too difficult	☐	☐
Lost the mental ability to complete them	☐	☐
Lost the physical ability to complete them	☐	☐
Unable to get hold of crosswords	☐	☐
Other	☐	☐

Cryptic Crosswords

If you have given up cryptic crosswords please indicate the reason for this. You can tick as many options as you like.

	Agree	NA
Lost interest	☐	☐
No time	☐	☐
Taken up other hobbies	☐	☐
Lost confidence	☐	☐
Found them too difficult	☐	☐
Lost the mental ability to complete them	☐	☐
Lost the physical ability to complete them	☐	☐
Unable to get hold of crosswords	☐	☐
Other	☐	☐

General Knowledge Crosswords

If you have given up general knowledge crosswords please indicate the reason for this. You can tick as many options as you like.

	Agree	NA
Lost interest	☐	☐
No time	☐	☐
Taken up other hobbies	☐	☐
Lost confidence	☐	☐
Found them too difficult	☐	☐
Lost the mental ability to complete them	☐	☐
Lost the physical ability to complete them	☐	☐
Unable to get hold of crosswords	☐	☐
Other	☐	☐

Section Four

Please only fill in this section if you <u>currently</u> attempt any specific types of crosswords on a regular basis.

This table is about how long you attempt each type of crossword for. Please indicate what proportion of your life you have attempted each type of crossword on a regular basis.

	0 – 25%	26 – 50%	51 – 75%	76 – 100%	NA
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐

Section Five

Please rate how easy you feel that these cryptic crossword clues are to solve.

	Very Easy	Fairly Easy	Moderate	Fairly Difficult	Very Difficult
1. Misshapen hat placed in cradle, rocked in church (9)	☐	☐	☐	☐	☐
2. Antelope – just born, we hear (3)	☐	☐	☐	☐	☐
3. Came in, holding can containing last of tea, and played host (11)	☐	☐	☐	☐	☐
4. Animal hiding in wardrobe? A stallion, maybe? (5)	☐	☐	☐	☐	☐
5. Be aware of shelf for encyclopaedia, perhaps (9)	☐	☐	☐	☐	☐
6. She was tied up, and Rome dared to hide her (9)	☐	☐	☐	☐	☐
7. Hirg? (Pythagorean) (11)	☐	☐	☐	☐	☐
8. Protection for chassis is subject to secrecy (9)	☐	☐	☐	☐	☐
9. Chase away, holding current carpet-cleaner (7)	☐	☐	☐	☐	☐
10. Observe bishopric (3)	☐	☐	☐	☐	☐

The solutions will appear at the end of the questionnaire.

Section Six

Please indicate how much you agree with each of the following statements

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
If I was given a list of 10 random words I would be able to remember all of them without noting them down	☐	☐	☐	☐	☐
I am able to devise mental strategies to remember important things (e.g. visualising an item I need to buy)	☐	☐	☐	☐	☐
I get the feeling I'm searching my memory for information that's on the tip of my tongue quite often.	☐	☐	☐	☐	☐
I rely on making notes/lists to remember things	☐	☐	☐	☐	☐
I rely on other people to ensure I remember important things	☐	☐	☐	☐	☐

Section Seven

Please tick the box which best completes the sentences below.

	100%	75%	50%	25%	0%
If I was shown a list of 15 words I would remember ___% of them	☐	☐	☐	☐	☐
In my prime, if I was shown a list of 15 words I would remember ___% of them	☐	☐	☐	☐	☐
If I went grocery shopping without a list I would remember ___% of the items I went to buy	☐	☐	☐	☐	☐
If I was introduced to 10 people I would remember	☐	☐	☐	☐	☐

___% of their names one hour later.					

Solutions to Cryptic Clues

1. Misshapen hat placed in cradle, rocked in church CATHEDRAL.
Misshapen is an anagram indicator, so an anagram of hat becomes ATH, cradle, rocked (another anagram indicator) becomes CEDRAL. The anagram of hat must then be placed within the anagram of cradle giving CATHEDRAL which is a type of church.

2. **Antelope – just born, we hear GNU**
'We hear' is an indicator of a homophone, meaning a word which sounds like another but is spelt differently. Just born can be new, and a type of antelope which sounds like new is a GNU.

3. **Came in, holding can containing last of tea, and played host. ENTERTAINED**
Came in gives us ENTERED, holding implies one word in another word. Can refers to a container, in this case a TIN. The "last of tea" gives us A. If you put these parts together with the cryptic meaning of "holding" you get ENTERTAIN. "Played the host" in this clue is the meaning indicator i.e. another word for ENTERTAINED.

4. **Animal hiding in wardrobe? A stallion, maybe? BEAST**
This clue suggests that there is an animal 'hiding' in the clue, this indicates the name can be found in the text but possibly split between words. In this case 'wardroBE A STallion' gives BEAST. "Maybe" indicates that the solution could be some kind of animal. Not necessarily a horse.

5. **Be aware of shelf for encyclopaedia, perhaps KNOWLEDGE**
To be aware of something is to KNOW and another word for shelf is LEDGE, put together to make KNOWLEDGE. Encyclopaedia is the meaning clue but the word 'perhaps' indicates that it is not another word for it, but it is a clue to the meaning.

6. **She was tied up, and Rome dared to hide her ANDROMEDA**
'Hide' is an indicator that the word is hidden within the text of the clue, 'AND ROME DAred'. The clues 'she' and 'tied up' allude to a famous women who has been tied up, in Greek mythology ANDROMEDA was tied up by her father.

7. **Hirg? (Pythagorean) RIGHTANGLED**
This is a backward anagram. Of the word in the clue 'Hirg' and the word tangled, which is an anagram indicator. The word 'Hirg' itself has no meaning. When Hirg and tangled are mixed up they make RIGHTANGLED the sort of triangles which feature in Pythagoras's famous theorem. This clue is extremely difficult and it is unlikely that other cryptic crosswords will have anything as difficult.

8. Protection for chassis is subject to secrecy UNDERSEAL
A double definition clue both halves allude to the same word. UNDERSEAL can mean to seal the chassis of a car with tar, but if something is under a wax seal it means it is subject to secrecy.

9. Chase away, holding current carpet-cleaner SHAMPOO
Chase away means the word SHOO, and held within this word is a word meaning current AMP, making SHAMPOO, which can be a carpet cleaner.

10. Observe bishopric. SEE
This is a double definition clue. Observe can represent SEE and bishopric.

APPENDIX FIVE

*This is a very quick questionnaire which is designed to assess the difficulty of certain cryptic crossword clues. We hope that you will find two minutes to fill in the questionnaire. We are trying to recruit individuals who do and do **not** attempt cryptic crosswords.* ***PLEASE COMPLETE THE QUESTIONNAIRE IN THE ORDER OUTLINED BELOW (i.e. section 1-4) AND PLEASE DO NOT FLICK THROUGH.***

Thank you for taking time to complete the questionnaire.

Section 1

Please fill in the following background information.

Age:	
Number of years in education (e.g. Primary school through to Postgraduate study):	
Occupation (or previous occupation if retired):	

Section 2

Please report your current crossword activity:

	Everyday	Several times a week	Several times a month	Less than once a month	Never
Cryptic crosswords	☐	☐	☐	☐	☐
Quick crosswords	☐	☐	☐	☐	☐
General knowledge crosswords	☐	☐	☐	☐	☐

Please indicate the amount of each crossword you complete (if you do not attempt a specific crossword more than several times a month, please tick not applicable):

	0 – 25%	26 – 50%	51 – 75%	76 – 100%	Not applicable
Quick crossword	☐	☐	☐	☐	☐

Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐

Please indicate how much effort is required to complete each type of crossword (if you do not attempt a specific crossword more than several times a month, please tick not applicable):

	0 – 25% effort	26 – 50% effort	51 – 75% effort	76 – 100% effort	Not applicable
Quick crossword	☐	☐	☐	☐	☐
Cryptic crossword	☐	☐	☐	☐	☐
General knowledge crossword	☐	☐	☐	☐	☐

Section 3

Please complete the following sentences by writing your answer in the space provided:

	Percentage
If I was shown a list of 15 words at my present age, I would remember ___% of them.	_ _ _%
When I think back to when I was in my prime (regarding my age), if I was shown a list of 15 words I would remember ___% of them.	_ _ _%
At my present age, if I went grocery shopping without a list I would remember ___% of the items I went to buy.	_ _ _%
At my present age, if I was introduced to 10 people I would remember ___% of their names one hour later.	_ _ _%

Section 4

Please try and complete the following ten cryptic crossword clues (even if you do not regularly attempt cryptic crosswords, please have a go):

1. Misshapen hat placed in cradle, rocked in church (9) _ _ _ _ _ _ _ _ _

2. Antelope – just born, we hear (3) _ _ _

3. Came in, holding can containing last of tea, and played host (11) _ _ _ _ _ _ _ _ _ _ _

4. Animal hiding in wardrobe? A stallion, maybe? (5) _ _ _ _ _

5. Be aware of shelf for encyclopaedia, perhaps (9) _ _ _ _ _ _ _ _ _

6. She was tied up, and Rome dared to hide her (9) _ _ _ _ _ _ _ _ _

7. Hirg? (Pythagorean) (11) _ _ _ _ _ _ _ _ _ _ _

8. Protection for chassis is subject to secrecy (9) _ _ _ _ _ _ _ _ _

9. Chase away, holding current carpet-cleaner (7) _ _ _ _ _ _ _

10. Observe bishopric (3) _ _ _

Thank you for taking part in this questionnaire. The solutions to each clue are on the next page.

Note that this appendix represents version one of this questionnaire and version two exchanged Section Three and Section Four. The solutions to Section Four can be found in Appendix IV.

APPENDIX SIX

Table A6.1. Word frequency ratings (Celex, 1993: wordforms per million for combined spoken and written frequency), AoA (months) and imageability ratings (1-7) taken from Morrison et al. (1997) for stimulus in Study Five.

Low-frequency				High-frequency			
Word	AoA	Frequency	Imageability	Word	AoA	Frequency	Imageability
Anchor	80.4	1.75	5.95	Apple	28.8	3.9	6.5
Axe	56.4	6.2	6.2	Arm	19.8	4.15	6.15
Bear	30.6	2.6	6.4	Biscuit	21.6	4.05	6.1
Bell	40.8	2.5	6.6	Bottle	27	4.25	6.35
Camel	64.8	1.65	6.4	Carrot	42	3.4	6.5
Cannon	82.8	1.5	5.55	Cigarette	66	3.3	6.25
Diamond	72	1.95	6.15	Dog	12	3.5	6.65
Donkey	40.8	2.1	6.55	Door	21.6	4.5	5.95
Flute	72	2.15	6.1	Foot	18	3.5	5.9
Gun	54	2.35	6.5	Glass	42	4.1	6
Harp	68.4	1.45	6	Hand	12	3.95	6.3
Helicopter	52.8	2	6.35	House	12	4	6.65
Judge	82.8	2.2	5.6	Jumper	38.4	4.15	6.2
Kite	49.2	1.65	6.65	Kettle	46.8	4.45	6.25
Leopard	66	1.55	6.15	Lips	32.4	2.85	6.2
Lobster	78	1.7	5.95	Microwave	108	3.2	5.85
Medal	70.8	1.6	5.8	Nose	14.4	3.6	5.8
Mountain	52.8	2.3	6.65	Pencil	37.2	4.05	6.35
Nut	82.8	2.6	5.7	Potato	36	3.9	6.2
Parachute	84	2.05	6.3	Purse	51.6	3.6	5.6
Pipe	68.4	2.05	5.65	Ring	48	3.45	5.95
Pumpkin	63.6	1.75	6.25	Ruler	54	3.1	5.75
Racoon	90	1.55	5.4	Sandwich	34.2	3.95	6.45
Shawl	79.2	1.55	5.45	Scissors	48	3.45	6.2
Ski	68.4	2.25	5.65	Shirt	46.8	3.75	6.3
Submarine	68.4	1.85	5.9	Table	25.2	4.2	6.55
Thimble	74.4	1.7	6	Telephone	42	4.35	6.4
Trumpet	63.6	1.9	6.4	Television	32.4	4.15	6.35
Windmill	55.2	1.9	6.5	Watch	42	4.1	6.3
Wizard	54	1.9	6.15	Window	38.4	3.85	6.15
Mean	65.58	2.08	6.1	Mean	36.62	3.83	6.21

APPENDIX SEVEN

Table A7.1. AoA (months; taken from Morrison et al., 1997), Word frequency ratings (Celex, 1993: wordforms per million for combined spoken and written frequency), and imageability ratings (1-7; taken from Morrison et al., 1997) for stimulus in Study Six.

Early-acquired				**Later-acquired**			
Word	AoA	Frequency	Imageability	Word	AoA	Frequency	Imageability
Aeroplane	42	3.1	6.55	Accordion	111.6	1.3	5.15
Balloon	28.8	2.9	6.55	Ashtray	70.8	2.9	5.55
Banana	25.2	3.7	6.55	Barn	64.8	2.2	5.75
Box	32.4	3.65	5.6	Barrel	79.2	2.15	6.1
Cake	28.8	3.4	6.4	Cactus	78	1.8	6.3
Clown	38.4	2	6.7	Candle	66	3.05	6.1
Cooker	44.4	4	5.85	Chisel	102	1.7	5.2
Crown	45.6	1.8	6.4	Eagle	66	1.95	6.2
Fence	42	2.4	5.95	Envelope	66	3.15	5.8
Flower	25.2	3	6.9	Genie	79.2	1.45	6.35
Glove	45.6	2.75	5.95	Microphone	97.2	2.05	6.1
Hat	23.4	2.9	6.66	Needle	69.6	2.6	6.05
Jelly	34.2	2.1	6	Nun	74.4	1.9	6.2
Jigsaw	38.4	1.95	6.25	Ostrich	67.2	1.65	5.65
Mitten	40.8	1.5	5.6	Padlock	81.6	2.6	5.6
Moon	34.2	3	6.65	Peach	64.8	2.95	5.9
Paintbrush	43.2	2.1	6.4	Pepper	62.4	3.6	5.45
Piano	45.6	2.65	6.35	Pineapple	64.8	2.65	6.25
Scarecrow	48	1.85	6.05	Pliers	98.4	1.9	5.85
Sheep	25.2	2.8	6.4	Porter	114	3.35	4.4
Slide	37.2	2.45	5.9	Scales	69.6	2.6	5.6
Snake	34.2	2.3	6.7	Screwdriver	72	2.5	6
Snowman	25.2	2.2	6.55	Seahorse	72	1.45	5.45
Strawberry	44.4	2.75	6.6	Skunk	80.4	1.35	5.55
Swing	32.4	2.35	6.3	Telescope	76.8	1.85	5.95
Tiger	46.8	2.2	6.6	Typewriter	67.2	2.1	5.85
Tractor	45.6	2.35	6.15	Vase	70.8	2.5	6.55
Umbrella	46.8	2.5	6.6	Violin	64.8	2.15	6.4
Wheel	38.4	2.95	6.45	Waistcoat	79.2	2.6	5.7
Witch	42	2.3	6.7	Zebra	68.4	1.75	6.5
Mean	37.48	2.6	6.34	Mean	76.64	2.26	5.85

APPENDIX EIGHT

Table A8.1. Ranked popularity of proper names taken from Merry (1995) used in Study Seven.

Popular Names			Unpopular Names		
Name	1944 Rank	1994 Rank	Name	1944 Rank	1994 Rank*
Andrew	45	20	Alan	8	101
Anthony	6	56	Barbara	10	101
Catherine	42	45	Barry	20	101
Charles	38	41	Bernard	37	101
Christopher	16	14	Brian	7	101
David	2	24	Carol	12	101
Edward	29	43	Colin	15	101
Elizabeth	15	25	Dennis	34	101
George	21	17	Derek	27	101
Georgina	84	33	Eric	39	101
Harry	65	6	Evelyn	71	101
Heather	58	76	Frederick	42	101
Helen	45	80	Gordon	44	101
Henry	63	48	Graham	22	101
James	10	2	Ian	23	101
Jennifer	18	42	Julia	70	101
John	1	37	Keith	14	101
Maria	57	86	Malcolm	24	101
Martin	41	87	Norman	43	101
Mary	4	94	Pamela	17	101
Michael	3	11	Pauline	14	101
Nicholas	76	42	Raymond	17	101
Patrick	31	63	Reginald	71	101
Paul	28	66	Ronald	26	101
Peter	4	51	Roy	30	101
Richard	11	49	Shirley	39	101
Robert	5	25	Terence	18	101
Sarah	86	12	Trevor	33	101
Thomas	19	2	Valerie	11	101
William	9	7	Veronica	52	101
Mean	31.07	40.13	Mean	29.67	101

*All names ranked as 101 due to only ranking available was 1 through 100.