Memory Compensation in Older Adults:
Assessment of Structural Characteristics and Individual Growth Trajectories

by

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ABSTRACT

Older adults can preserve their everyday memory competence, despite increasing limits to plasticity, by engaging in compensatory strategies. The ability to mitigate losses in cognitive functioning and optimize development can be achieved through a variety of compensation mechanisms. Identifying means of enhancing cognitive competence in everyday life is an important focus for gerontological research. Compensating for memory deficits or losses in normal aging is the focus of this study. The self-report Memory Compensation Questionnaire (MCQ) was used to measure five mechanisms of everyday memory compensation, as well as two general aspects of compensatory motivation and awareness. The MCQ was administered on three occasions, at 3-year intervals, to a large sample of healthy older adults (initially aged 55-85 years) from the Victoria Longitudinal Study (VLS). Data collected from the VLS archives is used to investigate four linked goals about memory compensation in late life. The first goal is to examine the underlying structure of memory compensation using the MCQ. The structure of memory compensation was identified using confirmatory factor analyses. The second goal addresses the issue of measurement invariance of the structure of the MCQ across age groups (young-old and old-old), gender, and time (three waves). The structure of memory compensation was equivalent across groups and occasions. The third goal focuses on examining both 6-year mean-level change (in three occasions) and interindividual differences (variability) in intraindividual changes in memory compensation using growth curve analyses. Late life changes in efforts to use memory compensation mechanisms were identified at the group-level (e.g., average increase in external aids) and at the individual-level (i.e., variability in average growth trajectories). The fourth goal tests for sources of individual differences in intraindividual changes in memory compensation over the six-year period. The covariates were chronological age, biological age, personality dispositions, memory self-efficacy, and episodic memory performance. Variability in changes in memory compensation were influenced by chronological age, several personality dimensions (e.g., conscientiousness, neuroticism), memory self-efficacy, and better memory performance. Adapting to memory challenges in the presence of resource limitations is pivotal for research advances in cognitive resilience and successful cognitive aging.

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Chapter 1

Introduction

Memory Compensation in Older Adults:
Assessment of Structural Characteristics and Individual Growth Trajectories

The decline of cognitive abilities in old age is well documented. Despite the presence of cognitive changes, the aging mind has the potential to alter its course of development (Baltes, 1993). The ability to mitigate losses in cognitive functioning is made possible partly through a set of mechanisms under the rubric "compensation" (Baltes, 1987; Dixon & Bäckman, 1995). Compensatory mechanisms are a vehicle for optimizing development and overcoming cognitive challenges. At a time in the lifespan when vulnerability to cognitive losses is high, shifting research attention to identifying means of enhancing cognitive competence in everyday life is an important focus for gerontological research.

Of special interest in the present study is the compensation for memory deficits or losses in normal aging (Dixon & Bäckman, 1999). Given that older adults experience memory problems, the potential for compensating for such memory difficulties becomes especially pivotal in the later portion of the lifespan. In the Victoria Longitudinal Study (VLS), initial work using the self-report Memory Compensation Questionnaire (MCQ) has documented that older adults report using many identifiable forms of memory compensation strategies (Dixon, de Frias, & Bäckman, 2001). The present study further examines memory compensation and aging using the multidimensional MCQ in a sample of older adults.

The present study uses a variety of data from the VLS archives to investigate four linked goals pertaining to memory compensation in late life. The first goal is to examine the structure of memory compensation using the MCQ. Confirmatory factor analyses are used to test the underlying structure of the five memory compensation strategies and the two general processes.

The second goal addresses the issue of measurement invariance of the structure of the MCQ across age groups, gender, and time (three waves). In principle, only after establishing equivalence in the structure of memory compensation can the researcher make meaningful inferences about quantitative group differences or longitudinal changes in the use of memory compensation mechanisms. Developmental researchers typically assume that psychological constructs hold the same meaning across multiple occasions of measurement (or between age groups). Invariance testing evaluates the validity of this important assumption.

The third goal of this study focuses on two related aspects of change in memory compensation elements: (a) to examine 6-year mean-level change (in three occasions), and (b) to evaluate interindividual differences (variability) in intraindividual changes. Growth curve analyses will be used to examine both aspects of change in memory compensation. It is expected that changes in the use of memory compensation strategies will occur at the group level (e.g., increases in external aids), along with variability in individual trajectories of change.

The fourth goal tests for sources of individual differences in intraindividual changes in memory compensation over the six-year period. Biological (e.g., biological age), cognitive (e.g., memory performance), and psychosocial (e.g., beliefs, personality) systems of influence are examined. More specifically, the covariates under study are: (a) chronological age, (b) biological age, (c) personality dispositions, (d) memory self-efficacy, and (e) memory performance.

The second chapter of this dissertation reviews the literature on compensation and aging. First, research on psychological compensation (especially memory) and measurement issues are raised. Second, a review of the literature on individual difference indicators in cognitive aging and their relevance to memory compensation is outlined. Sources of variation in cognitive changes have commonly been attributed to chronological age. A growing area of research focuses on the influence of biological age on cognitive changes (e.g., Anstey, Lord, & Smith, 1996; Baltes & Lindenberger, 1997; Christensen et al., 2000; Lindenberger & Baltes, 1994). Of interest is whether chronological age or biological age accounts for variability in rates of change in memory compensation. Psychosocial variables (e.g., personality dispositions and memory self-efficacy) may be identified as resources that foster competence in memory-demanding activities. This study will aim to identify a profile of personality dispositions and self-efficacy beliefs about memory that influence individual trajectories of memory compensation. Memory plasticity (or the ability to modify memory functioning) is a pivotal premise of memory compensation, and the ability to plan and implement compensatory strategies may be related to actual memory performance. The present study examines whether memory performance levels are influential sources of variation in individual trajectories of memory compensation. The goals and hypotheses of this study are detailed following the literature review.

The third chapter contains the methods of the study. Detailed information on the participants, measures, and statistical analyses are presented. The results of the statistical analyses are detailed in the fourth chapter. The fifth chapter contains a discussion of the results drawing on the available current literature, as well as implications, study limitations and future directions.

By pursuing the investigation of these four key goals, the present study will contribute to our understanding of the underlying structure of memory compensation, late life changes in efforts to compensate for memory impairments and changes, and influences on variability in changes in memory compensation. Attaining a better understanding of these issues will promote both theoretical endeavours in cognitive aging and improve our opportunities to promote successful cognitive and adaptive aging.

Chapter II

Literature Review

How can older adults preserve their everyday cognitive competence in the face of declining abilities and increasing limits to plasticity? Adverse cognitive impairments in late adulthood may be overcome by using compensatory strategies (Baltes, 1997; Bäckman & Dixon, 1992; Dixon & Bäckman, 1999). Compensation refers to processes of overcoming, or adapting to, age-related impairments or deficits (Dixon & Bäckman, 1995). Many healthy older adults experience memory failures (Bäckman, Small, & Wahlin, 2001; Hultsch, Hertzog, Dixon, & Small, 1998) and believe their memory to be declining (Hertzog & Hultsch, 2000), yet surprisingly little research has addressed compensation for memory changes. Developing the means to adapt to inevitable memory adversities is a central focus for anyone interested in aging successfully.

Psychological Compensation

Several mechanisms of compensation have been identified (Bäckman & Dixon, 1992; Dixon & Bäckman, 1995), and these can be applied to cognitive (e.g., memory) and noncognitive (e.g., social) domains. They are (a) remediation (e.g., investing more time or effort in overcoming a loss), (b) substitution (e.g., developing a new skill to replace a declining or ineffective one), (c) accommodation (e.g., adjusting goals and criteria to be more consistent with current demands and one's ability level), and (d) assimilation (e.g., modifying the environmental demands or expectations of others). The successful implementation of such behaviors may improve person-environment fit by reducing the discrepancy between normal older adults' capabilities and their daily demands (e.g., remembering to take medication, or remembering an appointment).

Research on psychological compensation and aging has included a broad network of domains such as: (a) maintaining everyday competence or professional success (e.g., Abraham & Hanson, 1995; Dixon, 1995; Freund & Baltes, 1998), (b) accommodating to personal or social losses (e.g., Brandtstädter & Wentura, 1995; Carstensen, Hanson, & Freund, 1995), (c) activating or recruiting new neuroanatomical regions related to task performance (e.g., Dixon & Bäckman, 1999; Reuter-Lorenz, Stanczak, & Miller, 1999), (d) overcoming normal sensory or cognitive deficits in late life (e.g., Salthouse, 1995; Wahl, Oswald, & Zimprich, 1999), and (e) rehabilitating or adjusting behaviorally to neurological diseases or injuries (e.g., Glisky & Glisky, 1999; Wilson, 1999). Although involving different levels of analysis (e.g., neurobiological to behavioral) and research methods, this rapidly growing body of research has underscored the promising nature of the concept of compensation for promoting healthy aging.

Memory compensation. A variety of experimental, clinical, and verbal report methods can be applied to memory compensation research (Dixon & Bäckman, 1992-93; Wilson, 1999; Wilson & Watson, 1996). An existing verbal report measure is the multidimensional Memory Compensation Questionnaire (MCQ; Dixon & Bäckman, 1992-93). The MCQ assesses self-reported efforts to compensate for memory losses, commitment to memory tasks, and awareness of memory changes. The MCQ contains five scales representing different aspects of everyday memory compensation behaviors. When available cognitive resources are insufficient, alternative means are needed to reach a desired goal (e.g., remembering to do something). The activation of substitutable skills is the most common type of memory compensation, and is represented in the MCQ in three scales: (a) external aids, (b) internal mnemonic strategies, and (c) relying on other people for memory assistance. External aids have been noted for their frequent use and effectiveness in various populations (e.g., Dixon & Hultsch, 1983; Glisky & Glisky, 1999). The use of mnemonics in normal aging and neuropsychological settings has been explored by many scholars (e.g., Camp, Markley, & Kramer, 1983; Kliegl & Baltes, 1987; Wilson & Watson, 1996). Because such strategies are associated with new learning, they may be less self-initiated in both normal and clinical populations of older adults (Dixon & Hultsch, 1983; Wilson, 1999), indicating that their frequency of use may be lower than other forms of compensation. Relying on other people (e.g., friend, caregiver) in one's social network is a relatively low-demand means of compensating for lost or ineffective cognitive resources. Indeed, drawing on a social support system can help maintain everyday memory performance (e.g., Dixon, 1999; Dixon & Gould, 1998; Wilson, 1999) and personal independence by freeing up resources for other activities (M. Baltes, 1995).

Memory compensation through the mechanism of remediation is represented by two MCQ scales that tap investment strategies. One scale measures the extent to which adults invest more time (e.g., reading slower, studying longer) in performing memory skills. A second scale taps the application of effort (e.g., increasing concentration) when performing a memory task. Time and effort are important (and demanding) cognitive resources which may be particularly vulnerable in late life (e.g., Bäckman & Dixon, 1992). Although extra time and effort may be needed as a result of slowed processing efficiency (Salthouse, 1996), extensive investment of these internally-driven strategies may be taxing for older adults with more serious memory impairments. Alternatively, externally-driven strategies (e.g., relying on other people for memory assistance) may be more successful (Glisky & Glisky, 1999; Wilson, 1999).

Two general constructs are represented by scales in the MCQ. One scale measures the beliefs, expectations, and criteria for success in everyday memory. The commitment or motivation to perform well in everyday memory tasks (although not a strategy) may be linked conceptually to actual compensatory efforts in daily life (e.g., Dixon & Bäckman, 1999; Prigatano, 1999). Correspondingly, goal adjustment, or the shifting of criteria of success, reflects accommodative-type processes. In principle, developing a lower criterion of success can guard an individual's sense of control by keeping goals commensurate with personal cognitive resources and daily memory demands. The second general construct represented is the awareness of changes in the need for memory compensation over the 5- to 10-year period prior to testing. Reporting that more memory compensation has been required recently may reflect insight into memory losses or difficulties. Some memory-impaired individuals may be unaware of, or deny, a cognitive deficit (e.g., Fleming, Strong, & Ashton, 1996). Fortunately, such metacognitive processes of awareness and monitoring are relatively intact in healthy older adults (Hertzog & Hultsch, 2000). Indeed, awareness of a memory deficit may be a first step to self-initiated compensatory strategy use (Dixon & Bäckman, 1995).

In a previous study, Dixon, de Frias, and Bäckman (2001) used the MCQ to investigate the extent to which memory compensation strategies were used by normal older adults in everyday life, and the extent to which this usage underwent mean-level change over a 3-year period. Based on this earlier study, the MCQ showed acceptable psychometric (reliability) properties across two occasions and two samples (alphas range .65-.83). In that sample of 55-85 year old men and women, the most commonly used compensatory strategy was external aids. However, interesting age by gender interactions were noted. Specifically, older men reported greater use of MCQ External and Reliance than younger men, whereas women were age invariant on these mechanisms. Three-year follow-up assessments showed no mean-level change in the frequency of engaging in any compensatory strategies. Based on this earlier work, the MCQ promises to be a useful tool for examining patterns of change and characteristics that may influence variation in change.

Measurement issues. When making quantitative comparisons across groups (in cross-sectional studies) or within a group across occasions of measurement (in longitudinal studies), assumptions are made about measurement equivalence (Hertzog & Dixon, 1996; Horn & McArdle, 1992; Horn, McArdle, & Mason, 1983; Labouvie, 1980; Schaie & Hofer, 2001). The term measurement equivalence (or invariance) refers to the assumption that the construct of interest (the dependent variable) has similar meaning to different groups or that this meaning remains equivalent over time (for the same group). Essentially, this implies that there is equivalence in the relations between the observed measure and the underlying construct (i.e., in the measurement properties) at all points of measurement or between groups. When this assumption is violated it is difficult to disentangle whether observed quantitative differences or changes in a psychological variable reflect differences (or changes) in how individuals behave on the measure or in the construct of interest (Hertzog & Dixon, 1996; Horn & McArdle, 1992). Stated differently, quantitative mean-level group differences or longitudinal changes in a construct may indicate instead that different constructs are being measured at each occasion or between groups, rather that actual quantitative differences (or changes) in the same construct. Accordingly, measurement invariance allows for meaningful inferences about group differences or longitudinal changes.

Before examining further mean-level changes and individual differences in intraindividual change in memory compensation, it is useful to determine the measurement equivalence of this construct. The confirmatory factor structure of memory compensation has not been empirically determined, nor has the measurement invariance of the memory compensation construct. In developmental research, commonly examined comparisons include both age and gender differences, along with longitudinal changes in a psychological construct. Too often such comparisons are made without first testing whether the same psychological constructs have equivalent qualitative (e.g., the same number and pattern of latent factors) and quantitative (e.g., invariance of factor weights) measurement properties. These measurement issues are addressed in the first and second goals of this study.

After testing for measurement invariance of the MCQ across group (age, gender) and longitudinal comparisons (i.e., stability of the factor structure across three occasions), the next key goal is to examine longitudinal changes in reported use of memory compensation behaviors. Previous research in the MCQ from the Victoria Longitudinal

Study revealed no mean-level intraindividual change in any scales over a 3-year period (Dixon et al., 2001). Since actual episodic memory performance shows little or no change over this relatively short period (Hultsch et al., 1998), quite conceivably older adults would not perceive the need to increase the use of compensatory behaviors to maintain effective levels of competency in daily memory activities. Traditional studies of change typically use statistical tests that assume parallel rates of change for all individuals (Willet, 1988). The present study uses growth curve analyses (Bryk & Raudenbush, 1992) to assess intraindividual change trajectories along with individual differences (variability) in change. Is there 6-year mean-level change in memory compensation? Does growth vary across individuals? Do some people use more, less, or the same amount of compensatory strategies over time? What are the between-person sources of variation in change? These are the type of questions that are addressed in the third and fourth goals of this study. The importance of studying interindividual differences in intraindividual changes (or differential trajectories of intraindividual change) has been documented in developmental research (Dixon & Hertzog, 1996; Hertzog & Dixon, 1996; Nesselroade, 1991; Schaie & Hofer, 2001).

Individual Difference Indicators and Memory Compensation

Several plausible reasons exist for why individuals may change at different rates and in different directions and why heterogeneity in developmental trajectories (e.g., growth, decline, or stability) may be observed. The following sections focus on factors that are known correlates and sources of variability (individual differences) in cognitive aging (for review, see Bäckman et al., 2001; Hultsch et al., 1998; Lindenberger &

Reischies, 2001; Schaie, 1996), and especially their relevance to the domain of interest in this study, memory compensation and aging. Domains of functioning from biological (e.g., health) and cultural (e.g., self-referent beliefs) systems of influence are presented.

Indices of functional age. Sources of variation (or individual differences) in cognitive change have commonly been attributed to developmental age. The most typically used index is the passage of time (or chronological age). However, chronological age is merely an index of time along which endogenous-biological and exogenous-environmental events occur (Birren & Cunningham, 1985). To understand why individuals differ in change necessitates an understanding of the underlying mechanisms driving these behavioural changes. An alternative index of developmental age includes indices based on specific aspects of functioning. The maturation of an individual's relative functional capacity is termed biological age (Anstey, Lord, & Smith, 1996). Biological age may be a more accurate measure of functional age than the passage of time (or one's position in the lifespan). To illustrate, a 70-year old individual may have an older biological age as a result of secondary (disease-related) aging. Because a given individual's chronological age and biological age may be incongruent, it becomes important to identify and use alternative markers of underlying physiological status as determinants of negative changes in memory performance. Indices of biological age are termed biomarkers, and include a broad spectrum of measures in the sensorimotor (e.g., visual acuity, grip strength), physiological (e.g., forced expiratory flow), and genetic (e.g., Apolipoprotein e4) domains. To the extent that biological age reflects physiological mechanisms and changing systems, it may be a more accurate and sensitive marker of functional age. Some areas of research have begun to use biomarkers to predict specific functional outcomes (e.g., driving, falls, and cognitive functioning; Anstey et al., 1996).

Researchers have attempted to isolate both cognitive (e.g., speed of processing; Salthouse, 1996) and noncognitive (e.g., sensory functioning, grip strength; Anstey & Smith, 1999; Baltes & Lindenberger, 1997; Christensen et al., 2000; Christensen, Mackinnon, Korten, & Jorm, 2001; Lindenberger & Baltes, 1994) measures that are mediators of cognitive aging. Much evidence is derived from cross-sectional designs (e.g., Anstey & Smith, 1999), but longitudinal studies are becoming available (e.g., Christensen et al., 2000; MacDonald, Dixon, Cohen, & Hazlitt, in press). The overall finding is that lower biological functioning is associated with poorer cognitive performance in late adulthood. MacDonald and colleagues (in press) reported that individuals with an average/older biological age declined faster on word recall than individuals with a younger biological age, across five waves in the Victoria Longitudinal Study. Using a longitudinal data set, Christensen and colleagues (2000) reported that initial levels of grip strength was not related to initial levels of memory performance, but that mean-level changes in both domains were related. By contrast, initial sensory impairments predicted memory changes. Christensen and colleagues state that changes in select biomarkers (i.e., grip strength, speed of processing) and memory covary over time.

The relatively high correlation between chronological age and biological age has lead to the criticism that relations of the latter with cognitive aging are spurious (Salthouse, Hambrick, & McGuthry, 1998). However, others argue that the unique variance explained by biological age after accounting for chronological age would support the former as a unique and meaningful index (Anstey & Smith, 1999). Interestingly, biological age accounted for unique variance in changes in memory performance (word and text recall), independent of chronological age (MacDonald et al., in press).

One postulation for these cross-domain (i.e., cognitive and noncognitive) associations is that abilities become dedifferentiated in late life (Baltes, 1997; Baltes, Lindenberger, & Staudinger, 1998; Lindenberger & Baltes, 1994), which implies that loss of functioning in multiple, and seemingly independent, domains is attributed to one or more common underlying mechanisms operating at the neurophysiological level. The integration of functioning across systems presupposes that age-related changes in some subsystems (e.g., visual) have implications for functioning in other systems (e.g., memory). For example, an individual with vision or hearing impairments may have difficulty participating in cognitive activities that require sensory capabilities, such as reading a newspaper or engaging in a conversation.

Given that biological limitations put increasing constraints on reserve capacity (Baltes et al., 1998), direct assessments of sensory and physiological status could act as potentially viable indexes of cognitive resources. Biological health status is a window to cognitive vulnerabilities and concomitant needs to enact compensation strategies. Accordingly, the interplay between age-related losses in biological functioning and memory compensation warrants attention. Demonstrating that biological age is a marker of changes in memory compensatory behaviors would indicate that biological processes moderate older adults' efforts to compensate for the reduced efficiency in the cognitive mechanics of the aging mind (i.e., memory). If losses in auditory and visual acuity reflect decline in the central nervous system, then investment of additional resources (extra time and effort) would be required to maintain successful memory functioning. Alternatively, decrements in sensorimotor functioning may require older adults to invest greater amounts of cognitive resources into compensating for such losses leaving less time available for managing other functional losses (e.g., memory; Li, Lindenberger, Freund, & Baltes, 2001; Lindenberger & Baltes, 1994). In support of this argument Li and colleagues (2001) reported an age-related selection of walking over memorizing (using a dual task paradigm), such that physical injury had greater costs over memory failure for older adults. On the one hand, older adults may elect to prioritize the compensation of health ailments over memory failures. On the other hand, poor health (e.g., sensory) status may lead to an increased use of investment-type compensatory strategies (e.g., reading a passage more slowly).

The relation between physical health conditions and memory compensation has been examined in a recent study by de Frias, Dixon, and Bäckman (2003). de Frias and colleagues found that (a) the presence of respiratory illness was related to applying less effort in daily memory activities, and (b) the presence of infirmities (i.e., arthritis, visual impairment, and back trouble) was related to investing greater time and effort in memory activities, and to relying more on others for memory assistance. In parallel to the findings of Li et al. (2001), respiratory illness may place constraints on one's personal resources, which could interfere with (or consume) the resources needed to engage in investment strategies. By contrast, the latter physical ailment is potentially more manageable and, therefore, more conducive to remediable efforts. Indeed, the limitation of resources and its effect on priorities in late adulthood should be considered when studying assistive strategies and the motivation to compensate.

Psychosocial indicators. Other sources of individual differences in intraindividual change (other than chronological age and biological age) are of interest. Psychosocial resources (e.g., personality dispositions and self-referent beliefs) have been examined in memory (Cavanaugh & Murphy, 1986; Meier, Perrig-Chiello, & Perrig, 2002; Lachman, 1991), metamemory (Lachman, Weaver, Bandura, Elliott, & Lewkowicz, 1992; Ponds & Jolles, 1996), and general compensation (Freund & Baltes, 1998, 2002) literatures. Meier et al. (2002) found that neuroticism was negatively correlated with everyday memory recall tasks, whereas extraversion had a positive relation. These results are similar to what other researchers have found with general compensation (Freund & Baltes, 1998, 2002). Psychosocial variables may serve as a key to identifying important resources that prolong functional competence and successful cognitive aging. The ability to adapt to functional loss or disability in practical memory situations might be determined by personality and metamemory domains of functioning.

The MCQ has been examined in relation to a variety of correlates in the psychosocial domain (as well as background and health characteristics). In a previous study, de Frias and colleagues (2003) explored the extent to which personality traits were associated with reported use of memory compensation strategies (using the MCQ). The key finding was that higher neuroticism and conscientiousness were related to reported use of several memory compensation strategies. A profile of a conscientious disposition includes showing competence, self-discipline, and goal planning (McCrae & John, 1992). This profile represents having a disposition to take control of one's ability to remember everyday information by actively engaging in planful goals (e.g., strategy implementation) in order to overcome memory-related losses. Conscientious individuals may be better able to manage challenging (memory) situations because they are prepared psychologically (e.g., anticipation and planning skills; Baltes et al., 1998). The neuroticism-memory compensation link is supported by existing literature that reports relations between neuroticism and number of coping strategies used (David & Suls, 1999), indices of general selection, optimization, and compensation (Freund & Baltes, 1998), and memory complaints (Ponds & Jolles, 1996). Feeling preoccupied and anxious about one's level of memory functioning may be the impetus needed to commit to compensatory strategies. On the other hand, to the extent that neuroticism places constraints on already depleted processing resources (e.g., preoccupation with worries and not focusing on task-related thoughts), it could also have detrimental effects on memory performance (Meier et al., 2002).

Cognitive resilience is the ability to overcome cognitive challenges and maintain cognitive functioning despite impairments (Staudinger, Marsiske, & Baltes, 1995). It may be facilitated by a unique constellation of personality dispositions by (a) becoming aware of memory difficulties, and (b) choosing to partake in behaviors that compensate for memory losses. A goal of the present study is to extend existing literature by exploring whether personality dispositions account for interindividual differences in 6-year intraindividual changes in mechanisms of memory compensation. In particular, neuroticism and conscientiousness are expected to have reliable associations with variations in intraindividual changes in MCQ scales. The present study will help to identify the constellation of personality dispositions that might be helpful (or detrimental) when negotiating and overcoming memory challenges is a goal in life.

A second psychosocial resource from the metamemory domain is self-referent beliefs about memory. As declines in cognitive processes (e.g., working memory, attention; Park, 2000) become more prevalent in late life, so might concerns about failures to remember information critical for everyday functioning. Perceptions of one's memory ability may influence task-related goals that people set for themselves (e.g., developing means to compensate for memory inadequacies). Beliefs that people hold about their competence in memory demanding situations have been linked to memory performance (Hertzog & Hultsch, 2000) and memory compensation (de Frias et al., 2003).

Metamemory processes may influence the extent to which older adults implement compensatory behaviors in response to actual or perceived memory changes. Several components of metamemory are noted in the literature including memory appraisals, self-efficacy, and control beliefs which are related to strategy construction or implementation and cognitive performance. Memory appraisals are noted to influence strategy selection (Berry, 1999; Berry & West, 1993; Cavanaugh, 1996; Hertzog & Dixon, 1994; Hultsch & Hertzog, 2000). Goal setting (e.g., managing a memory deficit by constructing a strategy) might be partly determined by self-efficacy beliefs (West, Welch, & Thorn, 2001). Bandura (1989) believes that self-efficacy affects task engagement behaviors (e.g., effort, persistence) which then influences cognitive performance (see also Berry & West, 1993).

Older adults report more memory complaints and have a lower perception of their memory ability than younger adults (Hultsch, Hertzog, & Dixon, 1987). Personal control over memory is another metamemory component which refers to beliefs about whether an individual can do something to improve the probability of recalling information (Lachman, 1991). Control beliefs about memory have been positively linked to coping strategies (i.e., external and internal memory strategies and social comparison; Verhaeghen, Geraerts, & Marcoen, 2000) and memory strategies (Lachman et al., 1992). Based on these findings, metacognitive processes (specifically self-referent beliefs about memory) may partly determine whether memory strategies are perceived as necessary, and consequently implemented.

de Frias and colleagues (2003) found that older adults with high memory self-efficacy (MSE) believed that their actual efforts to use memory compensation strategies had changed least in the preceding 5-10 year period. Furthermore, de Frias and colleagues found that higher memory self-efficacy was related to lower frequency of current strategy use. If healthy older adults believe their memory is relatively stable, and they hold high expectations about their capabilities, then arguably there is no need to use memory compensation strategies.

An interesting question is how self-efficacy beliefs about memory influence actual long-term changes in the use of memory compensation strategies in everyday life. As noted above, the previous cross-sectional VLS work showed that older adults who believe their memory to be stable tended to engage less frequently in concurrent compensation strategies. Nevertheless, over the long-term (with advancing age) the direction of the MSE-memory compensation relationship could change. Specifically, aging-related declines in memory could create greater memory challenges even for older adults who hold positive beliefs about their memory competence and controllability. In the face of a gradually growing mismatch between memory skills and memory expectations, high MSE older adults could respond adaptively by increasing their compensatory effort and motivation to succeed in new memory challenges. Arguably, over time older adults with positive beliefs about their memory would be exerting more effort in selecting means to compensate for memory challenges or losses.

A goal of the present study is to explore whether metamemory (i.e., awareness of memory status/self-efficacy beliefs) is predictive of individual differences in intraindividual changes in the use of memory compensation strategies. Self-referent beliefs about memory is another potential factor contributing to individual differences in not only level, but rate of change in memory compensation strategy use.

Memory aging. Age-related changes in memory, especially episodic memory, are well documented in the cognitive aging literature (Bäckman et al., 2001; Craik, 2000; Hultsch et al., 1998; Nilsson et al., 1997; Small, Dixon, Hultsch, & Hertzog, 1999). Episodic memory is responsible for the recollection of autobiographical events that have happened recently. Previous research from the VLS identified negative age differences in word recall and text recall (using cross-sectional designs) and memory decline on these tasks (based on longitudinal designs; Hultsch et al., 1998; Small et al., 1999). Episodic memory tasks that are novel and provide minimal environmental support (e.g., free recall) show the greatest sensitivity to aging. Age-related differences in episodic memory are reduced when supportive contextual information is provided, especially at encoding and retrieval (Bäckman, 1990; Craik, 2000). Episodic memory was the memory system selected and measured in relation to the MCQ scales for two reasons: (a) episodic memory is sensitive to aging, and (b) several of the MCQ items are representative of episodic memory ability.

Borrowing from a pivotal principle of life-span developmental theory, a theoretically and practically important issue is whether there is plasticity in memory aging. The potential for memory modifiability (or plasticity) is at the heart of memory compensation research. Whether shifting from normal to optimal levels or impaired to normal levels, the human potential to change the course of development is an intriguing feat. Several studies have documented the plasticity of the aging mind by demonstrating training gains in adults experiencing normal aging (Kliegl & Baltes, 1987; Neely & Bäckman, 1993, 1995), and to a limited degree, pathological aging (i.e., AD; Bäckman, 1992; Wilson, 1999). Older adults have the potential to benefit from implementing memory assistive strategies (e.g., mnemonics) to enhance their remembering capacity (Ball et al., 2002).

Which older adults are more likely to spontaneously use compensation strategies to manage difficulties in remembering information? Bäckman and Dixon (1992) suggest that individuals with especially mild or severe memory deficits are less likely to self-initiate compensating behaviors. The reason is that the former group are unlikely to detect a minor impairment or disability, whereas the latter group would have difficulties remembering that they have a memory problem in the first place (and they may already receive extensive social support negating the need to self-initiate the use of compensation strategies). The premise is that a certain level of intact memory ability is necessary to successfully plan and implement cognitive strategies. After all, remembering to use a strategy is a memory task (Wilson & Watson, 1996). The majority of older adults in convenience samples fall in the midrange of this severity continuum meaning that they are likely to be the people to self-initiate and succeed in using adaptive compensation techniques. Memory rehabilitation studies document the success of various strategies for the compensation of memory losses among healthy older adults (e.g., Glisky & Glisky, 1999) and adults with Alzheimer's Disease (Wilson, 1999; Wilson & Watson, 1996).

A goal of the present study is to examine whether actual memory performance is a source of variation (individual differences) in intraindividual changes in the use of memory compensation strategies and general processes. The origin for compensation is a memory deficit (Bäckman & Dixon, 1992). Therefore, assuming accurate memory awareness, memory performance should be indicative of who engages in such strategies. The multidimensional nature of memory, metamemory, and memory compensation necessitates making domain-specific links (Dixon, 1989) to optimize the magnitude of the relation between actual performance and reported use of memory assistive strategies. Indeed, memory functioning is an important factor that affects real-life behaviors and its relation to reported efforts to compensate is warranted.

Goals and Hypotheses

Memory compensation is a set of adaptive processes that assist individuals to optimize the fit between environmental demands and personal skills or goals. Several compensation strategies have been identified in the literature. Verbal reports of memory compensation has been surprisingly understudied in the cognitive aging literature. Understanding the structure of memory compensation (a multidimensional construct), how it changes over the years, and how it relates to known individual difference characteristics will clearly contribute to the literature on cognitive plasticity and successful cognitive aging.

There are four main goals of the present study. The first goal is to examine whether there is an underlying structure of memory compensation, as represented by the MCQ, in a sample of older adults. It is expected that memory compensation will have a coherent measurement structure at the first-order and second-order levels. More specifically, at the first-order level memory compensation will be represented by (a) a 5-factor model (MCQ External, Internal, Reliance, Time, and Effort) of specific memory-assistive strategies, and (b) a 2-factor model (MCQ Success and Change) of indicators of the motivation to compensate and awareness of changes in memory compensation. At the second-order level, memory compensation strategies will be represented by two higher level factors: (a) Substitution strategies (MCQ External, Internal, and Reliance), and (b) Investment strategies (MCQ Time and Effort).

The second goal of this study is to examine the multigroup (age and gender) and longitudinal measurement invariance of the structure of memory compensation. It is expected that the 5-factor structure representing compensation strategies and the 2-factor structure representing the motivation to compensate and awareness of memory compensation will cross-validate across age groups (young-old and old-old adults), gender (men and women), and three measurement occasions.

The third goal of this study is to examine 6-year (three-occasion) mean-level change and interindividual differences (variability) in intraindividual changes in memory compensation. It is expected that there will be a mean-level (a) increase in the use of select substitution strategies (i.e., MCQ External and Reliance), (b) increase in the use of investment strategies (i.e., MCQ Time and Effort), (c) decrease in the use of more demanding substitution strategies (i.e., MCQ Internal), and (d) an increase in reporting more recent use of compensatory strategies compared to prior years (i.e., MCQ Change). It is also expected that these average patterns of change will not be representative of all individuals. In other words, it is expected that there will be between-person variability in individual growth trajectories on all MCQ scales.

The fourth goal is to examine sources of individual differences (or variation) in intraindividual changes in the MCQ. Specific antecedents (or covariates) of individual growth trajectories of memory compensation to be tested are chronological age, biological age, personality dispositions, memory self-efficacy, and actual memory performance. The following specific relations between person-level characteristics and changes in MCQ are expected. First, an older chronological age will be related to using more investment-type strategies and easier-to-implement compensation strategies (i.e., MCQ External and Reliance) to overcome age-related memory decline. Second, an older biological age will especially be related to using more investment-type strategies and easier to implement compensation strategies. Individuals with lower biological vitality would be required to increase their use of selected memory compensation strategies (e.g., reading a passage more slowly) to mitigate declining reserve capacity. Third, higher neuroticism will be related to a decline in the use of compensation strategies. Higher levels of neuroticism may put strain on an individual's resources which would interfere with efforts to use memory compensation strategies. Alternatively, as suggested by earlier VLS cross-sectional findings (de Frias et al., 2003), feeling preoccupied and anxious about one's memory functioning may motivate an individual to engage in the means to mitigate memory problems. Also, higher conscientiousness will be related to an increase in the use of compensation strategies. Individuals with higher levels of conscientiousness (e.g., being planful and achievement thriving) would be expected to actively engage in means to compensate for memory impairments. Fourth, higher memory self-efficacy will be related to a long-term increase in the use of memory compensation strategies. Older adults who hold positive beliefs about their memory competence and control over their memory will be motivated, over time, to engage in compensation strategies to help mitigate losses or maintain effective memory functioning. Finally, older adults with relatively moderate (rather than especially severe) cognitive impairment would have the resources to self-initiate and manage memory strategies. By contrast, older adults with mild memory impairments would have the resources, but may not detect small alterations in functioning. The hypothesis is that using memory compensation strategies will improve actual memory performance. The majority of the VLS participants are relatively free of serious cognitive impairments, therefore, they would be able to detect (be aware of) changes in ability and subsequently adapt by using memory-related compensation techniques. The essence of the memory-memory compensation relationship is reciprocal in nature. Better memory performance levels will be related to a 6-year increase in the use of compensation strategies to remediate or maintain memory functioning in everyday activities. Similarly, prior 6-year use of memory compensation strategies will be related to better memory performance levels at the end of the measurement interval.

Chapter III

Method

Participants

The participants were drawn from a sample of community-dwelling adults (initially aged 55-85 years) from the Victoria Longitudinal Study (VLS), an on-going longitudinal-sequential study of individual differences in adult development. The data used for this study were taken from three waves from the second VLS sample (Sample 2). The first wave of testing for Sample 2 occurred in 1992 and the intervals between waves were three years (M Time 1 to Time 2 interval = 3.23; SD = .17; M Time 2 to Time 3 interval = 3.40; SD = .20). At Wave 1, there were 521 participants, including 350 women and 171 men (M age = 68.24 years , SD = 7.30). The average level of education was 14.88 years (SD = 3.13). At Wave 2, there were 401 participants, including 260 women and 141 men (M age = 71 years , SD = 7.2). The average level of education was 14.97 years (SD = 3.07). At Wave 3, there were 336 participants, including 211 women and 125 men (M age = 73.42 years , SD = 6.88). The average level of education was 15.17 years (SD = 3.05). Figure 1 displays the research design of the present study.

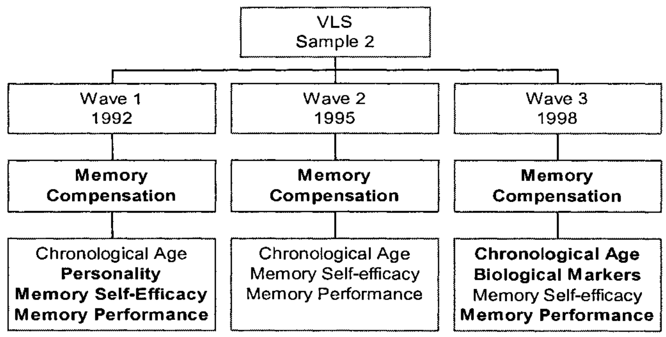

Figure 1. Research design of the VLS with information about measures assessed at each wave. Measures used for this study are in bold.

Memory Compensation Measure

Memory Compensation Questionnaire (MCQ). The MCQ is a self-report instrument assessing the variety and extent of means for compensating for memory losses and deficits. Respondents report the frequency with which they engage in functional, adaptive, or strategic memory-related behaviors related to everyday activities. Initial questionnaire and item development was conducted in several previous data collections (e.g., Dixon & Bäckman, 1992-93; Dixon et al., 2001). During this phase, a large pool of items was reduced to 44, representing seven a priori dimensions of memory compensation. The MCQ contains five scales that represent specific compensatory strategies relevant to everyday memory. Two scales represent more general processes linked to compensation. The latter scales measure (a) the level of commitment to success in everyday memory performance, and (b) the extent to which changes are believed to have occurred in each of the five compensation strategies. The seven MCQ scales are described below. Responses for each item are presented on a 5-point Likert scale with higher scores representing more frequent use of the indicated compensatory behavior.

(1) The External scale contains 8 items concerning the use of external memory aids (such as notes, calendars, and bookmarks) for enhancement of everyday memory performance. This scale is similar to one facet of the Strategy scale from the MIA instrument. As a form of memory compensation, the use of external aids has been discussed frequently (e.g., Wilson & Watson, 1996). A sample item reads, "Do you post notes on a board or other prominent place to help you remember things for the future (e.g., meetings or dates)?" For the present data (Wave 1), Cronbach's α estimate was .76.

(2) The Internal scale has 10 items focusing on the use of mnemonic strategies (such as imagery and rehearsal) for promoting effective memory performance. This scale is similar to one facet of the Strategy scale from the MIA instrument. A sample item reads, "Do you repeat telephone numbers to yourself in order to remember them well?" For the present data (Wave1), Cronbach's α estimate was .80.

(3) The Time scale has 5 items that assess the extent to which the respondent invests more time in performing a valued everyday memory task. Examples include reading passages more slowly and asking people to speak slowly when a goal is to remember the information. A sample items reads, "When you want to remember a story do you read it more than once?" For the present data (Wave1), Cronbach's α estimate was .65.

(4) The Effort scale has 6 items that focus on the investment or application of more effort in performing memory tasks. Examples include concentrating more or trying harder when the goal is to remember an event. A sample item reads, "Do you concentrate a lot to learn something you really want to remember?" For the present data (Wave1), Cronbach's α estimate was .72.

(5) The Reliance scale has 5 items concerning the extent to which the respondent recruits or uses other people as memory aids, such as asking a friend or spouse to help remember to do something. A sample item reads, "When you want to remember an important appointment do you ask somebody else (e.g., spouse or friend) to remind you?" For the present data (Wave1), Cronbach's α estimate was .82.

(6) The Success scale includes 5 items designed to reflect the extent to which a

respondent is committed to a high level of performance in everyday memory tasks. Commitment to success in memory performance may, when high, reflect a motivation to compensate for deficits and losses. Conversely, a low commitment to success may be reflected in either a relatively low endorsement of compensatory strategies or in a relaxation of criteria of success (see Dixon & Bäckman, 1995). A sample item reads, "Is it important for you to remember things perfectly (as verbatim as possible)?" For the present data (Wave1), Cronbach's α estimate was .82.

(7) The Change scale has 5 items which assess the extent to which the respondent believes changes have occurred over the last 5-10 years in each of the above six domains. A sample item reads, "Do you use such aids for memory as notebooks or putting things in certain places more or less often today compared to 5-10 years ago? For the present data (Wave1), Cronbach's α estimate was .75.

Biological Markers

Three biomarkers were selected from the VLS data set, based on previous research indicating they loaded strongly on a biological age factor (MacDonald et al., in press).

(1) Visual acuity. Distance visual acuity was assessed binocularly at a distance of 3 m to the participant using Snellen decimal units. Starting at the largest print line, the participant is asked to read the smallest line possible from a total of seven lines. Corrected vision is used instead of uncorrected, because correction will likely account for peripheral changes to the eye, thereby allowing for a direct assessment of that portion of sensory loss that represents more central-neuronal processes (Lindenberger & Baltes,

1994). The participant's score is the smallest line (i.e., 60, 36, 24, 18, 9, 6, 5, or 4) readable 50% or more of the time. Scores range from 1 to 7. Corrected close visual acuity was measured separately for the left and right eye at a distance of 40 cm with a chart that contains short reading passages. Print size ranges from 5 to 18. The performance score is the text passage that is successfully read with the smallest font size.

(2) Auditory acuity. This was tested with a portable pure tone audiometer using standard audiometric techniques. Pure tone thresholds were obtained for both left and right ears at 250, 500, 1000, 2000, 4000, and 8000 hertz (Hz). As higher frequencies may be inaudible to many older participants and lower frequencies may be insensitive to age differences (Anstey & Smith, 1999), mid-range frequencies were analyzed (i.e., 500 to 2000 Hz). The average of the frequency values for the left and right ears was the performance score.

(3) Grip strength. This was measured by using the Smedley hand dynamometer which measures the force exerted in kilograms. Participants were asked to squeeze the grip meter one hand at a time in a seated position. Two trials were given for each hand. The final score was the highest score out of two attempts performed with the dominant hand.

Psychosocial Measures

Two sets of psychosocial measures were selected, based on previous research (de Frias et al., 2003).

(1) Personality. The 181-item NEO Personality Inventory (Costa & McCrae, 1992) was used to measure personality dimensions: neuroticism (48 items), extraversion

(48 items), openness to experience (48 items), agreeableness (18 items), and conscientiousness (18 items). Participants indicate the extent to which they agree with each statement using a 5-point Likert scale. Previous research with other older adult samples in the VLS (e.g., Small, Hertzog, Hultsch, & Dixon, 2002) has established good structural and psychometric characteristics of the NEO in a comparable sample. Each dimension is measured as a summary score. A higher score denotes greater endorsement of a given disposition.

(2) Memory Self-Efficacy (MSE). A composite score of three subscales from the Metamemory in Adulthood (MIA) instrument was used to assess participants' beliefs about their ability to remember (Dixon, Hultsch, & Hertzog, 1988). These subscales were: (a) Capacity (17 items), which assesses perceptions of one's memory capacities using predictive reports of performance on various tasks, (b) Change (18 items), which reflects perceptions of one's memory abilities as being stable or undergoing long-term decline, and (c) Locus (9 items), which queries about one's perceived control over memory abilities. Internal consistency (Cronbach's alpha) estimates for Capacity, Change, and Locus was .83, .91, and .81, respectively.

Memory Performance Measures

Two aspects of episodic memory were measured.

(1) Word recall. Six categorized lists of common English nouns were drawn from the Howard (1980) and Battig and Montague (1969) norms. Each list contained six words from each of five taxonomic categories for a total of 30 words per list. Categories and exemplars were selected to minimize potential interference effects within and

between lists. In general, high-frequency exemplars ranked two through nine were chosen to minimize guessing, the most frequently used noun was not used. Participants had 2 min to study the words from each of two lists, followed immediately by a 5 min written recall test for each list. Participants were instructed to write down as many of the words as possible in any order. Parallel forms reliability of the word lists is reported as averaging at .64 across three times of measurement (Hultsch et al. 1998).

(2) Story recall. Six narrative stories were taken from a set of 25 parallel texts developed by Dixon, Hultsch, and Hertzog (1993). Each story described an event in the life (lives) of an older protagonist, who was either a woman (two stories), a man (two stories) or a couple (two stories). The structurally equivalent stories consisted of 24 sentences and contained approximately 300 words, organized into approximately 160 propositions (Dixon et al., 1993; Kintsch, 1974). The stories were well organized and contained the main theme of the story in the first few propositions.

Each participant studied and recalled two texts which were presented in typed booklets for study followed by written recall. Participants were given 4 min to study each story and 10 min to write their recall. Participants were instructed to recall as much of the substance of the story as possible, including the main ideas and details. They were told that they could recall the story in their own words, those of the story, or both. Parallel forms reliability of the stories average at .72 across two times of measurement (Waves 1 and 2).

To score story recall, the template text base is compared to the recall protocol by the individual (Turner & Green, 1978). Gist recall of the propositions (idea units) in the texts was used as a measure of quantity of recall. More information on the scoring system is available in Dixon and colleagues (1993; Small et al., 1999).

Statistical Analyses

Research Goal 1. All structural models were run with the LISREL 8.3 program (Jöreskog & Sörbom 1993). The factor structure of the MCQ was estimated using confirmatory factor analyses. The cross-sectional measurement model was also tested at Waves 2 and 3. Covariance matrices were analyzed. Several indices of model fit were considered in addition to the χ^2 test which is often significant in large samples ($N > 200$). These indices are the comparative fit index (CFI; Bentler, 1990), the goodness of fit index (GFI; Jöreskog & Sörbom 1993), and the root mean square error of approximation (RMSEA; Browne & Cudeck, 1992; Steiger, 1990). Typically, RMSEA values at or below .05 are considered acceptable (although some authors claim values between the .05 - .08 range are acceptable; e.g., Browne & Cudeck, 1992). Generally, CFI and GFI values greater than .90 are indicative of good model fit. However, with complex models (i.e., multiple latent factors and indicators) such criteria may need to be relaxed. CFI and GFI values in the mid .80s, and RMSEA values below .08, will be considered acceptable fit to the data. The χ^2 statistic tests the closeness of fit between the unrestricted sample covariance matrix and the restricted covariance matrix. The CFI compares the hypothesized model with the independence (or null) model. The GFI is an absolute index of fit that compares the hypothesized model with no model. The RMSEA tests how well the model fits the population covariance matrix.

Crossloadings in factor structures can occur when observed variables correlate with more than one latent factor. Because they indicate imperfect fit, we examined all possible crossloadings. The criteria used to determine crossloadings in the factor structure of memory compensation were the following: (a) indicators that crossload on more than one factor have a standardized expected lambda (factor loading) of .30 or greater, (b) modification indices suggest a significant improvement (drop) in chi-square (critical value = 3.84, df = 1) if the parameter were freely estimated (i.e., allowed to crossload), (c) when the crossloading has a similar value to the hypothesized indicator, and finally (d) the crossloading must make conceptual sense in order to consider making modifications (i.e., freeing up the parameter) to the hypothesized model.

There were two measurement models tested at the first-order level: (a) the first model tested the underlying structure of memory compensation based on a first-order 5-factor solution of the MCQ strategy scales (i.e., External, Internal, Reliance, Time, and Effort), and (b) the second model tested the underlying structure of the MCQ general scales (i.e., Success and Change). The MCQ Success and Change scales do not represent specific strategies, but rather general compensation processes (i.e., commitment to memory tasks and perceived change in memory compensation). Because these two MCQ scales do not assess specific memory compensation strategies per se, they were tested separately in a first-order 2-factor model. A further model was estimated to test the hypothesis that the 5 MCQ strategy scales would be represented by a hierarchical factor structure such that the first-order strategy factors are explained by a higher order (i.e., more general memory compensation) structure. More specifically, a hierarchical second-order factor model was estimated with the compensatory processes of substitution and investment-strategies at the higher-order level and the 5 specific strategy MCQ scales as first-order factors. As shown in Figure 2, markers of the Substitution Strategies Factor are MCQ External, Internal, and Reliance and markers of the Investment Strategies Factor are MCQ Time and Effort.

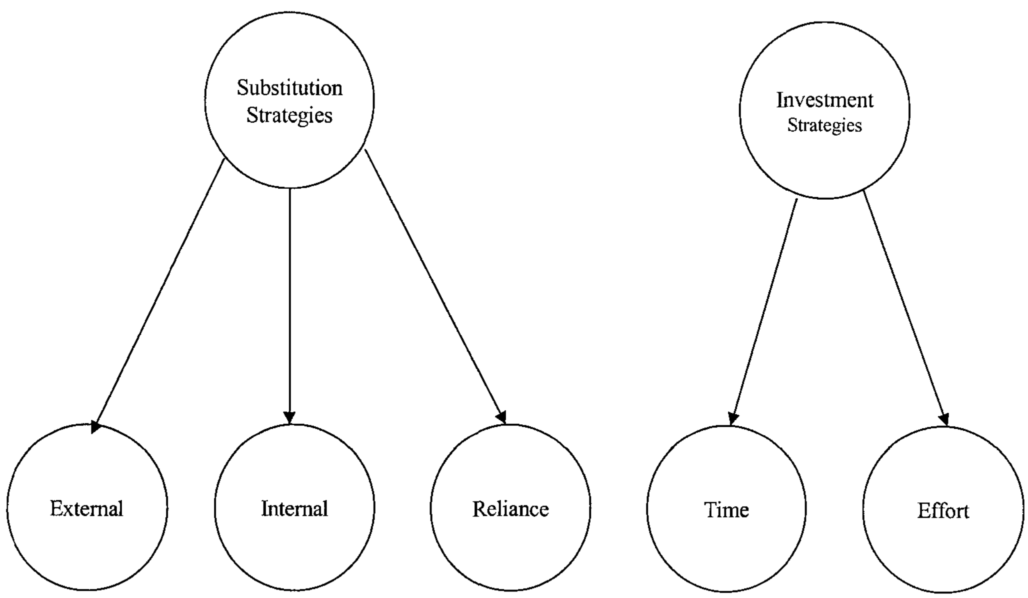

Figure 2. Structure of memory compensation strategies: Second-order factor model.

Research Goal 2. The second research question pertained to measurement invariance. The sequence of establishing measurement invariance involves comparing nested models with increasing constraints (Horn & McArdle, 1992; Meredith, 1993). The least constraining form of measurement invariance is configural invariance: This demonstrates factor pattern invariance. Configural invariance requires that the same number of factors and pattern (not magnitude) of salient factor loadings be equivalent across groups or time (Horn & McArdle, 1992). In this condition, all MCQ items marking the first-order factors (latent constructs) have their primary non-zero loadings on the same compensation strategy construct across occasions or groups. Configural invariance is a minimum requirement to establish factorial invariance. Other levels of measurement equivalence (e.g., metric invariance) involve placing more stringent constraints on the parameters. These constraints are the following: (a) weak factorial invariance (or metric invariance), involving equivalence of factor loadings (i.e., testing whether the factor variable weights are the same across conditions), (b) strong factorial invariance, which requires equivalence of intercepts (manifest variable means), and (c) strict factorial invariance, which requires that the unique variances be equivalent. These factorial invariance constraints are imposed, yet the factor variances, covariances, and factor means remain freely estimated.

Often these levels of invariance are unrealistic and, consequently, unmet in complex developmental data sets. Accordingly, developmental methodologists (Horn & McArdle, 1992; Horn, McArdle, & Mason, 1983) support the view that configural invariance is more practical for measurement in psychology. While configural invariance provides evidence of qualitative similarity across conditions, metric invariance establishes equivalence of quantitative characteristics (i.e., units of measurement for the factors). In this study, the sequence of testing measurement invariance were tests of configural invariance and weak metric invariance (i.e., equivalence of factor loadings) between groups (age and gender) and across three occasions for the 5 first-order MCQ strategy scales (e.g., MCQ External, Internal, Reliance, Time, and Effort) and the 2 MCQ general scales (e.g., MCQ Success and Change). First, multi-group invariance testing was performed using VLS Sample 2 Waves 1, 2 and 3. The sample was split into (a) young-old adults (ages 55-70 years at Wave 1) and old-old adults (ages 71-85 years at Wave 1), and (b) women and men. Second, longitudinal confirmatory factor analysis tested the equivalence of the factors over three testing occasions. Autocorrelation of the unique (error) variances was allowed since repeated measures data carry dependencies (Sörbom, 1975).

Research Goal 3. The third goal involves examining both mean-level 6-year (3-occasion) intraindividual change, and interindividual differences (variability) in intraindividual changes in memory compensation. To examine growth trajectories of the seven MCQ scales, a series of hierarchical linear models (HLM; Bryk & Raudenbush, 1987, 1992) were estimated. Specifically, HLM was used to examine (a) mean-level change in all MCQ scales, and (b) individual differences (variability) in rates of change. This statistical technique handles missing data such that all available data are used in the estimation process with more weight given to (a) cases with more complete data, and (b) cases with greater variability in change. Consequently, this procedure improves reliability of change estimates and statistical power.

Research Goal 4. The fourth goal examines the influences on variability in change trajectories of the seven MCQ scales. The first set of between-person covariates are the biological markers. Preliminary analyses involve testing the confirmatory factor structure of the four biological markers (i.e., auditory acuity, close and distant visual acuity, and grip strength) hypothesized to represent biological age. A classification scheme has been reported in the functional age literature (Anstey et al., 1996; MacDonald et al., in press), whereby visual acuity, auditory acuity, and grip strength represent sensorimotor biomarkers. Covariance matrices were analysed in a confirmatory factor analysis using LISREL 8.3. A single latent biomarker factor was estimated. The indices of model fit considered are the same as those from research goals 1 and 2 (e.g., χ^2, CFI, GFI, and RMSEA). The biomarkers factor was reverse coded such that a higher score reflects poorer functioning and an "older" biological age, thereby maintaining interpretative consistency with chronological age.

To examine covariates of variability in growth trajectories of the seven MCQ scales, a series of HLMs were estimated. The between-person sources of individual differences in change were (a) chronological age, (b) biological age, (c) five personality traits, (d) memory self-efficacy, and (e) episodic memory performance (using two word recall tasks and 2 text recall tasks).

Chapter IV

Results

Research Goal 1: Structure of the MCQ

This section has details on the results of the structural analyses (e.g., factor structure and measurement invariance) of the MCQ.

Confirmatory factor analysis: First-order five-factor models. The VLS sample used was S2W1. Using the 34 items of the MCQ pertaining to the five strategy scales, the first-order five factor model representing memory compensation strategies fit the data well, especially for a complex data set (χ^2 = 1424.44, df = 517, p < .001, RMSEA = .059, CFI = .82, GFI = .86). All factor loadings and factor variances were significantly different from zero. Inspection of the modification indices revealed a cross-loading for only one item, (specifically item c26) of the MCQ Time factor had a higher loading on the MCQ Internal factor (.61) than its expected Time factor (.49). This item reads, "Do you spend a lot of time on 'memory tricks' or other aids for memory in your daily life"? The other four indicators from the MCQ Time scale do not make reference to a specific strategy, but whether the respondent (a) asks people to speak more slowly, (b) reads a story more than once, (c) reads a newspaper more slowly, or (d) slows down his or her reading speed. Accordingly, two alternative models were estimated. The first model allowed item c26 to cross-load on MCQ Time and MCQ Internal, while the second model identified item c26 as an indicator of MCQ Internal. When item c26 was modeled as an indicator of MCQ Internal (not MCQ Time), and as cross-loading on both factors, the model fit was similar to when c26 was modeled as a sole indicator of MCQ Time.

However, there was no cross-loading for item c26 when it was modeled as a pure indicator of MCQ Internal. After considering the complexity of the phrasing of the question, item c26 was dropped from the model.

The modified 5-factor model with 33 items fit the data well and was an improvement over a model that included item c26 ($n = 513$; $\chi^2 = 1262.38$, $df = 485$, $p < .001$, RMSEA = .056, CFI = .84, GFI = .87). The memory compensation items loaded significantly onto their respective factors. Crossloadings (items c5, c11, c28, and c32) from the Internal, Time, and Effort factors were evident with both significant modification indices and values for standardized expected change in loadings exceeding .30. One additional indicator from MCQ Internal factor (item 25) had a crossloading on the MCQ External factor. Factor variances were significantly different from zero. The inter-factor correlation between Time and Internal dropped from .70 (with item c26 in the model) to .57 (without item c26 in the model). This model will be the base model for subsequent measurement invariance analyses. Standardized factor loadings and factor variances are presented in Table 1 and inter-factor correlations are listed in Table 2. Alternative models with fewer factors revealed a poorer fit to the data. For example, the MCQ Time and MCQ Effort factors were collapsed and a 4-factor model was tested ($n = 513$; $\chi^2 = 1308.88$, $df = 489$, $p < .000$, RMSEA = .057, CFI = .83, GFI = .87).

Table 1

Standardized Factor Loadings and Factor Variances for Sample 2 Wave 1 (S2W1)

Item	MCQ Factor				
	External	Internal	Reliance	Time	Effort
c1	**0.57**	0	0.05	-0.01	-0.03
c6	**0.41**	-0.02	0.03	0.04	0.04
c13	**0.67**	0.04	0.09	0.06	0.08
c18	**0.36**	0.18	-0.05	0.06	0.13
c21	**0.53**	0.23	0.03	0.10	0.22
c24	**0.68**	-0.18	-0.09	-0.1	-0.18
c27	**0.55**	-0.08	-0.05	-0.11	-0.11
c30	**0.56**	-0.04	-0.01	0.01	-0.02
c22	0.01	**0.63**	0.10	0.01	-0.12
c23	-0.15	**0.62**	-0.07	-0.02	-0.08
c25	0.50	**0.44**	-0.10	0.28	0.39
c28	-0.05	**0.51**	-0.02	0.06	0.36
c31	0.08	**0.51**	-0.09	-0.04	0.03
c33	0.02	**0.62**	-0.06	0.01	-0.12
c36	0.04	**0.38**	-0.05	-0.09	-0.02
c38	-0.14	**0.60**	0.10	-0.08	-0.19
c40	-0.17	**0.51**	-0.07	-0.19	-0.25
c43	0.04	**0.53**	0.18	0.09	0.21
c3	0	-0.03	**0.77**	-0.07	-0.02
c9	0.05	0.05	**0.78**	0.04	0.06
c12	-0.10	-0.06	**0.77**	-0.07	-0.11
c14	0.12	0.10	**0.57**	0.16	0.13

c17	-0.03	-0.03	**0.60**	0	-0.02
c2	0.13	0.26	0.28	**0.36**	0.39
c5	0.01	0.26	0.06	**0.43**	0.40
c11	-0.07	-0.24	-0.07	**0.76**	-0.46
c15	0	-0.11	-0.09	**0.71**	-0.24
c4	-0.14	-0.11	0.12	-0.08	**0.61**
c7	-0.03	-0.18	-0.02	0.08	**0.53**
c10	-0.06	-0.07	-0.03	0.16	**0.63**
c20	0.04	0.08	-0.05	0.01	**0.50**
c32	0.09	0.42	-0.18	-0.14	**0.50**
c37	0.15	-0.08	0.11	-0.06	**0.54**
Variance	0.52	0.49	0.72	0.61	0.34

Note. Values in bold represent standardized marker loadings. Values not bolded represent standardized expected loadings.

Table 2

First-Order Inter-Factor Correlations Between MCQ Scales for S2W1

	External	Internal	Reliance	Time	Effort
External	1				
Internal	0.49	1			
Reliance	0.15	0.31	1		
Time	0.47	0.57	0.25	1	
Effort	0.54	0.78	0.33	0.70	1

The final (33-item) first-order 5-factor model was also estimated in Wave 2 (W2) and Wave 3 (W3), separately. The model fit the data well at both W2 (n = 398; χ^2 = 1007.53, df = 485, p < .001, RMSEA = .05, CFI = .87, GFI = .87) and W3 (n = 335; χ^2 = 1077.76, df = 485, p < .001, RMSEA = .06, CFI = .84, GFI = .84). The MCQ items loaded significantly onto their respective factors. Standardized factor loadings ranged from .30s to .80s. Factor variances were significantly different from zero.

Confirmatory factor analysis: Second-order models. The VLS sample used was S2W1. Using the 33-item MCQ, the first-order five-factor model was next tested at the second-order level. A 2-factor model with Substitution and Investment as higher-level factors accounting for the relations among the first-order strategy-based factors (e.g., MCQ External, Internal, Reliance, Time, and Effort) had a reasonable fit to the data (χ^2 = 1272.45, df = 490, p < .001, RMSEA = .06, CFI = .84, GFI = .87). However, the higher-order inter-factor correlation was near unity ® = .98) suggesting that there are not two distinct factors at this level. The variance for the Substitution factor was .18. The variance for the Investment factor was .33. The second-order factors have a similar correlation with each of the first-order factors (listed in Table 3), indicating that two higher-order factors are not representative of the data.

Table 3

Correlations Between the First-Order and Second-Order Factors for S2W1

	External	Internal	Reliance	Time	Effort
Substitution	0.59	0.83	0.35	0.71	0.94
Investment	0.57	0.81	0.34	0.73	0.96

An alternative model that specified a single factor (labelled Compensation) at the second-order level also fit the data well (χ^2 = 1271.88, df = 490, p < .001, RMSEA = .06, CFI = .84, GFI = .87). The variance of the compensation factor was .31. Standardized factor loadings are as follows: External = .58, Internal = .82, Reliance = .35, Time = .73, and Effort = .95. Modification indices for PSI (unique variance of the endogenous factors) were nonsignificant which supports the presence of a single higher-level factor.

Confirmatory factor analysis: First-order two-factor models. The VLS sample used was S2W1. Using the 10 items of the two MCQ scales (Success and Change), the first-order 2-factor model representing the general MCQ scales fit the data exceptionally well (n = 509; χ^2 = 82.54, df = 34, p < .001, RMSEA = .05, CFI = .97, GFI = .97). All factor loadings and factor variances were significantly different from zero. The inter-factor correlation was .33. Standardized factor loadings and factor variances are listed in Table 4.

Table 4

First-Order Standardized Factor Loadings and Factor Variances for S2W1

Item	MCQ Factor	
	Success	Change
c8	**0.67**	0.03
c16	**0.73**	0
c35	**0.69**	0.03
c39	**0.56**	0
c42	**0.82**	-0.05
c19	-0.03	**0.39**
c29	0.08	**0.67**
c34	-0.12	**0.61**
c41	-0.01	**0.82**
c45	0.06	**0.58**
Variance	0.78	0.36

Note. Values in bold represent standardized marker loadings. Values not bolded represent standardized expected loadings.

The first-order 2-factor model was also estimated in W2 and W3, separately. The model fit the data well at W2 (n = 398; $\chi^2 = 48.07$, df = 34, p > .05, RMSEA = .03, CFI = .99, GFI = .98) and W3 (n = 335; $\chi^2 = 83.39$, df = 34, p < .001, RMSEA = .07, CFI = .94, GFI = .95). The memory compensation items loaded significantly onto their respective factors. Standardized factor loadings ranged from .30s to .80s. Factor variances were significantly different from zero.

Research Goal 2: Measurement Invariance

The measurement invariance of the 5-factor and 2-factor models were examined across groups (age, gender) at each wave, and occasions (3 waves) within the same group.

Measurement invariance across age: Five-factor model (W1). The 5-factor measurement model testing for configural invariance across young-old (n = 328) and old-old (n = 185) age groups fit the data reasonably well for W1 ($\chi^2 = 1838.04$, df = 970, p = .000, RMSEA = .06, CFI = .82), as based on the RMSEA fit index. All loadings and variances were significantly different from zero. All covariances were significantly different from zero, except for one pair in the old-old group (Reliance with External). Standardized factor loadings are listed in Table 5.

Table 5

Common Metric Completely Standardized Factor Loadings for Young-Old and Old-Old Adults: Five-Factor Model S2W1

	MCQ Factors				
Items	External	Internal	Reliance	Time	Effort
c1	.57 (.58)				
c6	.45 (.32)				
c13	.67 (.67)				
c18	.36 (.35)				
c21	.62 (.32)				
c24	.72 (.58)				
c27	.57 (.52)				
c30	.59 (.45)				
c22		.63 (.63)			
c23		.60 (.67)			
c25		.40 (.49)			
c28		.53 (.49)			
c31		.46 (.60)			
c33		.56 (.71)			
c36		.37 (.37)			
c38		.60 (.60)			
c40		.55 (.44)			
c43		.55 (.49)			
c3			.77 (.77)		
c9			.77 (.77)		
c12			.72 (.84)		

c14	.63 (.50)		
c17	.55 (.67)		
c2		.29 (.47)	
c5		.42 (.45)	
c11		.75 (.75)	
c15		.74 (.66)	
c4			.58 (.65)
c7			.53 (.53)
c10			.62 (.62)
c20			.50 (.52)
c32			.45 (.66)
c37			.55 (.51)

Note. Values for young-old adults are listed first and values for old-old adults are in parentheses.

Inspection of the modification indices and standardized expected change for lambda for the young-old adults revealed two potential cross-loadings. More specifically, item c2 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .43), and item c5 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .38). Inspection of the modification indices and standardized expected change for lambda for the old-old adults also revealed three potential cross-loadings. Item c5 (an indicator of MCQ Time; loading = .40) also loaded on Effort (expected loading = .40), item c28 (an indicator of MCQ Internal; loading = .53) also loaded on MCQ Effort (expected loading = .69), and item c32 (an indicator of MCQ Effort; loading = .45) also loaded on MCQ Internal (expected loading = .58).

Metric invariance of factor loadings across age groups was tested by constraining the factor loadings between the two age groups. This model did not result in a significant loss of fit over the configural model that places no constraints on parameters (χ^2 = 1863.14, df = 998, p = .000, RMSEA = .06, CFI = .82; $\Delta\chi^2$ = 25.10, Δdf = 28, p > .05).

Measurement invariance across age: Two-factor model (W1). The 2-factor measurement model (MCQ Success and Change) testing for configural invariance across the two age groups (YO: n = 326; OO: n = 183) fit the data exceptionally well (χ^2 = 118.27, df = 68, p = .000, RMSEA = .05, CFI = .96). All factor loadings, variances, and covariances are significantly different from zero. Standardized factor loadings are listed in Table 6.

Table 6

Common Metric Completely Standardized Factor Loadings for Young-Old and Old-Old Adults: Two-Factor Model S2W1

Items	MCQ Factors	
	Success	Change
c8	.65 (.66)	
c16	.72 (.71)	
c35	.71 (.64)	
c39	.58 (.51)	
c42	.83 (.83)	
c19		.42 (.35)
c29		.69 (.63)
c34		.71 (.45)
c41		.83 (.83)
c45		.64 (.47)

Note. Values for young-old adults are listed first and values for old-old adults are in parentheses.

Metric invariance of factor loadings across age groups was tested on the 2-factor model by constraining the factor loadings between the two age groups. This model did not result in a significant loss of fit over the configural model that places no constraints on parameters (χ^2 = 126.15, df = 76, p < .000, RMSEA = .05, CFI = .96; $\Delta\chi^2$ = 7.88, Δdf = 8, p > .05).

<u>Measurement invariance across age: Five-factor model (W2).</u> The same two-step sequence of evaluating measurement invariance across age was tested in W2. Configural invariance across young-old (n = 260) and old-old (n = 138) age groups was tested to examine the fit of the 5-factor measurement model for Wave 2 (χ^2 = 1563.32, df = 970, p = .000, RMSEA = .06, CFI = .84). The model fit the data satisfactorily for both age groups. All loadings and variances were significantly different from zero. All covariances were significantly different from zero, except for one pair in the young-old group (Reliance and External), and two pairs in the old-old group (External and Reliance; Time and Reliance). Standardized factor loadings are listed in Table 7.

Table 7

Common Metric Completely Standardized Factor Loadings for Young-Old and Old-Old Adults: Five-Factor Model for Sample 2 Wave 2 (S2W2)

	MCQ Factors				
Items	External	Internal	Reliance	Time	Effort
c1	.57 (.79)				
c6	.45 (.51)				
c13	.60 (.60)				
c18	.42 (.56)				
c21	.54 (.59)				
c24	.77 (.53)				
c27	.65 (.57)				
c30	.53 (.63)				
c22		.65 (.65)			
c23		.71 (.58)			
c25		.49 (.41)			
c28		.64 (.42)			
c31		.54 (.42)			
c33		.67 (.55)			
c36		.47 (.36)			
c38		.76 (.45)			
c40		.57 (.33)			
c43		.73 (.53)			
c3			.74 (.84)		
c9			.65 (.65)		
c12			.80 (.84)		

c14	.53 (.60)		
c17	.58 (.69)		
c2		.31 (.52)	
c5		.49 (.53)	
c11		.81 (.81)	
c15		.72 (.85)	
c4			.69 (.63)
c7			.50 (.84)
c10			.65 (.65)
c20			.46 (.61)
c32			.53 (.31)
c37			.56 (.65)

Note. Values for young-old adults are listed first and values for old-old adults are in parentheses.

Inspection of the modification indices and standardized expected change for lambda for the young-old adults revealed potential cross-loadings. More specifically, item c2 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .31), item c5 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .39), and item c32 (an indicator of MCQ Effort) also loaded on MCQ Internal (expected loading = .42). The one cross-loading for the old-old age group was item c20 (an indicator of MCQ Effort) which also loaded on MCQ Internal (expected loading = .59).

Metric invariance of factor loadings across age groups was tested by constraining the factor loadings between the two age groups. This model did not result in a significant loss of fit over the configural model that places no constraints on parameters (χ^2 = 1595.85, df = 998, p = .000, RMSEA = .06, CFI = .84; $\Delta\chi^2$ = 32.53, Δdf = 28, p > .05).

<u>Measurement invariance across age: Two-factor model (W2).</u> Configural invariance of the 2-factor model (MCQ Success and Change) across two age groups (YO: n = 261; OO: n = 137) fit the data exceptionally well (χ^2 = 92.87, df = 68, p = .02, RMSEA = .04, CFI = .98). All factor loadings, variances, and covariances are significantly different from zero. Standardized factor loadings are listed in Table 8.

Table 8

Common Metric Completely Standardized Factor Loadings for Young-Old and Old-Old Adults: Two-Factor Model S2W2

Items	MCQ Factors	
	Success	Change
c8	.74 (.69)	
c16	.82 (.67)	
c35	.73 (.60)	
c39	.49 (.59)	
c42	.82 (.82)	
c19		.46 (.27)
c29		.74 (.61)
c34		.87 (.62)
c41		.74 (.74)
c45		.79 (.55)

Note. Values for young-old adults are listed first and values for old-old adults are in parentheses.

Metric invariance of factor loadings for the 2-factor structure across age groups was tested by constraining the factor loadings between the two age groups. This model did not result in a significant loss of fit over the configural model that places no constraints on parameters (χ^2 = 105.26, df = 76, p = .02, RMSEA = .04, CFI = .98; $\Delta\chi^2$ = 12.39, Δdf = 8, p > .05).

Measurement invariance across age: Five-factor model (W3). The same two-step sequence of evaluating measurement invariance across age was tested in W3. Configural invariance across young-old (n = 229) and old-old (n = 107) age groups was tested to examine the fit of the 5-factor measurement model for Wave 3 (χ^2 = 1592.80, df = 970, p = .000, RMSEA = .06, CFI = .81). The model fit the data poorly for both age groups. All loadings and variances are significantly different from zero. The phi (factor variance) matrix for the old-old age group was not positive definite (i.e., MCQ Reliance factor had a standardized variance of 1.10). Setting the variance (phi) to a value below 1.00 (i.e., .90) did not solve the problem. This problem may have resulted because of the small sample size for this age group.

Measurement invariance across age: Two-factor model (W3). Configural invariance across young-old (n = 229) and old-old (n = 106) age groups was tested to examine the fit of the 2-factor (MCQ Success and Change) measurement model for W3 (χ^2 = 114.51, df = 68, p = .000, RMSEA = .06, CFI = .94). The model fit the data well for both age groups. All factor loadings and factor variances are significantly different from zero. The factor covariance was significant for the young-old adults, but not the old-old adults. Factor loadings are listed in Table 9.

Table 9

Common Metric Completely Standardized Factor Loadings for Young-Old and Old-Old Adults: Two-Factor Model S2W3

Items	MCQ Factors	
	Success	Change
c8	.64 (.67)	
c16	.70 (.84)	
c35	.70 (.61)	
c39	.59 (.57)	
c42	.77 (.77)	
c19		.31 (.41)
c29		.58 (.67)
c34		.67 (.61)
c41		.82 (.82)
c45		.45 (.58)

Note. Values for young-old adults are listed first and values for old-old adults are in parentheses.

Metric invariance of factor loadings across age groups was tested by constraining the factor loadings between the two age groups for W3. This model did not result in a significant loss of fit over the configural model that places no constraints on parameters (χ^2 = 120.55, df = 76, p = .000, RMSEA = .06, CFI = .95; $\Delta\chi^2$ = 6.04, Δdf = 8, p > .05).

Summary. The results of the measurement invariance analyses across age groups (YO and OO adults) indicate both configural and metric invariance of the 5-factor (MCQ External, Internal, Reliance, Time, and Effort) model for W1 and W2. No cross-loadings were found by age for MCQ External and MCQ Reliance. For the remaining MCQ strategy scales (i.e., MCQ Internal, Time, and Effort), only one to two cross-loadings by age group were observed. Measurement invariance cannot be inferred for W3 and a possible reason is that the sample size was too small. The results of the measurement invariance across age groups (YO and OO adults) indicate both configural and metric invariance of the 2-factor (MCQ Success and Change) model for W1, W2, and W3. No cross-loadings by age group were observed.

Overall, measurement invariance (e.g., configural and metric) was found for the MCQ strategy scales (for W1 and W2) and the MCQ general scales (across all 3 waves). Similarity of qualitative (e.g., factor pattern) and quantitative (e.g., metric of the factor) characteristics of the MCQ scales were found across age group. As predicted, the structure of the MCQ scales was similar for YO and OO adults.

Measurement invariance across gender: Five-factor model (W1). Configural invariance across gender (women: n = 343; men: n = 170) was tested to examine the fit of the 5-factor measurement model for Wave 1 (χ^2 = 1761.61, df = 970, p = .000, RMSEA =

.06, CFI = .82). The model fit the data satisfactorily for both genders. All factor loadings, factor variances, and factor covariances are significantly different from zero. Standardized factor loadings are listed in Table 10.

Table 10

Common Metric Completely Standardized Factor Loadings for Gender: Five-Factor Model S2W1

	MCQ Factors				
Items	External	Internal	Reliance	Time	Effort
c1	.54 (.58)				
c6	.39 (.46)				
c13	.65 (.65)				
c18	.30 (.40)				
c21	.54 (.46)				
c24	.54 (.82)				
c27	.52 (.51)				
c30	.54 (.53)				
c22		.63 (.63)			
c23		.62 (.63)			
c25		.39 (.48)			
c28		.48 (.58)			
c31		.50 (.51)			
c33		.52 (.81)			
c36		.34 (.42)			
c38		.56 (.70)			
c40		.45 (.63)			
c43		.55 (.46)			
c3			.70 (.84)		
c9			.78 (.78)		
c12			.71 (.83)		

c14	.59 (.55)		
c17	.50 (.72)		
c2		.39 (.36)	
c5		.48 (.33)	
c11		.75 (.75)	
c15		.69 (.73)	
c4			.56 (.83)
c7			.54 (.47)
c10			.64 (.64)
c20			.45 (.63)
c32			.43 (.69)
c37			.52 (.58)

Note. Values for women are listed first and values for men are in parentheses.

Inspection of the modification indices and standardized expected change for lambda for women revealed potential cross-loadings. More specifically, item c2 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .49), item c5 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .46), and item c32 (an indicator of MCQ Effort) also loaded on MCQ Internal (expected loading = .58). Modification indices and standardized expected change for lambda for the men revealed a potential cross-loading; Item c5 (an indicator of MCQ Time) also loaded on Effort (expected loading = .35).

Metric invariance of factor loadings across gender was tested by constraining the factor loadings between the two genders. This model resulted in a modest loss of fit (as indicated by the $\Delta\chi^2$ value) over the configural model that places no constraints on parameters (χ^2 = 1813.43, df = 998, p = .000, RMSEA = .06, CFI = .82; $\Delta\chi^2$ = 51.82, Δdf = 28, p < .05).

Measurement invariance across gender: Two-factor model (W1). Configural invariance of the 2-factor model (MCQ Success and Change) across gender (women: n = 339; men: n = 170) fit the data well (χ^2 = 129.52, df = 68, p = .000, RMSEA = .06, CFI = .96, GFI = .92). All factor loadings, variances, and covariances are significantly different from zero. Standardized factor loadings are listed in Table 11. Metric invariance of factor loadings across gender was tested by constraining the factor loadings between the two genders. This model resulted in a modest loss of fit over the configural model that places no constraints on parameters (χ^2 = 147.92, df = 76, p = .000, RMSEA = .06, CFI = .95; $\Delta\chi^2$ = 18.40, Δdf = 8, p < .05).

Table 11

Common Metric Completely Standardized Factor Loadings for Gender:

Two-Factor Model S2W1

Items	MCQ Factors	
	Success	Change
c8	.59 (.92)	
c16	.70 (.83)	
c35	.70 (.63)	
c39	.58 (.55)	
c42	.82 (.82)	
c19		.35 (.62)
c29		.60 (.83)
c34		.58 (.74)
c41		.82 (.82)
c45		.51 (.65)

Note. Values for women are listed first and values for men are in parentheses.

Measurement invariance across gender: Five-factor model (W2). Configural invariance across gender (women: n = 259; men: n = 139) was tested to examine the fit of the 5-factor measurement model for W2 (χ^2 = 1609.87, df = 970, p = .000, RMSEA = .06, CFI = .83). The model fit the data satisfactorily for both genders. All factor loadings and factor variances are significantly different from zero. All factor covariances are significant except for one pair for men (MCQ External and Internal). Standardized factor loadings are listed in Table 12.

Table 12

Common Metric Completely Standardized Factor Loadings for Gender: Five-Factor Model S2W2

Items	MCQ Factors				
	External	Internal	Reliance	Time	Effort
c1	.76 (.50)				
c6	.48 (.47)				
c13	.57 (.57)				
c18	.42 (.46)				
c21	.60 (.42)				
c24	.47 (.97)				
c27	.57 (.65)				
c30	.45 (.65)				
c22		.63 (.63)			
c23		.59 (.78)			
c25		.45 (.42)			
c28		.54 (.61)			
c31		.49 (.51)			
c33		.61 (.62)			
c36		.47 (.33)			
c38		.61 (.70)			
c40		.47 (.48)			
c43		.67 (.64)			
c3			.70 (.90)		
c9			.65 (.65)		
c12			.74 (.94)		

c14	.51 (.65)		
c17	.51 (.80)		
c2		.38 (.43)	
c5		.57 (.44)	
c11		.79 (.79)	
c15		.74 (.74)	
c4			.69 (.68)
c7			.63 (.48)
c10			.65 (.65)
c20			.52 (.46)
c32			.47 (.47)
c37			.62 (.52)

Note. Values for women are listed first and values for men are in parentheses.

Inspection of the modification indices and standardized expected change for lambda for women revealed potential cross-loadings. More specifically, item c2 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .31), item c5 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .53), and item c32 (an indicator of MCQ Effort) also loaded on MCQ Internal (expected loading = .55). Modification indices and standardized expected change for lambda for the men revealed no cross-loadings.

Metric invariance of factor loadings across gender was tested by constraining the factor loadings between the two genders. This model resulted in a modest loss of fit (as indicated by the $\Delta\chi^2$ value) over the configural model that places no constraints on parameters ($\chi^2 = 1655.28$, df = 998, p = .000, RMSEA = .06, CFI = .82; $\Delta\chi^2 = 45.41$, Δdf = 28, $p < .05$).

Measurement invariance across gender: Two-factor model (W2). Configural invariance of the 2-factor model (MCQ Success and Change) across gender (women: n = 258; men: n = 140) fit the data well ($\chi^2 = 91.13$, df = 68, p = .03, RMSEA = .04, CFI = .98). All factor loadings, factor variances, and factor covariances are significantly different from zero. Standardized factor loadings are listed in Table 13.

Table 13

Common Metric Completely Standardized Factor Loadings for Gender:

Two-Factor Model S2W2

Items	MCQ Factors	
	Success	Change
c8	.73 (.68)	
c16	.76 (.79)	
c35	.67 (.74)	
c39	.52 (.53)	
c42	.82 (.82)	
c19		.30 (.61)
c29		.62 (.84)
c34		.68 (.98)
c41		.74 (.74)
c45		.65 (.74)

Note. Values for women are listed first and values for men are in parentheses.

Metric invariance across gender was examined by constraining the factor loadings between the two genders. This model did not result in a significant loss of fit over the configural model that places no constraints on parameters (χ^2 = 100.95, df = 76, p = .03, RMSEA = .04, CFI = .98; $\Delta\chi^2$ = 9.82, Δdf = 8, p > .05).

Measurement Invariance Across Gender: Five-factor Model (W3). Configural invariance of the 5-factor structure was estimated across gender (women: n = 210; men: n = 125) for W3. The model fit the data satisfactorily for both genders (χ^2 = 1560.56, df = 970, p = .000, RMSEA = .06, CFI = .81). All factor loadings and factor variances are significantly different from zero. All factor covariances are significant except for one pair for men (MCQ Effort with Reliance). Modification indices indicated three potential crossloadings for women: (a) item c43 (an indicator of MCQ Internal) also loaded on MCQ Effort (expected loading = 1.06, (b) item c2 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .32), and (c) item c5 (an indicator of MCQ Time) also loaded on MCQ Effort (expected loading = .43). Modification indices indicated two potential crossloadings for men: (a) item c2 (an indicator of MCQ Time) also loaded on MCQ Reliance (expected loading = .33), and (b) item c33 (an indicator of MCQ Internal) also loaded on MCQ Time (expected loading = .38). Standardized factor loadings are listed in Table 14.

Table 14

Common Metric Completely Standardized Factor Loadings for Gender: Five-Factor Model S2W3

	MCQ Factors				
Items	External	Internal	Reliance	Time	Effort
c1	.62 (.51)				
c6	.41 (.48)				
c13	.59 (.59)				
c18	.36 (.55)				
c21	.61 (.47)				
c24	.53 (.89)				
c27	.23 (.64)				
c30	.62 (.57)				
c22		.60 (.60)			
c23		.67 (.61)			
c25		.39 (.56)			
c28		.60 (.49)			
c31		.53 (.52)			
c33		.60 (.52)			
c36		.43 (.29)			
c38		.59 (.60)			
c40		.48 (.53)			
c43		.69 (.46)			
c3			.72 (.73)		
c9			.76 (.76)		
c12			.74 (.85)		

c14	.57 (.64)		
c17	.58 (.75)		
c2		.45 (.46)	
c5		.53 (.57)	
c11		.86 (.86)	
c15		.79 (.75)	
c4			.57 (.88)
c7			.51 (.62)
c10			.59 (.59)
c20			.58 (.62)
c32			.46 (.89)
c37			.55 (.70)

Note. Values for women are listed first and values for men are in parentheses.

Metric invariance was examined by constraining the factor loadings between the two genders. This model resulted in a modest loss of fit (as indicated by the $\Delta\chi^2$ value) over the configural model that places no constraints on parameters ($\chi^2 = 1610.46$, df = 998, p = .00, RMSEA = .06, CFI = .80; $\Delta\chi^2 = 49.90$, $\Delta df = 28$, $p < .05$).

Measurement invariance across gender: Two-factor model (W3). Configural invariance of the 2-factor model (MCQ Success and Change) across gender (women: n = 210; men: n = 125) was estimated for W3. The model fit the data well ($\chi^2 = 129.72$, df = 68, p = .000, RMSEA = .07, CFI = .92). All factor loadings, factor variances, and factor covariances are significantly different from zero. Standardized factor loadings are listed in Table 15.

Table 15

Common Metric Completely Standardized Factor Loadings for Gender:

Two-Factor Model S2W3

Items	MCQ Factors	
	Success	Change
c8	.58 (.85)	
c16	.71 (.86)	
c35	.63 (.78)	
c39	.62 (.49)	
c42	.77 (.77)	
c19		.28 (.63)
c29		.57 (.71)
c34		.62 (.73)
c41		.82 (.82)
c45		.47 (.56)

Note. Values for women are listed first and values for men are in parentheses.

Metric invariance was examined by constraining the factor loadings between the two genders. This model did not result in a significant loss of fit (as indicated by the $\Delta\chi^2$ value) over the configural model that places no constraints on parameters ($\chi^2 = 140.13$, df $= 76$, $p = .000$, RMSEA = .07, CFI = .92; $\Delta\chi^2 = 10.41$, $\Delta df = 8$, $p > .05$).

Summary. The results of the measurement invariance across gender indicate configural invariance of the 5-factor (MCQ External, Internal, Reliance, Time, and Effort) model for W1, W2, and W3. No cross-loadings were found by gender for MCQ External, Internal, and Reliance for W1 and W2, and MCQ External and Reliance for W3. For MCQ investment-type strategies (i.e., MCQ Time and Effort), one to two cross-loadings (at each wave) for women were observed and one cross-loading (at W1 and W3) for men. For MCQ Internal, there was one cross-loading for women and men. Constraining the 5-factor model (i.e., testing for equivalence of factor weights) resulted in a small loss of fit based on the χ^2 statistic. The results of the measurement invariance across gender indicate configural and metric invariance of the 2-factor (MCQ Success and Change) model across waves (with a small loss of fit at W1 when testing for metric invariance). No cross-loadings by gender were observed.

Overall, there was configural and metric invariance for the 5-factor and 2-factor models across all 3 waves. Only a small loss of fit occurred by constraining the factor weights to equality for women and men. Similarity of qualitative (e.g., factor pattern) and quantitative (e.g., metric of variable) characteristics of the MCQ scales were found across gender. The structure of the MCQ scales was similar for women and men.

Measurement invariance across occasions: Five-factor model. Three waves of the

VLS Sample 2 (W1 to W3) were used to examine the longitudinal invariance of the 5 MCQ strategy scales (MCQ External, Internal, Reliance, Time, and Effort). The configural model (n = 322) of the 5-factor structure fit satisfactorily over a 6-year period (χ^2 = 7112.80, df = 4638, p = .000, RMSEA = .04, CFI = .82, GFI = .69). All factor loadings, factor variances, and factor covariances are significantly different from zero. Standardized factor loadings at each wave are listed in Table 16. All uniqueness terms of the indicators, correlated across time (autocorrelations and lagged correlations), were statistically significant with the exception of select item pairs from the MCQ Internal factor (i.e., c23t1 and c23t3), the MCQ Reliance factor (i.e., c3t1 and c3t3), and the MCQ Time factor (i.e., c11t1 and c11t2, c11t1 and c11t3, c11t2 and c11t3, and c15t2 and c15t3).

Table 16

Completely Standardized Factor Loadings at Each Wave: Five-Factor Model

Item	Wave	MCQ Factors				
		External	Internal	Reliance	Time	Effort
c1	1	.55				
	2	.57				
	3	.54				
c6	1	.47				
	2	.52				
	3	.43				
c13	1	.65				
	2	.58				
	3	.54				
c18	1	.34				
	2	.43				
	3	.49				
c21	1	.54				
	2	.51				
	3	.53				
c24	1	.75				
	2	.77				
	3	.74				

c27	1	.53	
	2	.59	
	3	.53	
c30	1	.63	
	2	.51	
	3	.66	
c22	1		.65
	2		.64
	3		.61
c23	1		.59
	2		.67
	3		.66
c25	1		.39
	2		.43
	3		.43
c28	1		.50
	2		.53
	3		.50
c31	1		.49
	2		.51
	3		.54

c33	1	.59	
	2	.62	
	3	.60	
c36	1	.40	
	2	.43	
	3	.41	
c38	1	.66	
	2	.66	
	3	.65	
c40	1	.56	
	2	.51	
	3	.56	
c43	1	.54	
	2	.66	
	3	.54	
c3	1		.79
	2		.78
	3		.75
c9	1		.79
	2		.69
	3		.76

c12	1	.79	
	2	.84	
	3	.81	
c14	1	.57	
	2	.59	
	3	.61	
c17	1	.61	
	2	.59	
	3	.66	
c2	1		.27
	2		.32
	3		.38
c5	1		.37
	2		.42
	3		.49
c11	1		.79
	2		.87
	3		.90
c15	1		.76
	2		.73
	3		.76

c4	1	.55
	2	.64
	3	.63
c7	1	.57
	2	.56
	3	.57
c10	1	.58
	2	.66
	3	.59
c20	1	.55
	2	.56
	3	.59
c32	1	.46
	2	.52
	3	.58
c37	1	.56
	2	.55
	3	.61

Metric invariance of the factor loadings for the 5-factor structure across a 6-year period was estimated. This model resulted in a modest loss of fit (based on the $\Delta\chi^2$ value) over the configural model that places no constraints on parameters ($\chi^2 = 7217.73$, df = 4694, p = .000, RMSEA = .04, CFI = .82, GFI = .69; $\Delta\chi^2 = 104.93$, Δdf = 56, $p < .05$).

Measurement invariance across occasions: Two-factor model. Longitudinal invariance of the 2-factor model (MCQ Success and Change) across a 6-year period (n = 322) was examined. The configural model fit well across the 6-year measurement interval ($\chi^2 = 515.06$, df = 360, p = .03, RMSEA = .04, CFI = .96, GFI = .90). All factor loadings, factor variances, and factor covariances are significantly different from zero. Standardized factor loadings are listed in Table 17. All uniqueness terms were statistically significant with the exception of autocorrelated item pairs from the MCQ Success factor (i.e., c8t1 and c8t2, c8t1 and c8t3, c8t2 and c8t3, c16t1 and c16t2, and c16t1 and c16t3), and the MCQ Change factor (i.e., c34t1 and c34t2, c34t1 and c34t3, c41t1 and c41t2, c41t2 and c41t3, and c45t2 and c45t3).

Table 17

Completely Standardized Factor Loadings at Each Wave: Two-Factor Model

Item	Wave	MCQ Factors	
		Success	Change
c8	1	.66	
	2	.72	
	3	.66	
c16	1	.76	
	2	.77	
	3	.75	
c35	1	.67	
	2	.67	
	3	.68	
c39	1	.60	
	2	.55	
	3	.58	
c42	1	.84	
	2	.84	
	3	.77	
c19	1		.47
	2		.43
	3		.44

c29	1	.60
	2	.64
	3	.64
c34	1	.75
	2	.71
	3	.70
c41	1	.82
	2	.77
	3	.74
c45	1	.61
	2	.73
	3	.45

Metric invariance of the factor loadings for the 2-factor structure across a 6-year period was estimated. This model did not result in a significant loss of fit over the configural model that places no constraints on parameters ($\chi^2 = 535.82$, df = 376, p = .000, RMSEA = .04, CFI = .96, GFI = .90; $\Delta\chi^2 = 20.76$, Δdf = 16, p > .05).

Summary. The results of the measurement invariance across occasions (i.e., longitudinal invariance) indicate configural invariance of the 5-factor (MCQ External, Internal, Reliance, Time, and Effort) model and configural and metric invariance of the 2-factor model (MCQ Success and Change). Constraining the factor loadings to be equal across time (i.e., testing for metric invariance) led to a small loss of model fit for the 5-factor model of MCQ strategies. Overall, the structure of the MCQ scales are invariant (i.e., do not change) across a 6-year testing period.

Research Goal 3: Change and Variability of the MCQ

Before examining growth trajectories, factor composites of the MCQ scales were created. As there are different ways of creating factors, three methods were developed for purposes of comparing their correlations. The first method involved creating factor scores using the factor score regression weights from the cross-sectional models. These models examined MCQ items at each wave separately (W1, W2, and W3). The second method involved creating factor scores using factor score regression weights from the longitudinal models which included only those individuals present across the three occasions of measurement. The third method of creating MCQ factors was to create unit weighting (averaging) of the salient indicators of each scale. The correlations between the different methods of creating factors were near unity (e.g., all correlations were between .92 and 1.0; M r = .98). As a result, unit weighting (averaging) of the MCQ scales was selected for use in subsequent HLM analyses. Unit weighting allows for easier cross-validation (replication) across samples or data sets.

HLM analyses were used to examine mean-level changes and individual differences (variability) in changes in the seven MCQ scales. For all models, listwise deletion of level 1 within-person variables (MCQ scales) was selected. Listwise deletion selects only those cases with full MCQ data at any given wave of measurement (i.e., complete MCQ data at Waves 1, 2, or 3). The data sets used in the previous section on structural equation modelling were merged across all three waves for the 5 strategy scales and the 2 general scales, separately, and used in the present HLM analyses. Intraindividual change models were estimated separately for data sets containing the covariates measured at Waves 1 and 3.

Level 1 models were analysed separately for each of the seven MCQ scales as follows:

Level 1 (within-person model): $$\text{Memory Compensation}_{ti} = \beta_{0i} + \beta_{1i}\,(\text{Wave}) + r_{ti} \qquad (1)$$

In equation 1, reports of memory compensation strategies for a given person (i) at a given time (t) was modelled as a function of that person's performance at the start of the study (W1; the intercept), the average linear effect of time across waves (the slope), plus a random within-person error term. Random coefficients models (i.e., the growth parameters are free to vary across individuals) were estimated for each MCQ scale to determine whether there was intraindividual change across time. The significance level for the fixed slope coefficient indicates whether there are mean-level differences across a 6-year period in MCQ scales. The test for the random effects indicates whether there was significant interindividual variation in the mean growth curve.

Data set with Wave 3 predictors. Longitudinal data from 292 older adults (for the strategy scales) and 291 older adults (for the general scales) across 3 occasions of measurement provided 866 and 864 person-time cases, respectively. Random coefficients models without level 2 covariates were estimated for each of the 7 MCQ factors. A summary of the HLM findings (fixed effects for intercept: column 1; fixed effects for slope: column 2; and random effect for slope: column 5) are listed in Table 18. For all MCQ factors, fixed intercepts (mean level use of memory compensation at the first wave of measurement) and random intercepts (individual differences in level) were significantly different from zero. Average rate of change was significant for MCQ External (.04) such that the use of external aids increased over the 6-year period. The negative fixed slope for MCQ Internal (-.03) and MCQ Time (-.04) indicates that internal mnemonic and time investment strategies are used less frequently over the 6-year period. The overall change in MCQ External, Internal, and Time over the period of the 6-year study can be determined by multiplying the fixed slope coefficient by the number of waves (n = 3, or in this case the maximum value of time that was coded which represents the number of retest occasions). In these analyses, the time variable was recoded to 0 (Wave 1), 1, (Wave 2) and 2 (Wave 3). Specifically, there was a total average (a) increase of .08 (slope = .04 * 2) in MCQ External reports, (b) decrease of -.06 (slope = -.03 * 2) in MCQ Internal reports, and (c) decrease of -.08 (slope = -.04 * 2) in MCQ Time reports. All random slope effects with the exception of MCQ Time were significant, indicating that there were individual differences in intraindividual change in memory compensation. The slope for MCQ Time was fixed indicating that individuals invested in this memory compensation strategy at parallel rates over the testing period.

Table 18

Intraindividual Change in Memory Compensation

	Fixed Effect				Random Effect	
Measure	Intercept γ_{00}	Slope γ_{10}	SE	t	Slope U_1 (Variance Component)	χ^2
External	3.23	0.04	0.01	3.18**	0.01	339.53*
Internal	2.22	-0.03	0.01	-2.53**	0.01	356.89**
Reliance	1.19	-0.01	0.02	-0.60	0.04	422.11**
Time	2.09	-0.04	0.02	-1.99*	n.s.	n.s.
Effort	2.53	.00	0.02	0.13	0.02	388.70**
Success	1.80	0.03	0.02	1.57	0.04	399.94**
Change	2.40	.00	0.01	-0.11	0.01	401.09**

Note. SE and t-values are for the fixed slope effect.

*$p < .05$, **$p < .01$.

Data set with Wave 1 predictors. Longitudinal data from 497 older adults (for the strategy scales) and 492 older adults (for the general scales) across 3 occasions of measurement provided 1208 and 1201 person-time cases, respectively. Random coefficients models with no level 2 covariates were estimated for each of the 7 MCQ scales. A summary of the HLM change findings are listed in Table 19. For all MCQ factors, fixed intercepts (mean level use of memory compensation at the first wave of measurement) and random intercepts (individual differences in level) were significantly different from zero. The rate of change for MCQ External and MCQ Time did not differ across individuals, therefore the models were re-estimated as a fixed slope. The average rate of change for MCQ External (.03) was significant. This indicates that the average use of external aids increased to a small degree from a predicted value of 3.29 (Wave 1) to 3.35 (Wave 3) over the 6-year period. The average rate of change for MCQ Internal (-.03) decreased to a small degree from a predicted value of 2.27 (Wave 1) to 2.21 (Wave 3) across 6-years. The average rate of change for MCQ Time (-.05) also decreased to a small degree from a predicted value of 2.18 (Wave 1) to 2.08 (Wave 3) over the 6-year period. The models for MCQ External and MCQ Time were re-estimated because the random slope estimate was not significant. The rate of change for these two MCQ scales is the same for all individuals. The individual growth trajectories for MCQ scales are presented in Figures 3 to 9.

Table 19

Intraindividual Change in Memory Compensation

	Fixed Effect				Random Effect	
Measure	Intercept γ_{00}	Slope γ_{10}	SE	t	Slope U_1 (Variance Component)	χ^2
External	3.29	0.03	0	3.36**	--	n.s.
Internal	2.27	-0.03	0	-2.37*	0.01	482.44**
Reliance	1.20	-0.01	0	-0.43	0.03	520.14**
Time	2.18	-0.05	0	-2.78**	--	n.s.
Effort	2.58	0.01	0	0.77	0.02	504.62**
Success	1.89	0.03	0	1.70	0.04	536.54**
Change	2.46	-0.01	0	-0.63	0.01	499.08**

Note. SE and t-values pertain to the slope estimate.

*p < .05; **p < .01; ***p < .001.

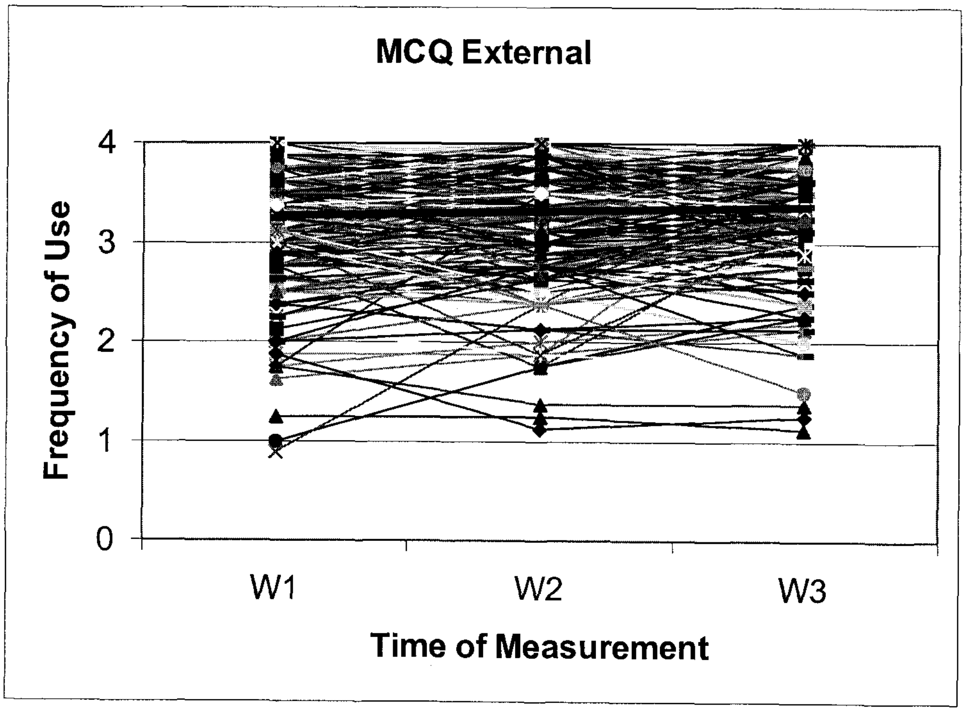

Figure 3. Individual growth trajectories of MCQ External. Mean growth curve is represented by a thick black line. W1 = Wave 1; W2 = Wave 2; W3 = Wave 3. Significant six-year mean-level increase in external aids, and no variability in change.

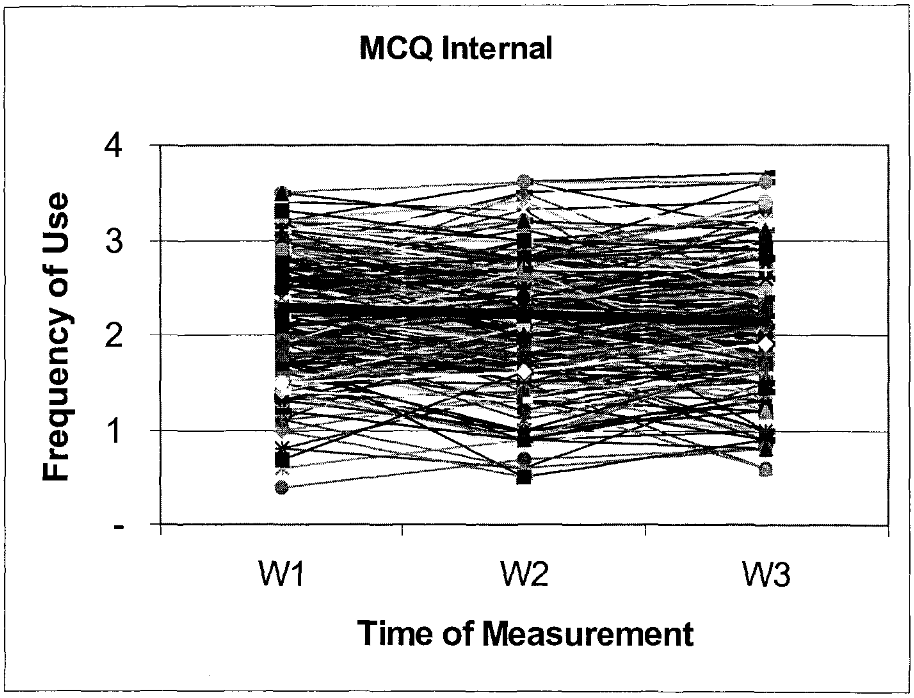

Figure 4. Individual growth trajectories of MCQ Internal. Mean growth curve is represented by a thick black line. W1 = Wave 1; W2 = Wave 2; W3 = Wave 3. Significant six-year mean-level decrease in internal mnemonic strategies and variability in change.

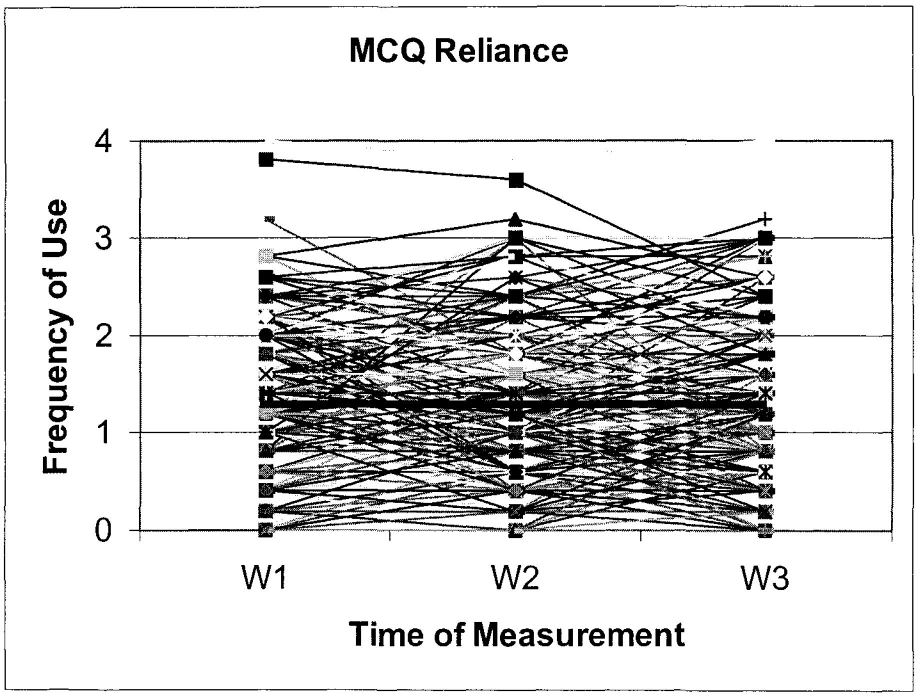

Figure 5. Individual growth trajectories of MCQ Reliance. Mean growth curve is represented by a thick black line. W1 = Wave 1; W2 = Wave 2; W3 = Wave 3. There is significant variability in change and no mean-level change in MCQ Reliance.

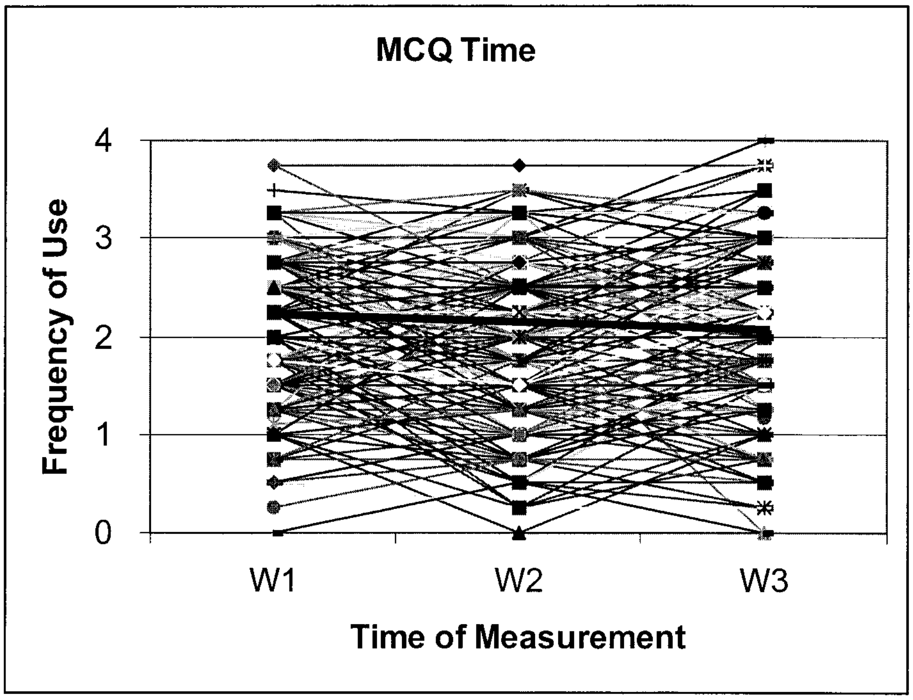

Figure 6. Individual growth trajectories of MCQ Time. Mean growth curve is represented by a thick black line. W1 = Wave 1; W2 = Wave 2; W3 = Wave 3. Significant 6-year mean-level decrease in time investment and no variability in rate of change.

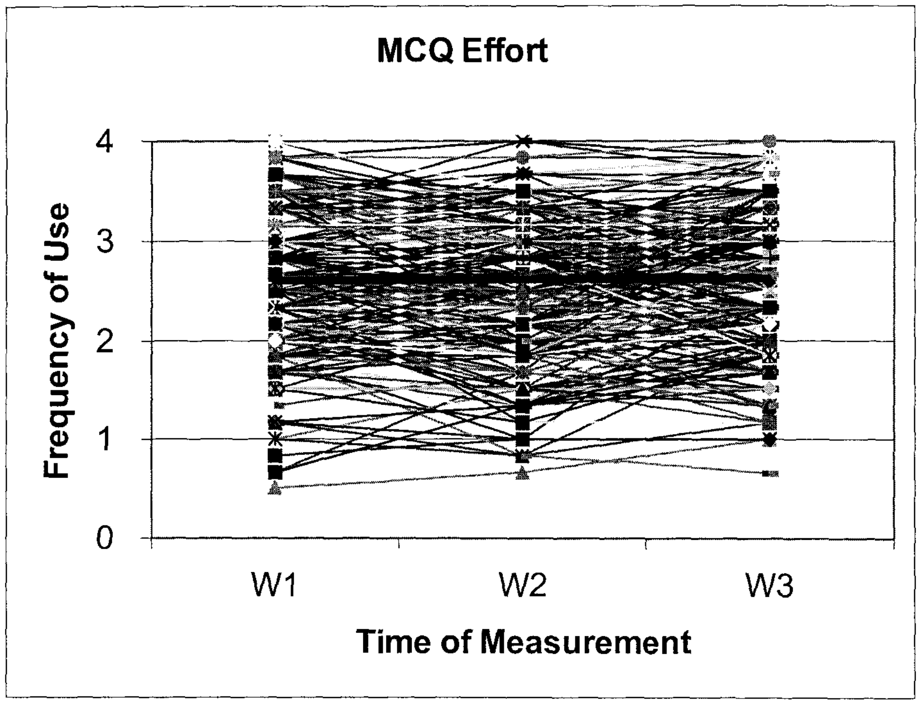

Figure 7. Individual growth trajectories of MCQ Effort. Mean growth curve is represented by a thick black line. W1 = Wave 1; W2 = Wave 2; W3 = Wave 3. Significant variability in change for effort investment, but no six-year mean-level change.

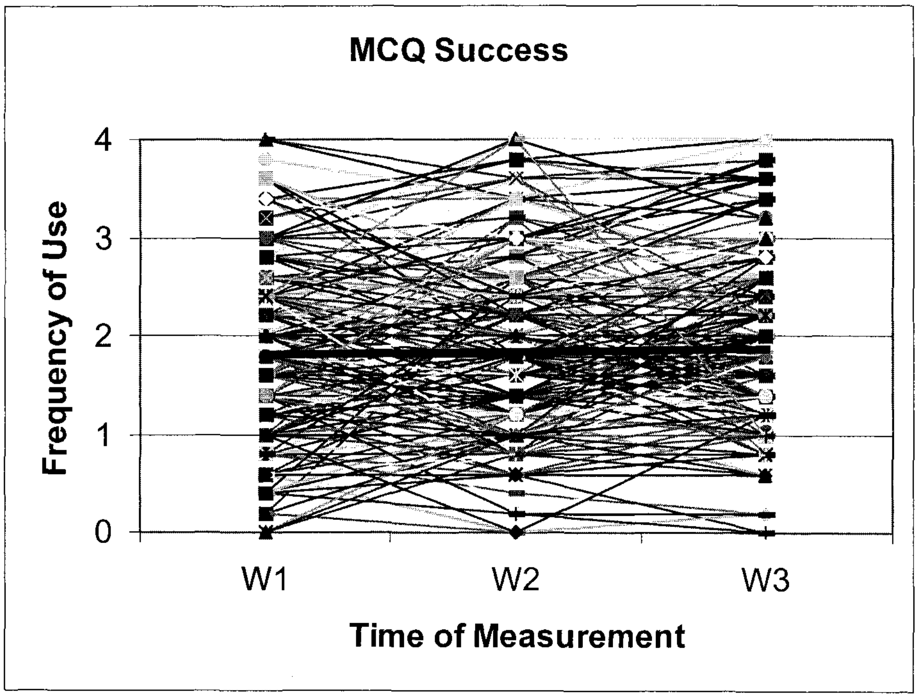

Figure 8. Individual growth trajectories of MCQ Success. Mean growth curve is represented by a thick black line. W1 = Wave 1; W2 = Wave 2; W3 = Wave 3. Significant variability in change for the motivation to succeed, but no six-year mean-level change.

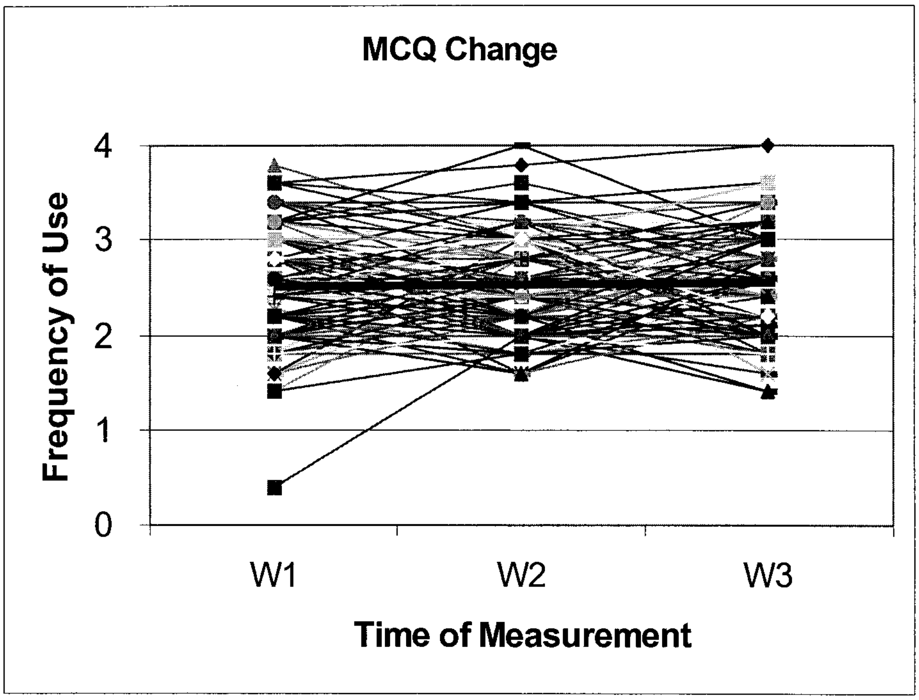

Figure 9. Individual growth trajectories of MCQ Change. Mean growth curve is represented by a thick black line. W1 = Wave 1; W2 = Wave 2; W3 = Wave 3. Significant variability in rate of change for MCQ Change and no mean-level change.

Research Goal 4: Influences on Variability in Change

HLM analyses were used to examine sources of individual differences (variability) in changes in the seven MCQ scales. The between-person sources of individual differences in change on the seven MCQ scales were (a) chronological age, (b) biological age, (c) personality traits, (d) memory self-efficacy, and (e) episodic memory performance. Listwise deletion of the level 2 (between-person) covariates is a requirement in HLM. The correlations among the correlates are shown in Table 20. Correlations between age, education, and MCQ at Wave 1 are presented in Table 21.

Table 20

Correlations Among the Correlates of MCQ Scales

	1	2	3	4	5	6	7	8	9
1. Chronological age	-								
2. Biological age	.49*	-							
3. Conscientiousness	-.03	-.08	-						
4. Agreeableness	-.01	.01	.21*	-					
5. Neuroticism	-.10	.05	-.28*	-.25*	-				
6. Extraversion	-.10	-.03	.21*	.16*	-.25*	-			
7. Openness to experience	-.13*	-.06	-.02	.06	.03	.37*	-		
8. Memory self-efficacy	-.13*	-.09	.19*	.04	-.24*	.25*	.32*	-	
9. Episodic memory Wave 1	-.19*	-.09	.02	.13*	.00	.00	.26*	.19*	-
10. Episodic memory Wave 3	-.38*	-.21*	.05	.10	.02	-.01	.20*	.18*	.72*

Note. $*p < .05$.

Table 21

Correlations Among Age, Education, and the MCQ Scales at Wave 1

	MCQ Scales						
	External	Internal	Reliance	Time	Effort	Success	Change
Age	.07	.00	.05	.07	.03	.16*	.14*
Education	-.11*	.01	-.06	-.03	-.09*	-.13*	-.07

Note. *p < .05.

At level 1, each person's development is represented by an individual growth trajectory (an intercept, β_{0i}, and a slope, β_{1i}), as described in equation 1. At level 2, these parameters become the outcome variables that depend on stable between-person sources of variation. Essentially, these variables represent an intercept (β_0) and slope (β_1) as outcomes model. Separate two-stage models were analysed for each MCQ scale. A sample description (using chronological age and biological age as level 2 predictors) of a level 2 equation follows:

Level 2 (between-person model): $\beta_{0i} = \gamma_{00} + \gamma_{01}$ (Chronological age) + γ_{02} (Biological age) + U_{0i} (2)

$\beta_{1i} = \gamma_{10} + \gamma_{11}$ (Chronological age) + γ_{12} (Biological age) + U_{1i} (3)

In equation 2, a given person's score at the first wave of measurement, $\beta_{0i,}$ was modelled as a function of the average level across all participants in the first wave, γ_{00} (fixed effect), the average group difference in memory compensation for chronological (γ_{01}) and biological (γ_{02}) age, plus a random effect of how the individual varies around the grand mean (i.e., initial individual differences) after controlling for initial status, chronological age, and biological age, U_{0i} (between-person variance in the intercept). The parameters γ_{01} and γ_{02} estimate the cross-sectional "age" effect. In equation 3, linear average rate of change in memory compensation for a given person, β_{1i}, was modelled as a function of the sample average change in memory compensation controlling for chronological and biological age, γ_{10}, the effect of chronological age, γ_{11} (average difference in change) and biological age, γ_{12} (average difference in change), on the rate of change, plus a random effect, U_{1i}, that represents between-person variability in the slopes. Stated differently, the random effect estimated whether there are significant interindividual differences in intraindividual change after controlling for other parameters (i.e., occasion of measurement, chronological age, and biological age). The parameters γ_{11} and γ_{12} estimate the longitudinal age effect.

Chronological age. Chronological age was treated as both a continuous variable and a dichotomous variable in HLM analyses. Two chronological age categories were created as follows: young-old chronological age (range: ages 61-76 years) and old-old chronological age (range: ages 77-91 years). HLM analyses were used to examined the independent role of chronological age on prior 6-year change in MCQ scales. Chronological age (treated as a dichotomous variable) was a significant moderator of changes in MCQ Time after controlling for biological age (γ_{11} = .11, SE = .04, t = 2.58, p = .01). The slope for the young-old (YO) age group was negative (γ_{10} = -.07, SE = .02, t = -2.96, p < .01), whereas the slope for the old-old (OO) age group was positive (-.07 + .11 = .04). Over a 6-year period the YO age group decrease their investment time on memory tasks by -.14 units (-.07 * 2), whereas the OO age group increase their investment time by .08 units over the same period. The moderating effect of chronological age on rate of change in MCQ Time is presented in Figure 10. When chronological age was treated as a continuous variable, the effect of age was positive (γ_{11} = .01, p < .01). For every one year increase in age, there was a corresponding .01 (or .10 for every decade) increase in time spent on memory tasks.

Biological age. Before analyzing the effect of biological age on memory compensation, the factor structure of the biomarkers was examined. Four biomarker indicators were standardized to t-scores (i.e., M = 50, SD = 10) before entry into structural modelling analyses. The factor structure of the biomarkers fit the data exceptionally well (χ^2 = 2.22, df = 2, p > .05, RMSEA = .02, CFI = 1.00, GFI = 1.00). The significant factor loadings are as follows: grip strength (λ = .35), close vision (λ = .43), distance vision (λ = .67), and hearing (λ = .39). A factor score composite was created by using the factor score regression weights estimated in LISREL (Biological age factor = grip strength * .11 + close vision * .14 + distance vision * .34 + hearing * .13). The variance of the Biological age factor was significant (phi = 41.40). Chronological age and biological age have a moderate size correlation (r = .49). Biological age was treated as both a continuous variable and a dichotomous variable in HLM analyses. Two biological age categories were created as follows: younger biological age (score below mean of 50; 62% of the sample), and older biological age (score at mean of 50 or greater; 38% of the sample). HLM analyses were used to examined the independent role of biological age on prior 6-year change in MCQ scales.

Biological age (whether treated as a continuous or dichotomous variable) was not a significant predictor of prior changes in memory compensation for this sample of older adults. One plausible reason for the null findings is that three waves of measurement was insufficient to differentiate among individual growth curves.

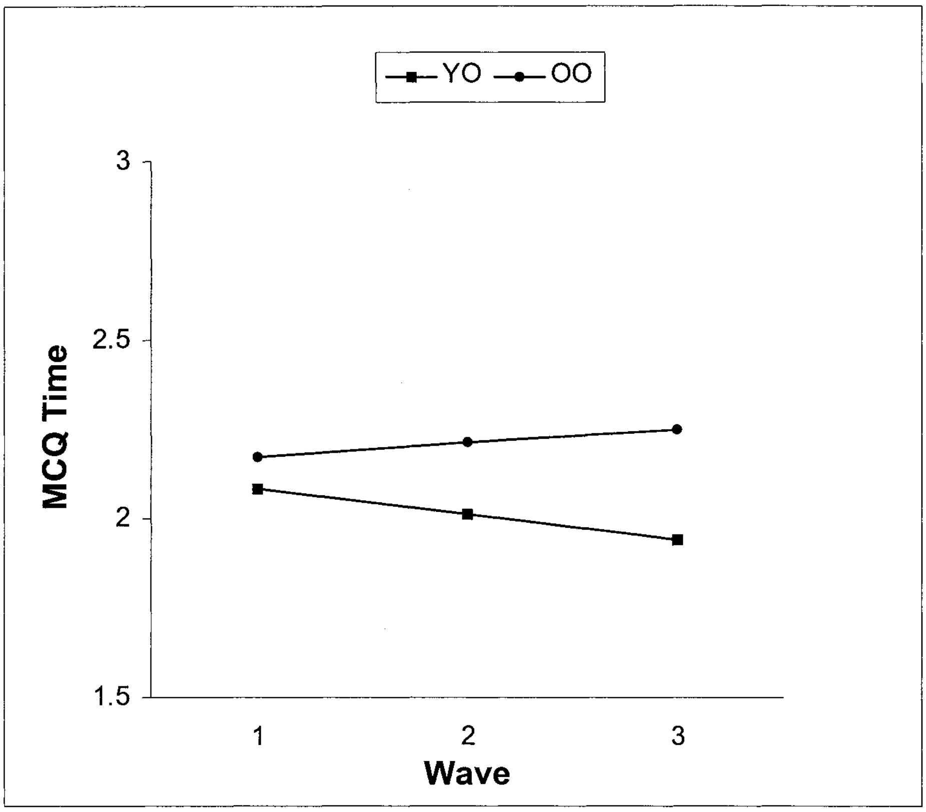

Figure 10. Young-old (YO) and old-old (OO) adults differ in rate of change in MCQ Time.

Psychosocial characteristics and memory performance. The following section contains the results for personality, memory self-efficacy, and memory performance as between-person sources of interindividual differences in intraindividual changes in memory compensation over a 6-year period. The five personality traits were entered simultaneously in a single block. Memory self-efficacy and episodic memory performance (i.e., a composite of two word recall and two text recall tasks) were entered separately.

Three separate two-stage models were analysed for each MCQ scale. The same level 1 model was analyzed with three variations of the level 2 models. These HLM models are the following:

Level 1 (within-person model): $\text{Memory Compensation}_{ti} = \beta_{0i} + \beta_{1i}\,(\text{Wave}) + r_{ti}$

Level 2 (between-person model): $\beta_{0i} = \gamma_{00} + \gamma_{01}\text{-}\gamma_{05}\,(\text{Personality traits}) + U_{0i}$

$\beta_{1i} = \gamma_{10} + \gamma_{11}\text{-}\gamma_{15}\,(\text{Personality traits}) + U_{1i}$

Level 2 (between-person model): $\beta_{0i} = \gamma_{00} + \gamma_{01}\,(\text{MSE}) + U_{0i}$

$\beta_{1i} = \gamma_{10} + \gamma_{11}\,(\text{MSE}) + U_{1i}$

Level 2 (between-person model): $\beta_{0i} = \gamma_{00} + \gamma_{01}\,(\text{Episodic memory}) + U_{0i}$

$\beta_{1i} = \gamma_{10} + \gamma_{11}\,(\text{Episodic memory}) + \text{U1i}$

<u>Personality traits.</u> Personality traits were significant predictors of interindividual differences in changes in MCQ scales. Table 22 lists the HLM estimates. Conscientiousness, neuroticism, and agreeableness had a negative effect on rates of change for select MCQ scales (i.e., MCQ External, Internal, Effort, Success, and Change). In general, for every 1 unit increase in a given personality trait there was a corresponding decrease in the rate of memory compensation strategy use. The interpretation of the interaction effect (gamma_{11}) is as follows. Higher Conscientiousness predicted a decrease in MCQ External, Internal, Effort, and Success. Higher Neuroticism predicted a drop in MCQ Effort. Higher Agreeableness predicted a decrease in MCQ Change. In contrast, higher Extraversion predicted an increase in motivation on memory tasks.

One method of probing the interaction is to calculate the slope for the regression of Y on X at levels of a given personality trait (mean centered) at each wave. Three values were selected for each personality trait: (a) 1 SD below the mean, (b) the mean (always 0 because continuous level 2 variables are mean centered in HLM), and (c) 1 SD above the mean. Predicted values for Y (MCQ scale) were calculated based on the intercept ($B_0 = \gamma_{00} + \gamma_{01}$) and the slope ($B_1 = \gamma_{10} + \gamma_{11}$) coefficients provided in HLM. A sample equation is as follows:

Predicted Y = $B_0 + B_1 X$ (where X = time; values are 0 = W1, 1 = W2, and 2 = W3)

$B_0 = \gamma_{00} + \gamma_{01} * W$ (where W = a value of the level 2 predictor)

$B_1 = \gamma_{10} + \gamma_{11} * W$

The plots of the predicted values of MCQ at each wave for each of the three values of a given personality trait are presented in Figures 11 to 17. The plots for Conscientiousness and Neuroticism show that a 6-year increment in the use of memory compensation strategies occurs for individuals lower in these personality traits. By contrast, there is an overall decline at higher values of these personality traits resulting in a negative interaction effect (see Figure 11 and Figures 13-15). A cross-over at the mean describes the moderating role of Conscientiousness on changes in MCQ Internal (as displayed in Figure 12). Specifically, there is stability in growth at the mean with individuals higher in Conscientiousness (e.g., 1 SD above the mean) declining below the mean curve. Figure 16 shows that for higher values of Extraversion there are increases in MCQ Success over the six-year period. Figure 17 shows that for higher values of Agreeableness there is a decline in MCQ Change, with no change in MCQ Change for individuals with a mean score on Agreeableness (Table 22, row 37, column 3).

Table 22

Personality Traits Are a Source of Interindividual Differences in Intraindividual Changes in MCQ Scales

Measure	Slope Reference	Slope	SE	t
External	Overall mean slope	.033	.01	3.24**
	Conscientiousness	-.005	.00	-3.39***
	Agreeableness	.002	.00	1.10
	Neuroticism	-.001	.00	-1.90
	Extraversion	.000	.00	-.65
	Openness to experience	.000	.00	-.10
Internal	Overall mean slope	-.031	.01	-2.51**
	Conscientiousness	-.006	.00	-3.47***
	Agreeableness	.002	.00	1.14
	Neuroticism	-.000	.00	-.28
	Extraversion	.001	.00	1.01
	Openness to experience	-.001	.00	-1.59

Reliance	Overall mean slope	-.008	.02	-.46
	Conscientiousness	-.003	.00	-1.35
	Agreeableness	.002	.00	.53
	Neuroticism	-.000	.00	-.30
	Extraversion	-.000	.00	-.00
	Openness to experience	.000	.00	.25
Time	Overall mean slope	-.044	.02	-2.72**
	Conscientiousness	-.003	.00	-1.30
	Agreeableness	.001	.00	.41
	Neuroticism	.000	.00	.16
	Extraversion	-.000	.00	-.27
	Openness to experience	-.001	.00	-1.32
Effort	Overall mean slope	.010	.02	.62
	Conscientiousness	-.004	.00	-1.93*
	Agreeableness	.001	.00	.52
	Neuroticism	-.002	.00	-1.98*
	Extraversion	.000	.00	.76
	Openness to experience	.000	.00	.99

Success	Overall mean slope	.032	.02	1.65
	Conscientiousness	-.006	.00	-2.46**
	Agreeableness	-.001	.00	-.41
	Neuroticism	.000	.00	.28
	Extraversion	.003	.00	2.04*
	Openness to experience	.001	.00	.46
Change	Overall mean slope	-.007	.02	-.56
	Conscientiousness	.000	.00	.21
	Agreeableness	-.004	.00	-1.94*
	Neuroticism	.001	.00	-1.31
	Extraversion	.000	.00	.41
	Openness to experience	.000	.00	.30

Note. With adjustment for robust standard error, the effect of Neuroticism on MCQ External is significant ($\gamma = -.001$).

*$p < .05$; **$p < .01$; ***$p < .001$.

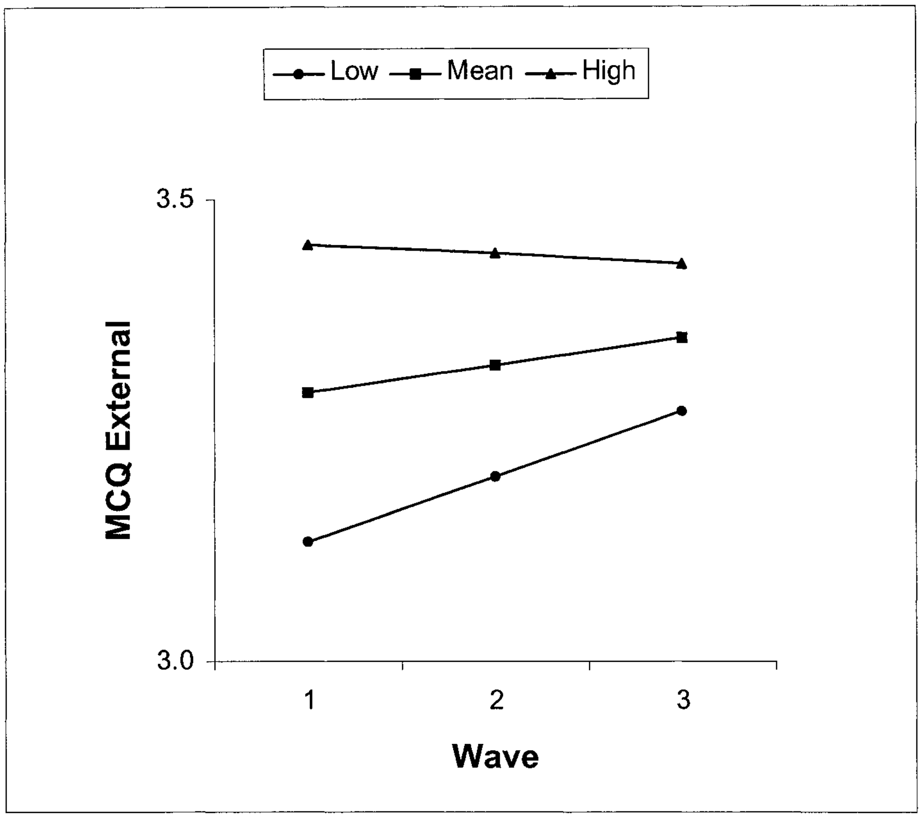

Figure 11. Conscientiousness moderates changes in MCQ External.

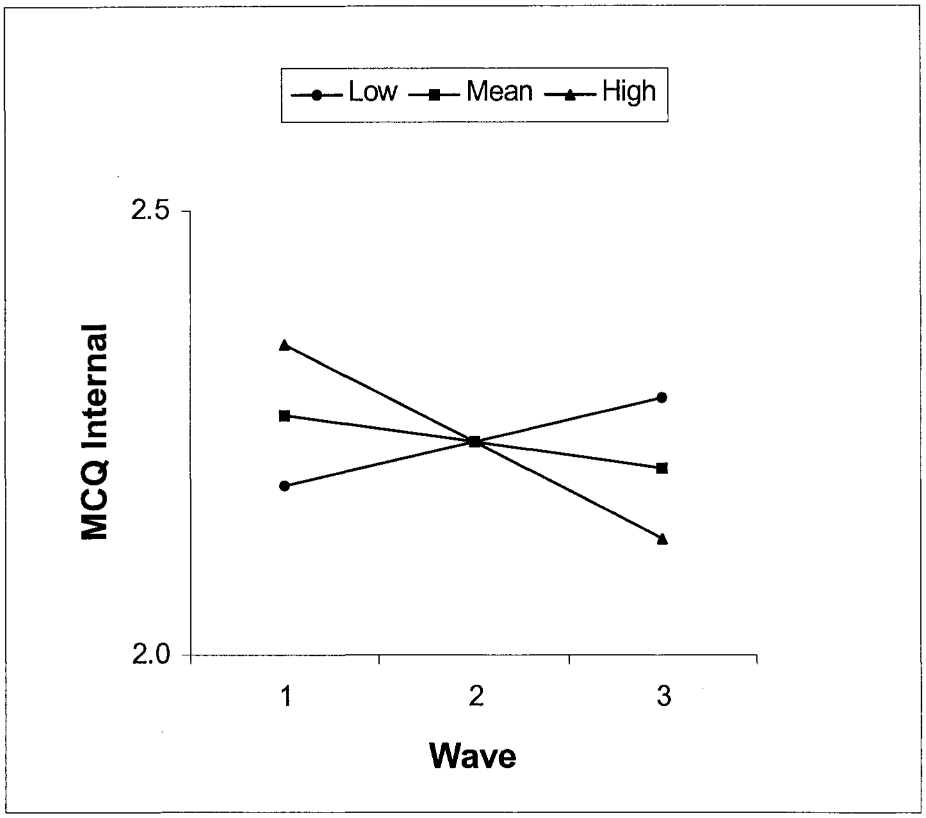

Figure 12. Conscientiousness moderates changes in MCQ Internal.

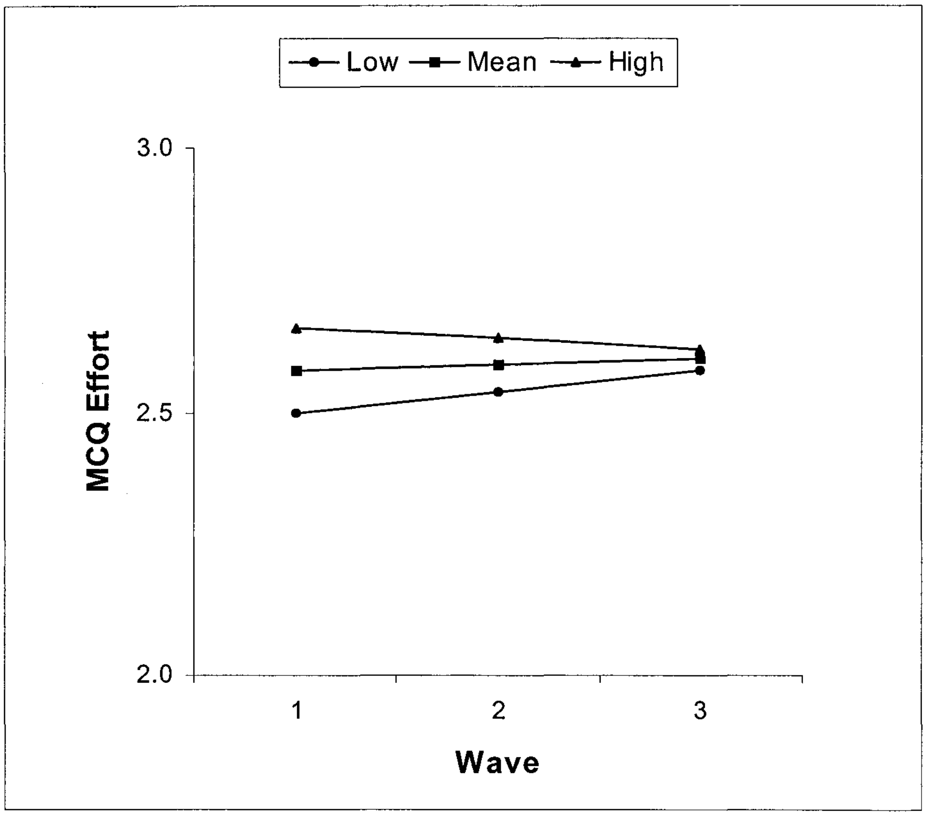

Figure 13. Conscientiousness moderates changes in MCQ Effort.

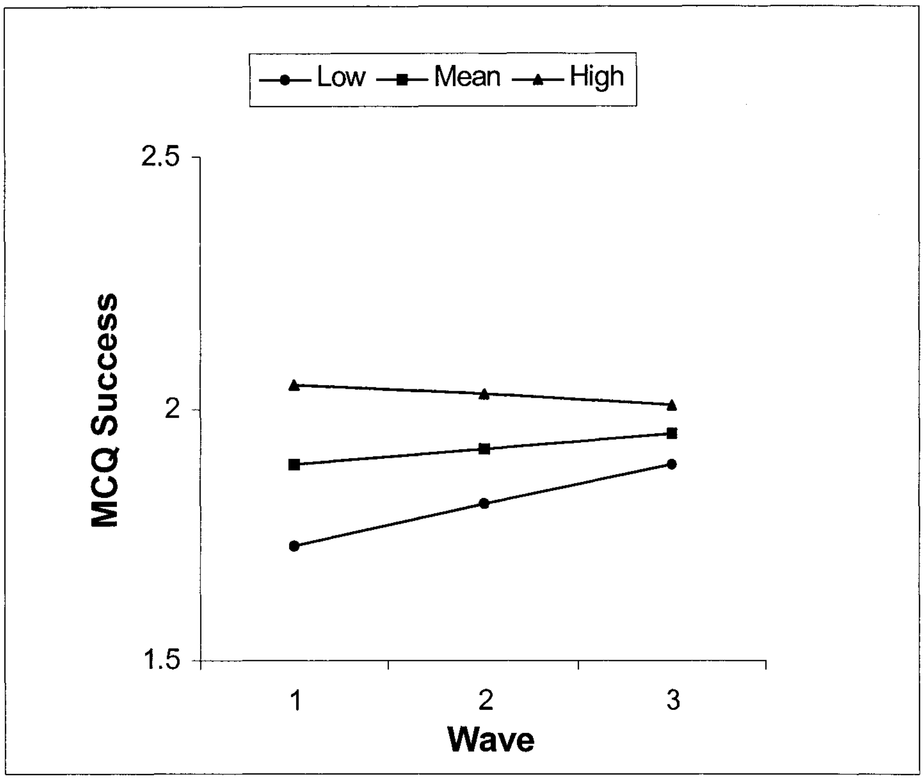

Figure 14. Conscientiousness moderates changes in MCQ Success.

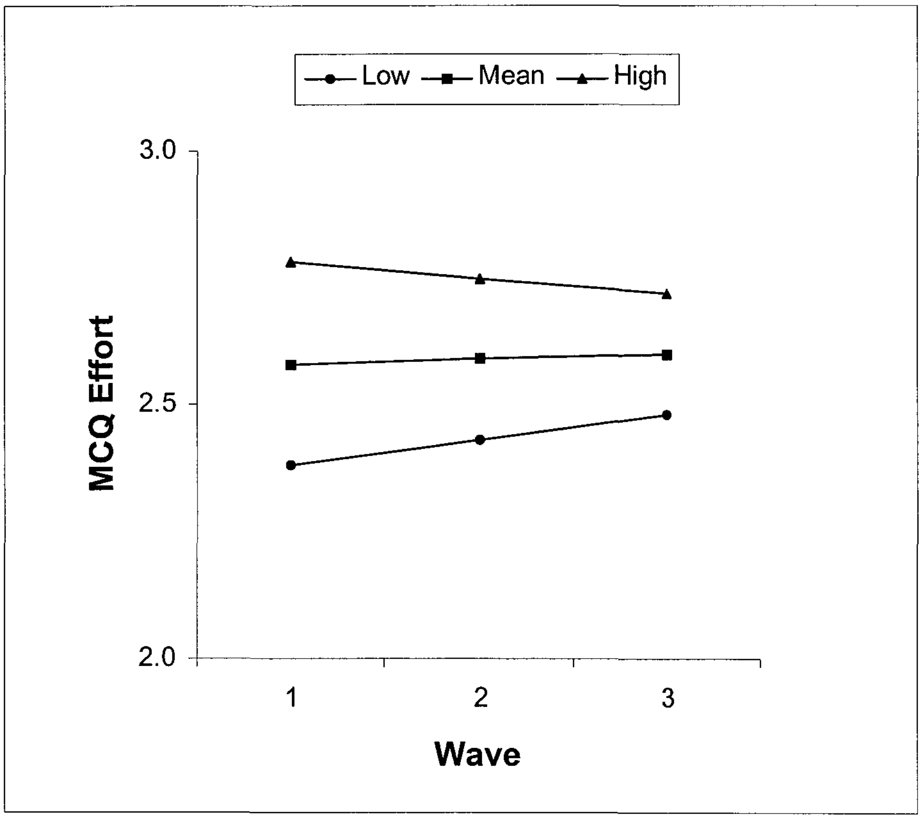

Figure 15. Neuroticism moderates changes in MCQ Effort.

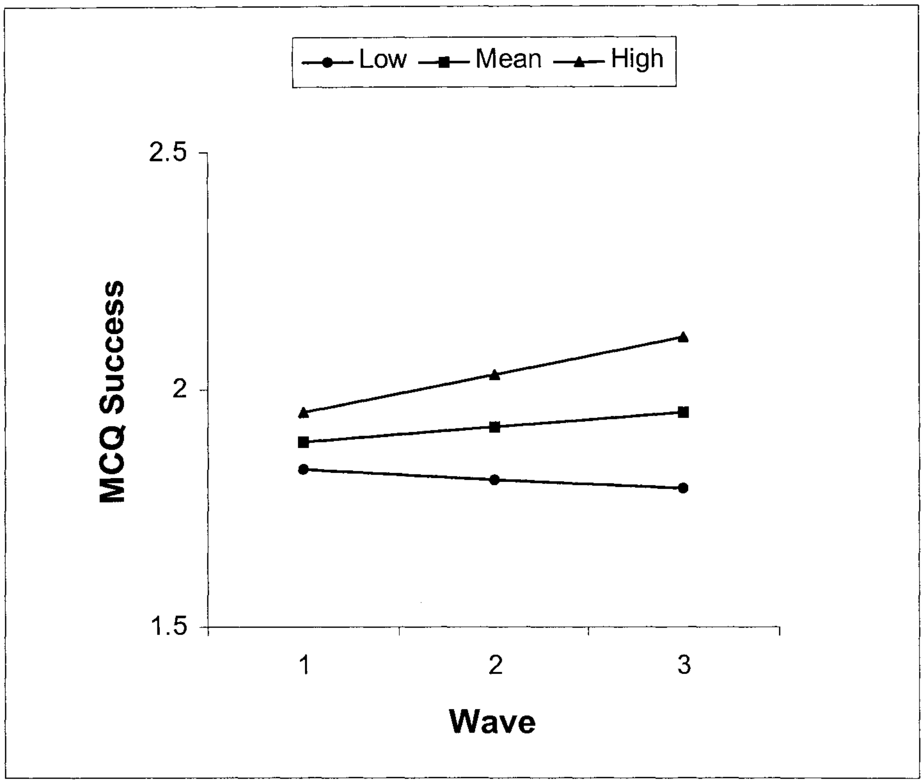

Figure 16. Extraversion moderates changes in MCQ Success.

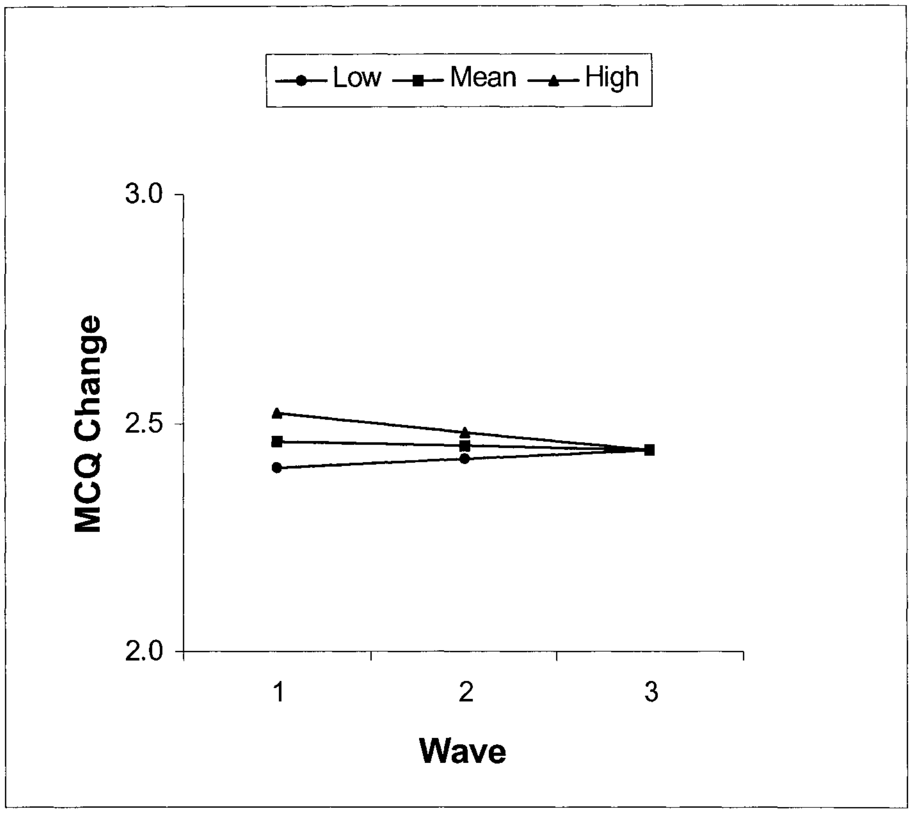

Figure 17. Agreeableness moderates changes in MCQ Change.

Memory self-efficacy (MSE). The next set of analyses pertain to how level of MSE relates to changes in MCQ scales. The one significant relation observed was between MSE and MCQ Change. MSE was a significant covariate of individual differences in intraindividual changes in MCQ Change scales. HLM estimates are presented in Table 23. Specifically, for individuals scoring above the mean on MSE (M = 44.57), there was a 6-year increase in MCQ Change. The slope for the regression of Y on X at levels of MSE (mean centered) at each wave was computed. The selected values of MSE were (a) 1 SD below the mean (-7.29), (b) the mean (0), and (c) 1 SD above the mean (7.29). A given individual with an MSE score at 1 SD below the mean has the following predicted values for Y (MCQ Change) at each wave: Wave 1 = 2.68, Wave 2 = 2.63, Wave 3 = 2.58. A given individual with a mean MSE score has the following predicted values for Y (MCQ Change) at each wave: Wave 1 = 2.46, Wave 2 = 2.45, and Wave 3 = 2.44. A given individual with an MSE score at 1 SD above the mean has the following predicted values for Y (MCQ Change) at each wave: Wave 1 = 2.24, Wave 2 = 2.27, and Wave 3 = 2.30. The predicted values indicate that for individuals scoring (a) at the mean of MSE there is little change in MCQ Change, (b) below the mean of MSE there is a drop in the slope for MCQ Change, and (c) above the mean of MSE there is an increment in the slope across waves. The moderating role for MSE is shown in Figure 18.

Table 23

Memory Self-Efficacy as a Source of Interindividual Differences in Intraindividual Changes in MCQ Scales

Measure		Slope	SE	t
External	γ_{10}	.035	.01	3.35***
	γ_{11}	.001	.00	.62
Internal	γ_{10}	-.029	.01	-2.31*
	γ_{11}	-.001	.00	-.63
Reliance	γ_{10}	-.005	.02	-.29
	γ_{11}	-.001	.00	-.29
Time	γ_{10}	-.04	.02	-2.62**
	γ_{11}	-.00	.00	-1.41
Effort	γ_{10}	.012	.02	.76
	γ_{11}	.003	.00	1.16
Success	γ_{10}	.033	.02	1.64
	γ_{11}	.003	.00	1.08
Change	γ_{10}	-.007	.01	-.59
	γ_{11}	.005	.00	2.81**

Note. *p < .05; **p < .01; ***p < .001.

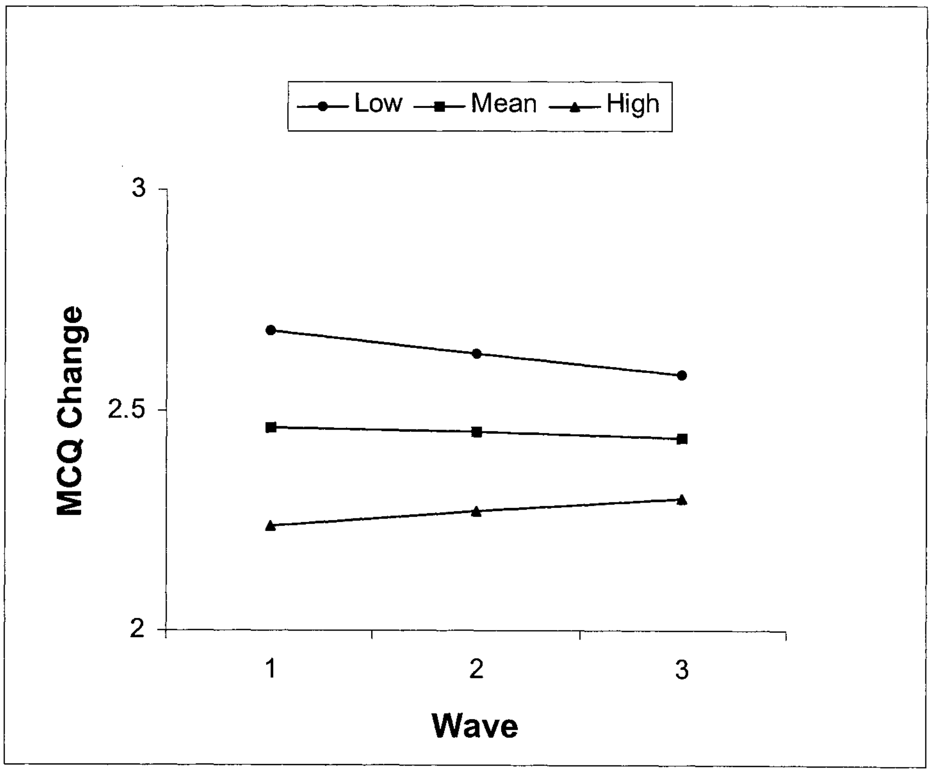

Figure 18. Memory self-efficacy moderates changes in MCQ Change.

Memory performance. We next turn to the analyses on episodic memory performance tested as a source of individual differences in rates of change on MCQ scales. A composite score of episodic memory was created by summing the values for word recall and text recall for all participants. Two word recall tasks and two text recall tasks were provided for each participant. A separate average score for word recall and text recall was computed. For word recall, the average proportion of words recalled out of 30 was calculated before entry into the composite score. The unit of analysis for the episodic memory composite is the proportion of words and story propositions correctly recalled. This episodic memory composite was entered into HLM. The HLM estimates for episodic memory performance are listed in Table 24. Episodic memory performance was a significant predictor of individual differences in intraindividual changes in MCQ External ($gamma_{11}$ = .30; column 3, row 2) and MCQ Effort ($gamma_{11}$ = .54; column 3, row 10). The interaction term (gamma11) indicated that for every 1 unit increase in episodic memory performance, there is a .30 (MCQ External) and .54 (MCQ Effort) difference in the slope. Individuals with better memory at Wave 1 are reporting an increased use of external aids and effort investment over the 6-year period.

Table 24

Episodic Memory Performance (at Wave 1) as a Source of Interindividual Differences in Intraindividual Changes in MCQ Scales

Measure		Slope	SE	t
External	Time effect, γ_{10}	.03	.01	2.86**
	Episodic memory, γ_{11}	.30	.10	2.97**
Internal	Time effect, γ_{10}	-.03	.01	-2.44*
	Episodic memory, γ_{11}	.18	.12	1.43
Reliance	Time effect, γ_{10}	.00	.02	.01
	Episodic memory, γ_{11}	-.11	.18	-.64
Time	Time effect, γ_{10}	-.04	.02	-2.50**
	Episodic memory, γ_{11}	.02	.16	.16
Effort	Time effect, γ_{10}	.00	.02	.15
	Episodic memory, γ_{11}	.54	.15	3.51***
Success	Time effect, γ_{10}	.03	.02	1.72
	Episodic memory, γ_{11}	.17	.19	.87
Change	Time effect, γ_{10}	-.00	.01	-.24
	Episodic memory, γ_{11}	.10	.12	.85

Note. *$p < .05$; **$p < .01$; ***$p < .001$.

The slope for the regression of Y on X at levels of episodic memory performance (mean centered) at each wave was computed. The three selected values of episodic memory were (a) 1 SD below the mean (-.11), (b) the mean (0), and (c) 1 SD above the mean (.11). A plot of the slope (for MCQ External) by memory performance (at Wave 1) interaction is displayed in Figure 19. A plot of the slope (for MCQ Effort) by memory performance (at Wave 1) interaction is displayed in Figure 20. The predicted values indicate that as levels of episodic memory performance (at Wave 1) increase there is a corresponding increase in the use of external aids over the 6-year period. The predicted values indicate that the slope of MCQ Effort increases across waves for individuals scoring above the mean on memory performance (at Wave 1), compared to individuals at the mean (showing little change) and below the mean (showing decline).

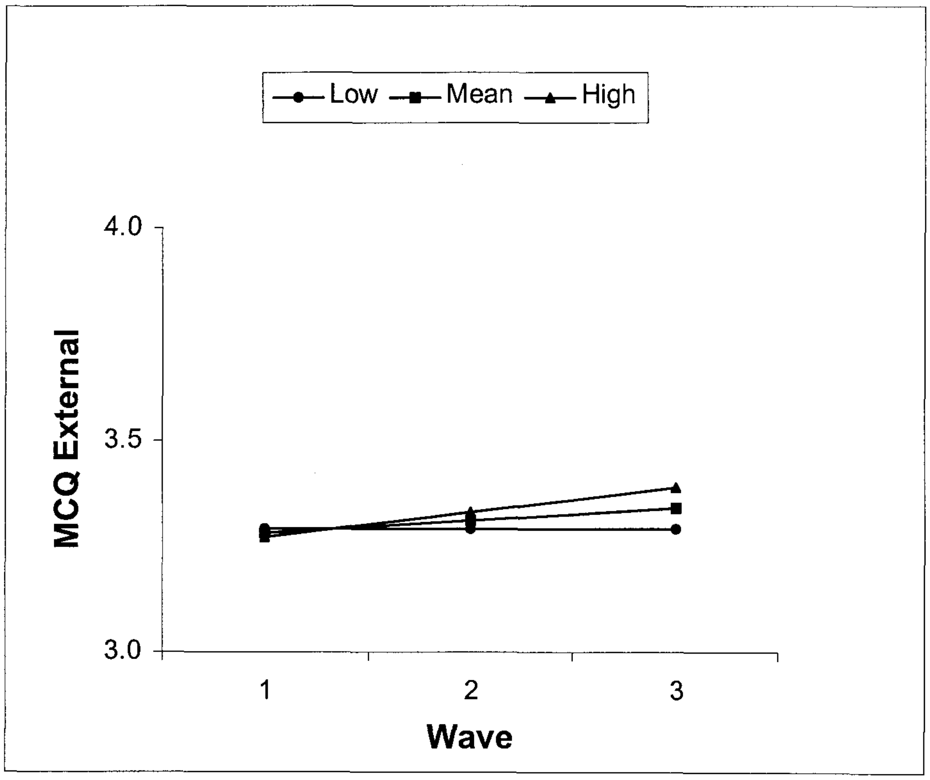

Figure 19. Episodic memory performance (at Wave 1) moderates changes in MCQ External.

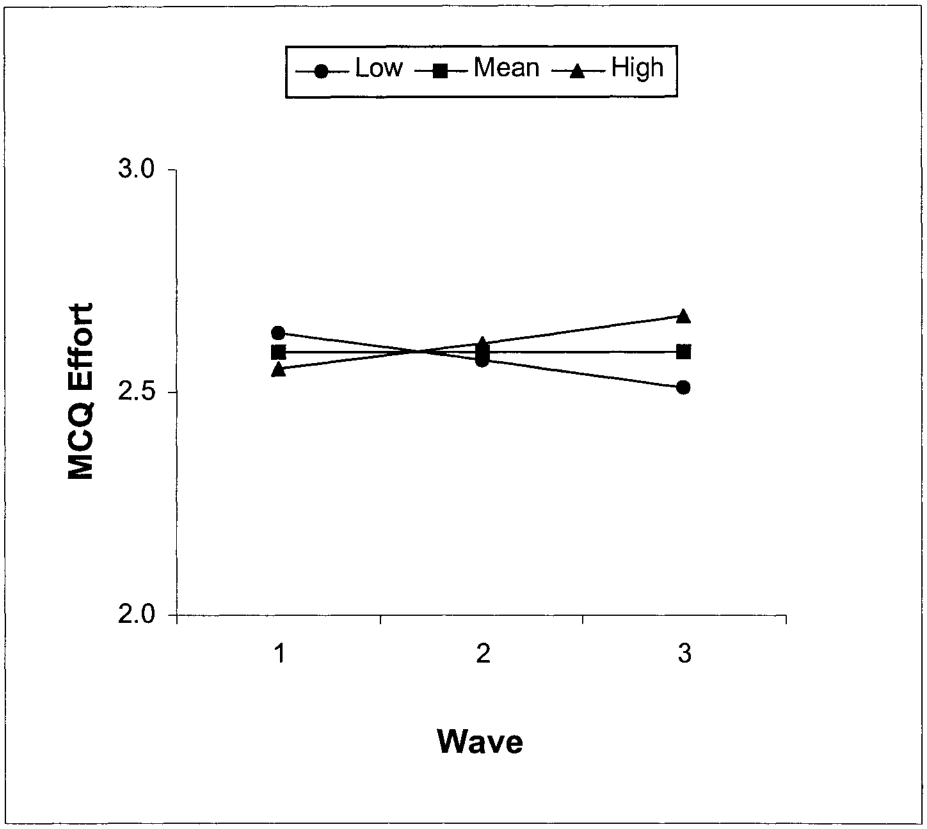

Figure 20. Episodic memory performance (at Wave 1) moderates changes in MCQ Effort.

Episodic memory performance measured at Wave 3 was used as a predictor of individual differences in prior 6-year changes in the MCQ scales. The significant interactions were noted for MCQ External ($gamma_{11}$ = .21; Table 25, column 3, row 2) and MCQ Effort ($gamma_{11}$ = .28; Table 25, column 3, row 10). The same changes in two MCQ scales are predicted by episodic memory performance at Wave 3. Individuals with better memory (at Wave 3) are reporting an increased use of external aids and effort investment over the prior 6-year period. The HLM estimates for episodic memory performance are listed in Table 25.

The slope for the regression of Y on X at levels of episodic memory performance (mean centered) at each wave was computed. The three selected values of episodic memory at W3 were (a) 1 SD below the mean (-.12), (b) the mean (0), and (c) 1 SD above the mean (.12). A plot of the slope (for MCQ External) by memory performance (at Wave 3) interaction is displayed in Figure 21. A plot of the slope (for MCQ Effort) by memory performance (at Wave 3) interaction is displayed in Figure 22. The predicted values indicate that as levels of episodic memory performance (at Wave 3) increase there is a corresponding increase in the use of external aids over the 6-year period. The same pattern is found between memory performance (whether measured at Wave 1 or Wave 3) and 6-year changes in MCQ External. The predicted values for MCQ Effort indicate that as levels of episodic memory performance (at Wave 3) increase there is a corresponding increase in effort investment over the six-year period.

Table 25

Episodic Memory Performance (at Wave 3) as a Source of Interindividual Differences in Prior 6-Year Intraindividual Changes in MCQ Scales

Measure		Slope	SE	t
External	Time effect, γ_{10}	.04	.01	3.47***
	Episodic memory, γ_{11}	.21	.09	2.36**
Internal	Time effect, γ_{10}	-.03	.01	-2.33*
	Episodic memory, γ_{11}	.09	.11	.80
Reliance	Time effect, γ_{10}	-.01	.02	-.50
	Episodic memory, γ_{11}	-.18	.15	-1.18
Time	Time effect, γ_{10}	-.04	.02	-2.15*
	Episodic memory, γ_{11}	.08	.14	.59
Effort	Time effect, γ_{10}	.01	.02	.68
	Episodic memory, γ_{11}	.28	.14	1.99*
Success	Time effect, γ_{10}	.04	.02	1.82
	Episodic memory, γ_{11}	.27	.17	1.55
Change	Time effect, γ_{10}	.00	.01	.09
	Episodic memory, γ_{11}	-.04	.11	-.36

Note. *$p < .05$; **$p < .01$; ***$p < .001$.

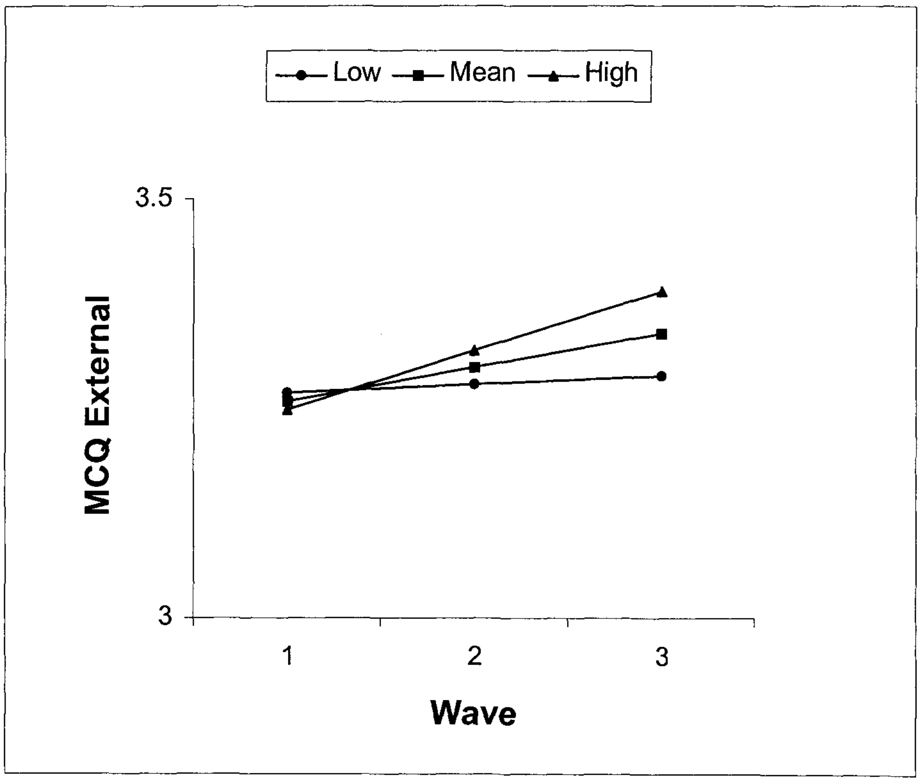

Figure 21. Episodic memory performance (at Wave 3) moderates changes in MCQ External.

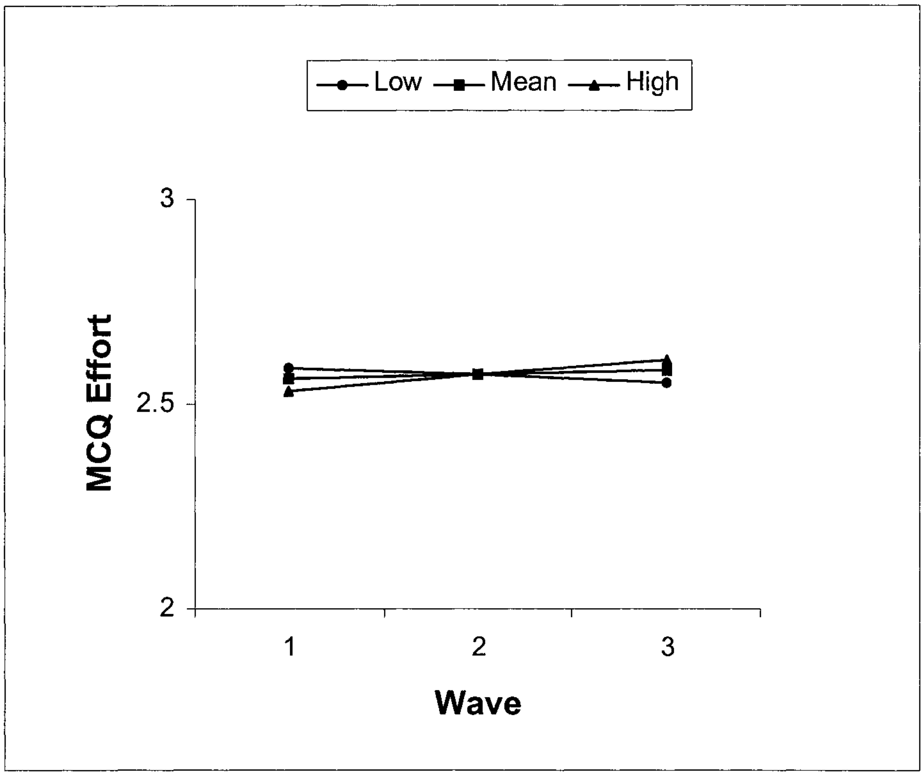

Figure 22. Episodic memory performance (at Wave 3) moderates changes in MCQ Effort.

Chapter V

Discussion

The purposes of this study were to investigate structural and measurement characteristics of the Memory Compensation Questionnaire (MCQ), as well as changes and differences in 6-year individual growth trajectories. Four research goals were identified. The first research goal was to examine the structure of the MCQ. Three specific aims were to test (a) the hypothesized 5-factor model of memory compensation strategies (i.e., MCQ External, Internal, Reliance, Time, and Effort), (b) the hierarchical structure of the 5-factor model, and (c) the hypothesized 2-factor model of the motivation to compensate and awareness of compensation (i.e., MCQ Success and Change). The second research goal was to examine measurement invariance (configural and metric equivalence) along several dimensions of the 5-factor and 2-factor MCQ structures. Specifically, measurement invariance was investigated across group (age and gender) and longitudinal (3 wave, 6-year) comparisons. A discussion of the first and second goals of the study are covered in the next two sections, along with the implications of these findings. The third research goal was to examine 6-year characteristics of the seven MCQ scales. This includes attention to both mean-level change and individual differences (variability) in intraindividual change. The fourth research goal was to investigate sources of individual differences in intraindividual changes in memory compensation. The selected covariates of variation in rate of change in memory compensation were chronological age, biological age, five personality dispositions, memory self-efficacy, and episodic memory performance. The discussion of the third and fourth goals are covered in the third and fourth sections, respectively, along with the implications of these findings. The final two sections identify the limitations of this study and future directions for this research area, along with the conclusion.

Structural Characteristics of the MCQ

The underlying structure of the 44-item MCQ was examined in a sample of older adults aged 55 to 85 years (at the first wave of testing).

Confirmatory factor analyses: First-order models. Overall, the results of confirmatory factor analysis indicated that the hypothesized 5-factor model of MCQ strategies (i.e., External, Internal, Reliance, Time, and Effort) was accurately identified at each of three waves of measurement. Of the 34 items representing these five scales, only one item was problematic. Specifically, an item from MCQ Time was dropped because it cross-loaded on MCQ Internal. The item was phrased such that both memory compensation mechanisms could be inferred. The structure of two general compensatory processes measured by the MCQ (i.e., motivation to compensate and awareness of compensation) were also successfully identified as distinct constructs of memory compensation. Based on this information, the MCQ is a viable instrument for researchers or clinical practitioners who are interested in measuring these five distinct memory compensation strategies and two related general processes. This study provides empirical support for the memory compensation model described by Dixon and Bäckman (1995), which has the potential to further the understanding of how older adults mitigate memory difficulties and losses. Clinical practioners who are assessing the memory impairments of clients can administer the MCQ (or selected scales) to (a) determine which memory compensation strategies are being reported, and (b) to encourage the use of the most effective strategies tailored to individual needs (e.g., focusing on external aids for older adults with more serious cognitive impairments; Wilson & Watson, 1996; Wilson, 1999).

Confirmatory factor analysis: Second-order models. The purpose of conducting these hierarchical tests was to determine whether the underlying conceptual space of memory compensation strategies could be further reduced into higher-order mechanisms of compensation. Specifically, a second-order two-factor model was tested with Substitution (MCQ External, Internal, and Reliance) and Investment (MCQ Time and Effort) factors as expected higher-level constructs. However, this 2-factor hierarchical structure of MCQ strategies was not representative of the data. Instead, the analyses indicate that there is a dependency or cross-over in the conceptual space of substitution and investment type compensatory mechanisms. Alternatively, a single higher-order factor was a better representation of the relations among the first-order strategy-based factors. This latter finding suggests that the MCQ strategy-based factors could be represented and integrated by an overarching memory compensation construct. The significance of finding a unitary hierarchical structure is that it brings cohesion to the conceptual space of memory compensation. While there is disagreement about the precise definition or grouping of compensatory mechanisms (for review, see Dixon & Bäckman, 1995, 1999), the present findings indicate that memory compensation can be defined as a general superordinate construct that underlies several related (yet distinct) mechanisms.

Implications. The theoretical implication for establishing an underlying structure of memory compensation is that the MCQ is demonstrated to be a multidimensional instrument. The seven distinct memory compensation constructs can then be examined for multidirectionality in change. Several practical implications of the relations among the MCQ factors are identified. The planning and successful utilization of external-based and internal-based memory compensation strategies in everyday life requires a component of time and effort investment which should not be overlooked. Practically speaking, the MCQ strategy of choice is using external aids because they are easy to use and generalizable (Dixon & Hultsch, 1983). Accordingly, MCQ External was reported as the most frequently used memory compensatory strategy (Dixon et al., 2001). However, when a reserve of cognitive resources are available, investment-type strategies (e.g., spending additional time on a task) may be encouraged. Investment strategies are more primitive (i.e., are a more proximal marker of central nervous system functioning), and consequently, linked to more complex strategies (e.g., internal mnemonics, external aids). Optimizing the use of investment strategies may sharpen the effectiveness of related compensatory efforts. Conceivably, to the extent that resource-demanding strategies (e.g., trying harder, reading a passage more than once) are overtaxing to older adults they may choose to forgo the use of these strategies. It may be the case that when an older individual reduces the frequency of engaging in investment-type strategies this behavior may be an indication of parallel adjustments in the extent to which other strategies are used (e.g., internal mnemonic strategies). Interestingly, this could be the point at which recruiting other people (MCQ Reliance) for memory assistance predominates.

Two lines of research in psychological compensation supports the argument that choosing others to help with daily activities is efficient. First, prior work on everyday competence (M. Baltes, 1995) indicates that dependency on other people relieves internal resources for other daily activities. Second, research on cognitive collaboration indicates that older adults believe their memory is more effective when working with well-acquainted collaborators, rather than alone (Dixon, 1999; Dixon, Gagnon, & Crow, 1998). A clinician treating an older adult with relatively serious cognitive impairments may focus on increasing the recruitment of other people for memory assistance or using external aids, rather than training of internal mnemonic strategies (which places more demands on memory). A practical implication of finding a hierarchical unitary memory compensation construct is that practioners could select a sample of key MCQ items from each scale and administer a short version of the MCQ to more cognitively impaired older adults.

Measurement Invariance

The measurement invariance of the hypothesized set of factor structures was examined across groups (i.e., age and gender) and occasions (3 waves).

Measurement invariance across age. The measurement invariance (configural and metric equivalence of factor loadings) of memory compensation across young-old (YO) and old-old (OO) adults was supported at Wave 1 and Wave 2 for the 5-factor model, and at all three waves for the 2-factor model. At Wave 3, measurement invariance was not established across age groups for the 5-factor model. The problem was that the phi (factor variance) matrix for the OO age group was not positive definite (i.e., the MCQ Reliance factor had a standardized variance exceeding unity). This misidentification likely occurred because of the small sample size for the OO age group (n = 107) for Wave 3. Establishing that the factor structure of the memory compensation strategies and general processes is equivalent across age groups (at the specified waves) means that quantitative comparisons between YO and OO adults can be interpreted as group differences in the same construct. Conceptually, establishing measurement equivalence indicates that the meaning of memory compensation as measured by the MCQ is similar for YO and OO adults.

Memory compensation strategies were linked at each of three occasions for YO and OO adults, with the exception of a few cases. The interfactor correlations between two substitution strategies (i.e., MCQ External and Reliance) were not significantly different from zero for the OO age group (at Wave 1), and both YO and OO adults (at Wave 2). For these specific situations, external-based strategies (human or object) are highly unconnected and likely serve independent functions. One implication is that individuals who use external aids are not necessarily the ones relying on other people for memory assistance. These constructs may be differentially related to other psychological constructs (e.g., dependency). At Wave 2, MCQ Time and Reliance were also unrelated for the OO age group, which could occur if "other people" are initiating memory assistance. At Wave 3, interfactor correlations for the general processes (i.e., MCQ Success and Change) were not significant for OO adults, which may be explained by the smaller sample size. Alternatively, the motivation to succeed and awareness of using compensation strategies may be independently driven processes of memory compensation. Presumably, one's level of motivation will have some impact on whether changes in efforts to compensate are reported. However, for more impaired individuals who may lack awareness of a memory deficit, it may not be surprising that awareness and motivation are unconnected. Overall, the majority of MCQ factors are linked for YO and OO adults at each of three waves.

Measurement invariance across gender. Configural invariance of the 5-factor model (representing memory compensation strategies) and the 2-factor model (representing general processes) across gender was established at each testing occasion. Constraining the factor loadings to equality resulted in a minor drop in fit to the 5-factor model (across waves) and the 2-factor model (for Wave 3). MCQ strategy factors were significantly related to each other across all occasions with the following exceptions for men: (a) MCQ External and Internal (Wave 1 and Wave 2), and (b) MCQ Effort and Reliance (Wave 3). The latter could occur if other people are initiating memory assistance, rather than the individual. There is no theoretical reason why MCQ Reliance and investment strategies necessarily need to be highly correlated. The MCQ can be used to test for gender differences in using memory compensation mechanisms because the same meaning is implied in both groups.

Measurement invariance across occasions. Longitudinal configural invariance was established for the structure of memory compensation strategies (5-factor model) and general processes of motivation and awareness (2-factor model). Constraining the factor loadings to be identical across three waves resulted in a small loss of fit for the 5-factor model, but not the 2-factor model. The implication of establishing longitudinal invariance is that the MCQ is a valid instrument for assessing changes in memory compensation because the underlying constructs are equivalent across time.

Summary. The results of the structural analyses of the MCQ supports the first two hypotheses of the study: (a) There exists an underlying memory compensation structure (i.e., a 5-factor model representing strategies and a 2-factor model of general compensation processes) as measured by the MCQ, and (b) these two structures are equivalent across groups (age, gender) and 3 waves (6-year period). The few exceptions to the identified factor patterns may suggest that partial measurement invariance (i.e., not all of the configurally invariant MCQ items have identical metric factor loadings; Byrne, Shavelson, & Muthén, 1989) was accepted. To pinpoint which parameters are not invariant across groups or waves the equality of each lambda (regression of latent factors onto observed variables) is tested individually (Byrne et al., 1989). The relaxing of constrained parameters (e.g., loadings) should be guided by substantive theory and then cross-validated. In the strictest sense, not being able to constrain all factor loadings to be equivalent means that only partial measurement invariance exists for the MCQ. However, it is noteworthy to mention that (a) the loss of model fit was small in all cases when the assumption of metric invariance (i.e., identical factor loadings) was violated, and (b) developmental researchers support the view that configural invariance is a more practical assumption (Horn & McArdle, 1992).

Previous work using the MCQ (Dixon et al., 2001) has established reliability and validity of the measure for the same sample. Investigating the psychometric properties of the MCQ (as with all psychological measures) is important. However, the present study takes an additional step in understanding the measurement characteristics of the MCQ.

This study is the first to determine both the underlying structure of memory compensation in healthy older adults and that this structure is similarly defined in cross-sectional group and longitudinal comparisons. The multi-dimensional MCQ instrument is an advantage over single item or domain-general indicators of psychological compensation, especially when linkages to everyday memory competence are pivotal. A greater understanding of how memory compensation fits with existing models of successful aging (e.g., selection, optimization, and compensation or SOC; Freund & Baltes, 1998, 2002) can be empirically tested using the MCQ. For example, future research could investigate whether memory compensation mechanisms (using the MCQ scales) are linked to more general life-management strategies (i.e., SOC) in late life.

Change and Variability of the MCQ

The third research goal was to examine 6-year mean-level changes and interindividual differences (variability) in intraindividual change. The results of growth curve modeling indicate that, on average, older adults adjust their use of three memory compensation strategies over the 6-year period. Specifically, there was a small 6-year mean-level (a) increase in the use of external aids, (b) decrease in the use of internal mnemonic strategies, and (c) decrease in time investment. The endorsement of the remaining two strategies (MCQ Reliance and Effort) and general compensation processes (MCQ Success and Change) remained unchanged during this overall period.

The mean-level results of this study differ from prior VLS research (Dixon et al., 2001) which noted no change in any MCQ scales over a shorter, 3-year testing period. The present study was conducted over a longer, 6-year period and found reliable (but small) average change in three strategies. The study by Dixon and colleagues used data from Sample 1 (Waves 2 and 3) and Sample 2 (Waves 1 and 2), whereas the present study only used Sample 2 (Waves 1, 2, and 3). To understand the location of the change in these three strategies (e.g., whether between Wave 1 and Wave 2, or Wave 2 and Wave 3, or Wave 1 to Wave 3), follow-up repeated measures analysis of variance was conducted on each of the two-wave data segments. There was a significant decline in MCQ Time between Wave 1 and Wave 2, and a significant increase in MCQ External from Wave 2 to Wave 3. These diagnostic analyses indicate that average change in MCQ Internal are detected after a 6-year period, whereas average changes in MCQ Time occurred earlier than changes in MCQ External.

The direction of change can be summarized as an increase in the use of easier-to-use strategies (i.e., external aids) and a decrease in more resource-demanding strategies (i.e., internal mnemonic strategies and time investment). External aids (e.g., notes and calendars) are commonly used strategies in everyday life and are implemented in rehabilitation programs for memory-impaired adults (Glisky & Glisky, 1999; Wilson & Watson, 1996). Prior research has noted that the use of such strategies is preferred and effective for managing everyday memory demands (Dixon et al., 2001; Wilson, 1999). Memory-impaired individuals can select from or be given a range of external aids to guide their remembering of information in a new way (Wilson, 1995; Wilson & Watson, 1996). However, for more severely impaired individuals, use of external aids may be difficult to apply in daily remembering activities because remembering to use a strategy is also a memory task (Wilson & Watson, 1996). In this case, restructuring of environments (e.g., labelling household items, using automatic devices) and recruiting other people is more effective (Wilson, 1999). The significant decline in more resource-demanding strategies (i.e., internal mnemonic strategies and time investment) over this 6-year testing period may suggest that older adults begin to prioritize among available strategies and select those that are less cognitively intensive, and more generally applicable. Of interest in future data collections is whether the magnitude of change accelerates after longer time periods. Older adults have fewer attentional resources, which may hinder effective learning and remembering of new information, a necessary ability when using internal mnemonic strategies. Indeed, the complexity and resource demanding nature of these mnemonics may be one reason why they are not commonly self-initiated by brain-injured individuals (Glisky & Glisky, 1999; Wilson, 1999), and used less frequently over time in this sample of healthy older adults. Conceivably, the memory demands that these older adults face (6 years later) may have changed resulting in overall shifts in strategies used with external aids being more effective. That MCQ Internal and Time undergo the same average trajectory (i.e., decline) over the 6-year period can also be traced to their moderate-sized interfactor correlation ($r = .57$; Table 2), reinforcing the dependency between more resource-demanding substitution-type strategies and investment-type strategies. The average trajectory of memory compensatory strategies and related processes of motivation and awareness are relatively stable over a 6-year period with only small changes in substitution and investment strategies. It would be interesting to see whether other models of compensation (e.g., SOC) show change; however, this information is not available in the existing literature. Neighbouring concepts from the metamemory domain (e.g., belief systems) are also relatively stable. This suggests that compensatory mechanisms and metamemory share underlying processes.

The second component of the third research goal was to examine the extent of variation (individual differences) in intraindividual changes in the MCQ scales. With only two exceptions (i.e., MCQ Time, and MCQ External for the data set with Wave 1 covariates), significant variation in the mean growth curve was observed. Overall, individuals do not follow parallel patterns of change in reported use of memory compensation over the 6-year period. Instead, a given individual's growth trajectory can be represented by growth, decline, or no change in memory compensation. The implication is that models that assume a fixed slope for all individuals (i.e., parallel rates of change) are not accurate representations of the underlying nature of change in the MCQ scales.

Influences on Variability in Change

While it is interesting to examine the patterns of change in memory compensation strategies and processes, it is also important to examine antecedents or correlates of changes in the MCQ scales. How older adults deal with memory problems in everyday life may be partly determined by person-level characteristics. The fourth goal was to examine sources of the individual differences in intraindividual changes in the MCQ scales. A total of five domains were examined that range from biological to cultural systems. These variables are the following: (a) chronological age, (b) biological age, (c) five personality dispositions, (d) memory self-efficacy, and (e) episodic memory performance.

Chronological age. Chronological age was expected to predict prior 6-year increase in the use of memory compensation strategies to mitigate age-related impairments in memory. The results of this study confirm this hypothesis for only MCQ Time, as no other changes in MCQ scales had significant relations with chronological age (treated as a continuous or dichotomous variable). It is interesting to note that the OO age group (rather than the YO age group) used more of this strategy (e.g., reading a passage more than once, slowing down reading speed). The investment of additional time in a skill (i.e., competency on memory tasks) has been noted as forestalling or attenuating memory deficits (Glisky & Glisky, 1999). Overall, intraindividual changes in reported use of memory compensation is similar for young-old and old-old adults. The passage of time (or chronological age) was not a robust source of individual differences in intraindividual changes in MCQ scales.

Biological age. The factor structure of biological age was established with four biological markers from the VLS (i.e., close and distant visual acuity, auditory acuity, and grip strength). The confirmatory factor analysis identified a single latent factor that accounted for the relations among the four marker variables. The pattern of the loadings was consistent with prior exploratory factor analysis work with a similar set of biological markers from a different VLS sample (MacDonald et al., in press), and from a comprehensive overview of literature on functional age (Anstey et al., 1996). Contrary to the hypothesis, biological age did not account for significant interindividual differences in (prior 6-year) intraindividual changes in any MCQ scales. The null finding occurred regardless of how biological age was treated (i.e., as a continuous or dichotomous variable). A possible explanation for the lack of any significant effects is that only three waves of measurement were available. In HLM, the ability to detect reliability in change is essential and additional waves of data would increase statistical power (Willet, 1992). The availability of additional waves (beyond the 3 waves available) would help to distinguish among individuals and their unique (differential) rates of change in MCQ scales.

Psychosocial indicators. The two sources of individual differences in intraindividual change in MCQ scales examined from the psychosocial domain were personality traits and self-referent beliefs about memory. These person-level characteristics may influence how memory problems are perceived and, in turn, managed (compensated for) in daily situations. In the present study, the expectation was that individuals who are conscientious (e.g., self-disciplined, determined, planful) would be expected to engage in means to mitigate memory challenges that may arise in daily situations. By contrast, individuals who are higher in neuroticism (i.e., possess worried and anxious tendencies) would be less capable of managing compensatory strategies.

Of the five personality traits, conscientiousness was the most prominent moderator of individual differences in intraindividual changes in MCQ strategies and general processes. At lower levels of conscientiousness, there was a tendency for increasing the use of external aids, effort investment, and motivation, but at higher levels of conscientiousness there was a reduction in the use of these strategies and internal mnemonics over the 6-year period. In a recent study, de Frias and colleagues (2003) noted that higher levels of conscientiousness was associated with higher levels of MCQ

External, Internal, Effort, and Success at a single occasion (Wave 1). The present study of memory compensation and prior research on general compensation (Freund & Baltes, 2002) also supports this cross-sectional finding. Specifically, Freund and Baltes found positive correlations between conscientiousness and general compensation. A profile of a conscientious disposition contains the following characteristics: showing competence, achievement striving and efficiency, and goal planning (McCrae & John, 1992). Individuals possessing this profile would be expected to take control of their ability to remember everyday information by actively engaging in planful goals (e.g., recover or manage memory problems) and develop necessary means (e.g., strategy implementation) to offset such challenges. One postulation is that individuals exhibiting higher levels of this profile may not feel the need to increase the use of strategies because memory deficits have not been detected. Indeed, these individuals are already reporting greater use of compensatory strategies than individuals at lower levels of conscientiousness. The moderating role of perceived severity of deficits has been noted in relation to compensatory actions (Bäckman & Dixon, 1992) and strategy selection (David & Suls, 1999). Conscientiousness may be related to compensating efforts in ways that are interactive with other characteristics (e.g., appraisal of severity). Therefore, this sample of older adults might be making conscientious and accurate adjustments based on their competence levels or changing daily demands.

In a recent study, de Frias and colleagues (2003) reported that higher neuroticism covaried with higher levels of all MCQ scales at a single occasion. Interestingly, the longitudinal predictions in the present study are that higher neuroticism was a significant predictor of 6-year reduction in reported use of two MCQ strategies (i.e., the use of external aids and investment of effort on memory tasks). At higher levels of neuroticism, possessing worry-related thoughts may drain one's resources (e.g., time and energy), and thereby, restrict efforts to engage in compensation strategies. Indeed, experiencing nervous tension can be associated with ineffective coping (McCrae & John, 1992). Prior research has noted that neuroticism was negatively correlated with episodic memory performance (Meier et al., 2002) and linked to expressing more frequent memory complaints in older adults (e.g., Ponds & Jolles, 1996). Individuals possessing more intense neuroticism-based dispositions may appraise stressful situations (e.g., memory deficits) as threats rather than challenges to be overcome (David & Suls, 1999), which would interfere with efforts to compensate for memory problems.

Extraversion was a significant predictor of individual differences in intraindividual changes in MCQ Success (i.e., motivation to succeed on memory tasks). Other researchers have noted positive correlations between extraversion and general compensation (Freund & Baltes, 1998, 2002). Ascendance and ambition are characteristics of an extraverted disposition; this means that a more extraverted person would presumably seek out opportunities to attain a desired goal. Agreeableness was a significant predictor of individual differences in intraindividual changes in one general process (i.e., MCQ Change). At Wave 1, higher levels of agreeableness was associated with higher levels of MCQ Change. The longitudinal prediction is that higher agreeableness was a significant predictor of 6-year reduction of reported changes in compensatory strategies (i.e., MCQ Change). During the 6-year period, the differences between levels of agreeableness (e.g., higher vs. lower) dissipated. Openness to experience was the only personality trait that was not a significant covariate of intraindividual changes in any MCQ scales. Null findings between this personality trait and the MCQ have been reported in a previous cross-sectional study using data from the VLS (de Frias et al., 2003).

Upon suggestions from a reviewer (M. E. Lachman, personal communication, January 28, 2003), posthoc analyses were conducted to control for the effects of age and education on changes in memory compensation prior to examining the effects of the predictors. These analyses revealed that controlling for age and education did not eliminate the effects of memory performance or memory self-efficacy on changes in memory compensation. However, age and education entered in the same model as the personality traits eliminated the previously significant effects of four personality traits on changes in memory compensation reports. Specifically, the following relations were no longer significant when age and education were covaried: (a) conscientiousness and changes in MCQ Effort, (b) neuroticism and changes in MCQ Effort, (c) extraversion and changes in MCQ Success, and (d) agreeableness and changes in MCQ Change. The three remaining relations involving conscientiousness and changes in memory compensation reports (i.e., MCQ External, Internal, and Success) continued to be significant after controlling for age and education. Whereas age was not a significant predictor of changes in the MCQ, education was related to a 6-year increase in effort investment. The as yet unknown mechanisms responsible for the observed relationships among age, education, personality, and memory compensation should be further explored. For now, results and interpretations concerning personality-memory compensation changes that are affected by age and education should be considered tentative.

Personality influences both cognitive changes (Meier et al., 2002), general compensation (Freund & Baltes, 1998, 2002), and memory compensation (de Frias et al., 2003) at one point in time. In this study, personality influenced 6-year change in the use of memory compensation strategies. Personality dispositions may hinder (e.g., neuroticism) or facilitate (e.g., conscientiousness) the ability to overcome memory challenges.

The second psychosocial variable used to examine variation in the trajectories of the MCQ scales was self-referent beliefs about memory. Self-efficacy (or beliefs about the effectiveness of one's ability) has a particularly strong influence on tasks that are important to the self (Berry & West, 1993). Conceivably, self-referent beliefs, as one component of metacognition, may moderate how much older adults partake in compensatory behaviors to make adjustments to failing cognitive abilities (Bäckman & Dixon, 1992; Berry, 1999; Hertzog & Hultsch, 2000). Self-efficacy appraisals of one's memory system are especially pivotal when memory challenges and problems arise (Berry, 1999). Such appraisals can influence the construction of strategies (i.e., plans of action to reach a desired goal; Hertzog & Dixon, 1994; Hertzog & Hultsch, 2000), and commitment to desired goals (e.g., striving in everyday demands; Bandura, 1989; Cavanaugh, 1996) in the face of memory failures. Berry (1999) reported that study time was a partial mediating factor between memory self-efficacy and word recall performance for individuals expressing memory complaints. The effects of memory beliefs on task engagement may be stronger for older adults who believe that memory is important (Berry & West, 1993; Cavanaugh, Feldman, & Hertzog, 1998).

The beliefs individuals ascribe to their memory capacity may affect their decision to compensate for memory failures. Interestingly, older adults with higher (above average) memory self-efficacy believed that their efforts to use memory compensation strategies had changed (increased), as compared to those individuals at the mean (no change) or below the mean (small decline). Notably, individual differences in MSE are reduced over the 6-year period, indicating that individuals differed more at Wave 1 than over time. One postulation for the different trajectories in memory compensation awareness is that memory demands have increased since initial testing and those individuals with optimistic (yet realistic) beliefs about their memory react by using more strategies. Monitoring one's prior history of strategy use may involve (a) providing an appraisal of one's current memory capacity, and (b) deciding whether adjustments in strategy implementation have been made, perhaps in agreement with "in the moment" (yet stable) memory appraisals. If older adults assess their memory as stable, this would lead them to believe that more adaptive strategies have been enacted that foster stable memory skills.

Memory appraisals are believed to have an influence on resource allocation and strategy selection (Bandura, 1989; Berry & West, 1993; Cavanaugh, 1996; Dixon & Hultsch, 1983; Hertzog & Dixon, 1994; Hultsch & Hertzog, 2000; Lachman, 1991), and cognitive compensation (Dixon & Bäckman, 1999). An interesting question is whether understanding motivations for memory compensation can be advanced through metamemory assessments. For example, appraisals about memory ability could be a window to whether older adults believe that compensation behaviors are necessary to function in daily life. The moderating role of self-referent beliefs about memory has been noted in relation to memory changes (Cavanaugh, 1996). Individuals with stronger self-efficacy beliefs are expected to seek out more challenging cognitive environments (Cavanaugh, 1996). Self-referent beliefs about memory may serve adaptive functions (e.g., cognitive resilience; Staudinger & Pasupathi, 2000). Believing that one's memory is effective can be an impetus for recruiting and selecting means to actualize and maintain this status which benefits everyday memory competence. One postulation is that interventions in metamemory (e.g., knowledge of strategies, and awareness of appraisals and their impact) may indirectly influence memory compensation which in turn may improve actual memory performance (Dixon, 2000a; Lachman, 1991).

Memory performance. Memory changes due to normal or disease-related factors are a central concern to memory researchers. A variety of means are available to mitigate memory impairments or deficits (Dixon & Bäckman, 1999; Wilson, 1999). How people differ in the extent to which compensations are implemented may be partly determined by their actual memory abilities. The hypothesis was that higher levels of episodic memory performance would be related to a 6-year increase in the use of compensation strategies. Older adults with better memory functioning increased their use of external aids and applied increasing effort on memory tasks over the 6-year period. By contrast, lower memory performers (those below the mean) did not change their use of external aids and decreased their application of effort on memory tasks during this period. Those individuals who perform better on laboratory-based memory tasks are also reporting an increased use of memory compensation techniques. A similar relation was found when episodic memory performance was measured at Wave 3, which indicates that the influence of episodic memory performance on changes in these two MCQ scales is robust, regardless of whether prior or subsequent 6-year change in external aids and effort investment is assessed. Based on these findings, both actual memory performance and beliefs about memory are predictive of changes in how much memory compensations are utilized to remember everyday information.

The multi-dimensionality of the MCQ has provided for a rich sample of numerous strategies that, once implemented, can provide the necessary means to manage memory difficulties for remembering information pertinent to daily life. Although the present study did not include data on memory changes (because of insufficient degrees of freedom to estimate this covariation in change parameter), level of performance was measured at the start of the study and at the most recent wave. It is reassuring that relatively vulnerable memory abilities show promising connections to memory compensation.

The present findings contribute to prior literature noting the benefits of strategy implementation on memory performance (e.g., Bäckman & Dixon, 1992; Ball et al., 2002; Dixon & Bäckman, 1999; Camp et al., 1983; Kliegl & Baltes, 1987; Glisky & Glisky, 1999; Wilson, 1999). If older adults improve their everyday competency levels by utilizing compensatory techniques then such strategies are effective means for successful cognitive aging. This study indicates that despite possible losses in reserve capacity, older adults continue to demonstrate the potential for plasticity of behavioral functions (Baltes, 1997; Dixon, 2000b).

Implications. Why is it interesting to investigate predictors of between-person variation in changes in memory compensation? Limits in reserve capacity and available resources (e.g., health, cognitive processes) work to constrain the boundaries of human plasticity. Compensation, as a set of mechanisms for actualizing successful cognitive aging, may be dependent on a myriad of factors that could foster or constrain the means to overcome memory impairments or deficits. Individual differences in changes in memory compensation may partly be determined or moderated by aging-induced biological (e.g., memory, biological age, personality) and sociocultural (self-referent beliefs) domains, and possibly biocultural interactions (Baltes, 1997). Resources from these domains (e.g., conscientious personality, better memory) may strengthen one's ability to anticipate and adapt to changes in memory functioning.

Self-referent beliefs about memory (MSE) was a moderator of the rate of change in one MCQ scale (i.e., Change). Can memory compensation research be advanced through metamemory assessments? Learning about how people evaluate their memory ability (e.g., level of efficacy or control over memory) may be indicative of whether people believe that compensatory strategies are necessary to function in daily life. Beliefs about control over memory aging may play a role in the initiation and implementation of strategies to overcome memory adversities (Lachman, 1991) and actual memory performance (Lachman, Steinberg, & Trotter, 1987). Intervention in metamemory (e.g., teaching strategies or efficacy enhancement for individuals with relatively intact memory;

Lachman et al., 1992) may directly influence memory compensation, and subsequently memory performance. Rehabilitative programs may be designed to promote self-awareness by helping people to monitor their progress, and enhance dimensions of personality (e.g., conscientiousness, optimism, changing negative attitudes) to better facilitate adaptive behaviours (Dawson et al., 1999).

Self-reports of changes in the use of compensation behaviors have been linked to actual memory performance. It is interesting to find the benefits of memory compensation in a relatively healthy sample of older adults who are beginning to experience moderate memory loss. Memory training that explicitly makes linkages between compensation strategies and memory performance may influence how older adults make adjustments in how frequently such strategies are applied in daily situations. Wilson and Watson (1996) discuss the memory compensation model by Dixon and Bäckman (1995) and provide examples of how memory training can improve memory and help individuals to compensate in specific situations (e.g., on the job). Memory compensation programs are typically designed to assist memory-impaired older adults. An implication of the present study is that memory compensation programs could also optimize the fit between competencies of healthy older adults and their everyday demands. Rehabilitation programs could teach older adults about the different strategies (and memory tricks) available and the benefit of using such techniques (e.g., external aids). For example, managing practical activities (e.g., shopping, meetings, medication use) and work-related activities (e.g., developing a research grant) can be facilitated by using external strategies (e.g., keeping notes or calendars as reminders, or collaboration, respectively). Such compensatory strategies can contribute to successful cognitive aging and adaptive living.

Limitations and Future Directions

Several limitations of this study are noted and organized into three sections: (a) MCQ instrument, (b) structural analyses, and (c) change analyses. These limitations are presented along with future lines of research on memory compensation.

MCQ instrument. The MCQ is clearly a reliable and valid self-report instrument that assesses efforts made to use compensatory mechanisms relevant to everyday memory. While the multiple MCQ items were designed to tap common memory activities (e.g., reading a newspaper, watching television, or relying on others), it is possible that not all items are applicable to all individuals which may underestimate the amount of time spent on compensatory strategies. For example, not all individuals have the opportunity to experience situations that call for using compensatory strategies or they may rely on alternative mediums (e.g., browse the internet for news information instead of the TV or newspaper). However, the multidimensional nature and good psychometric properties of the seven MCQ scales mitigates this potential criticism, and any differences in compensatory opportunities represented by these everyday situations are likely to be random.

Several mechanisms are identified in the MCQ; however, no item or scale asks whether participants have had to restructure their goals in response to memory problems. The restructuring of goals is a common form of compensation which has been termed accommodation (Brandstädter & Renner, 1990) and selection (Baltes, 1987) in the compensation literature. It would also be interesting to see what standards individuals hold about their memory capability. Such information could complement and test the construct validity of the MCQ Success scale which taps the motivation to succeed. Perhaps older adults do not find it important to remember information as "perfectly as possible" because they are restructuring their goal priorities to be more consistent with what they can manage effectively. Accordingly, they may be highly motivated within their defined standards.

Future directions for using the MCQ to assess memory compensation may include several possibilities. First, developing a modified (shorter) version of the MCQ (e.g., selecting key items within each scale or selecting relevant scales) to be administered to samples with moderate-sized cognitive impairments would enhance its utility in clinical practice. A second area of future study could develop means to further test the construct and predictive validity of reported efforts to compensate. Other methods of assessing memory compensation and its construct validity include (a) online monitoring of strategy use and whether adjustments to strategy choice are made in response to increased task difficulty, and (b) proxy reports (e.g., family member) to determine whether respondents are accurately reporting responses to the MCQ Reliance scale. The predictive validity of memory compensation scales was tested by relating it to actual episodic memory performance (at Wave 1 and Wave 3). Predictive validity could also be tested with other performance measures that show sensitivity to aging, such as working memory and executive functioning. This set of cognitive abilities would presumably affect the ability to plan, initiate, and effectively implement compensatory strategies. New data in the VLS will be available to examine these questions.

A third area of future study could focus on expanding the MCQ to include supplementary questions about (a) whether these strategies are used "in response" to memory problems, (b) the last time (or number of times on average each month) they engaged in the everyday memory activities noted in the MCQ (e.g., newspaper reading, conversation with others), which would affect the range and interpretation of the rating responses, and (c) whether their memory demands have changed. With respect to inquiry A above, it would be interesting to distinguish between individuals who have been using strategies during much of their adult lives (i.e., individual differences persist) from those older adults who have had to use these strategies more frequently in response to memory problems. The latter case would be more explicitly linked to the origin of compensation (i.e., a mismatch between abilities and daily demands; Dixon & Bäckman, 1995). The proposed supplement question B above would provide information on the opportunities encountered by an older adult that would necessitate the use of memory compensation. Do all individuals have the same opportunity to interact with other people and benefit from their assistance? While MCQ Reliance may be an effective strategy, respondents may report a low rating on this scale because they are not in situations that are supportive of this experience, rather than a low score indicating a deliberate decision to "select" other strategies. Another argument is that the temporal spacing of engaging in compensatory strategies would provide information on recency which may affect the magnitude of relations between the MCQ scales and covariates (e.g., memory performance). For example, if the last time someone used a given strategy was 6 months prior to testing, then assessing memory performance levels at time of testing may lead to smaller effects. The proposed supplemental question C above would provide additional information on the genesis of reasons to compensate. It could be the case that individuals are compensating not because of declining memory functioning, but rather that the demands placed on their memory have changed (i.e., increased). Information on memory ability and environmental demands (e.g., changes in work load, providing care for an impaired individual) would provide a more integrative account of the origin of compensation and factors that may be related to changes in efforts to compensate.

Structural analyses. Limitations to the structural characteristics of the MCQ are also noted. The fit indices (notably, CFI and GFI) for the 5-factor structure of MCQ strategies were lower (.80s) than conventional cutoff criteria (> .90) set by methodologists (e.g., Hu & Bentler, 1999). However, the RMSEA values were within the acceptable range (< .08; Browne & Cudeck, 1992). Many measurement models were estimated (across waves, age groups, and gender) and a criticism could be made about why a single three-way (i.e., wave by age by gender) measurement invariance model was not tested. The reason for examining age, gender, and wave in separate models was because the available sample size was not large enough to accommodate a single model. Missing data (due to drop outs) at Waves 2 and 3 precluded this investigation. The failure to find a superordinate 2-factor model (substitution and investment) of memory compensation indicates that the theoretical hypothesis was an inaccurate representation of the data. The superordinate substitution and investment factors were highly correlated and this resulted in establishing that a unitary hierarchical structure of memory compensation was a better representation to the data.

Change analyses. Intraindividual changes in MCQ scales and variability in these scales were examined using HLM techniques. The limited number of waves available for this sample (n = 3) eliminated the possibility of assessing relations between intraindividual changes in MCQ scales and similar changes in related domains (e.g., memory performance, self-referent beliefs about memory, personality traits, and biological health). The ability to differentiate among unique individual trajectories of MCQ scales would be facilitated by the availability of additional waves of measurement which increases reliability of change.

The null findings between biological age and change in MCQ scales may be partly explained by the limited number of data points used to assess differences in rates of change. Biological age was measured at the third wave of testing which means that this a select sample of older adults who may not be experiencing large variations in biological status. One implication of this potentially constricted biological age indicator is that longer spans of reported compensatory efforts may help to differentiate how relatively younger and older biological age groups make changes in their use of memory compensation strategies. Another possibility is that robust biological age and changes in MCQ report associations may be found for more vulnerable samples of older adults (e.g., limitations in health or cognition domains). Similarly, the results were restricted to one assessment of biological status at Wave 3. Quite conceivably, changes in biological vitality, rather than current level of biological functioning, could be more sensitive to memory compensation changes. The advent of the next wave (Wave 4) will provide the means to model how biological aging processes are linked to changes in memory compensation mechanisms. Biological age was measured by indices of sensory and physiological status. Alternative indicators of biological aging (e.g., balance, genetic markers) could also be investigated interactively in relation to changes in MCQ scales.

Linkages between intraindividual changes in memory compensation and personality were robust for select NEO traits. One limitation of this set of analyses was that only a single wave of personality data was available. In some cases, the effect of personality on memory compensation was greater when it was measured concurrently. Future research could examine how changes in personality traits either moderate or mediate changes in reported efforts to using compensatory mechanisms.

On a post hoc basis, possible selective sample attrition was examined among the predictor variables at Wave 1. Comparisons using analyses of variance (ANOVA) were made between (a) continuers to Wave 2 and drop outs after Wave 1, and (b) continuers to Wave 3 and drop outs after Waves 1 or 2. No significant group (continuers, drop outs) differences were observed among the five personality traits. However, group differences were noted for memory performance and MSE. These findings indicated that 3-year and 6-year continuers, as compared to attrited participants, performed better on memory tasks and held more positive beliefs about their memory. Given that (a) individuals who return to the study have somewhat better memory functioning and higher MSE at Wave 1, and (b) individuals with better memory and higher MSE also increase their use of memory compensation strategies over the 6-year period, some further research or qualification in the change patterns may be considered.

Selective sample attrition was also examined among all seven MCQ scales, but in these analyses the focus was on change. Comparisons using HLM were made between (a) drop outs (after Waves 1 and 2) vs. 6-year continuers in level and change in the MCQ scales, and (b) 3-year continuers (drop outs after Wave 2) vs. 6-year continuers on level and change in the MCQ scales. For comparison A, group differences were noted for level of MCQ Time, Success, and Change. Drop outs reported using more time management, were more motivated on memory tasks, and reported a greater change in the use of memory compensation strategies at baseline than did 3-occasion returners. Continuers reported using more external aids over time than drop outs. For comparison B, although drop outs reported using more external aids at baseline than 6-year continuers, no group differences in changes in any MCQ scales were noted. The attrition analyses indicate that for select MCQ scales, drop outs report using more memory compensation strategies at baseline (i.e., external aids and investment of more time on memory tasks) than participants who return for testing on all three occasions. Further consideration should be given to the interpretation of intraindividual changes in the MCQ noted in this study. However, the minimal selective attrition noted for change in the MCQ (one of seven scales) indicates that the HLM findings on predictors of interindividual differences in intraindividual changes are generally unbiased.

Conclusion

The present study contributes to our understanding of (a) how the MCQ behaves in multiple groups and across occasions, (b) intraindividual changes in reported use of memory compensation strategies, and (c) identifiable sources of interindividual differences in these changes. Specific strategies can be isolated for purposes of developing a more individualistic rehabilitation program. Adapting to memory challenges in the face of declining resources is an important focus for research on cognitive resilience and successful cognitive aging.

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Appendix

MEMORY COMPENSATION QUESTIONNAIRE (MCQ)

Directions

Different people use their memory in different ways in their everyday lives. For example, some people make shopping lists, whereas others do not. Some people are good at remembering some things, whereas others are not. In this questionnaire, we would like you to tell us about how you use your memory. There are no right or wrong answers to these questions because people are different. Please take your time and answer each of these questions to the best of your ability.

Each question is followed by five choices. Read the choices carefully for each question. Choose one of the choices and draw a circle around the letter corresponding to that choice. Mark only one number for each question.

Some of the questions ask how often you do certain things that may be related to your memory. For example:

Do you make a list of things to be accomplished during the day?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always

---

In this example you could choose any one of the answers. Choose the one that comes closest to what you usually do. Don't worry if the time estimate is not exact or if there are some exceptions.

Keep these points in mind

(1) Please answer every question, even if it doesn't seem to apply to you very well.

(2) Answer as honestly as you can what is true for you. Please do not mark something because it seems like the "right thing to say".

1.	Do you use shopping lists when you go shopping?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
2.	Do you ask people to speak slowly when you want to remember what they are saying?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
3.	When you want to remember an important appointment do you ask somebody else (for example, spouse or friend) to remind you?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
4.	Do you put in a lot of effort when you want to remember an important conversation with a person?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
5.	When you want to remember a story do you read it more than once?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
6.	When you are reading a book, do you use a bookmark to indicate where you stopped reading last time?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never

7.	Do you put in effort when you want to memorize a funny story?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
8.	When you want to remember a newspaper article is it important to you to remember it perfectly?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
9.	When an interesting T.V. program is going to be on in the next few days do you ask somebody else to help you remember (for example, spouse or friend)?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
10.	Do you concentrate a lot to learn something you really want to remember?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
11.	When you want to remember a newspaper article do you read it more slowly?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
12.	When you want to remember an event such as a birthday, do you ask somebody else (for example, spouse or friend) to help you remember?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always

13.	Do you post notes on a board or other prominent place to help you remember things for the future (for example, meetings or dates)?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
14.	When you want to remember the name of a particular person, do you ask somebody else (for example, spouse or friend) to help you remember?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
15.	When you are reading something that really interests you (and that you want to remember) do you slow down your reading speed?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
16.	When you want to remember a conversation is it important to you to remember it perfectly?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
17.	Do you sometimes ask someone (for example, spouse or friend) to help you remember when you are going to start a trip?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
18.	Do you put things (for example, glasses or keys) in particular places to remember where they are for future purposes?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never

19.	Do you ask other people (for example, spouse or friend) to help you remember things more or less often today compared to 5 - 10 years ago?	1. Much more often 2. More often 3. No difference 4. Less often 5. Much less often
20.	Do you try hard when you want to remember an important telephone number?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
21.	Do you put things in obvious places (for example, briefcase in front of the door) in order to remember them when you're going out?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
22.	When you want to remember something from a T.V. program do you use "memory tricks" like grouping or repeating to yourself?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
23.	Do you take your time to go through and reconstruct an event you want to remember?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
24.	Do you write down appointments (for example, with the hairdresser or the dentist) in a notebook or calendar?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never

25.	Before an important day do you think about or plan the things you have to do?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
26.	Do you spend a lot of time on " memory tricks" or other aids for memory in your daily life?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
27.	Do you note birthdays in a notebook or calendar in order to remember them?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
28.	Do you repeat telephone numbers to yourself in order to remember them well?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
29.	Do you spend more or less time learning important things today compared to 5 - 10 years ago (for example, reading things more slowly or reading them more than once)?	1. Much more time 2. More time 3. No difference 4. Less time 5. Much less time
30.	Do you write down telephone numbers in a calendar or notebook in order to remember them?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never

31.	When you want to remember the name of a person do you try to associate the name with the person's face?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
32.	Do you concentrate when you want to learn the name of a person you have just met?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
33.	When you want to remember something that happened in a particular day do you review and reconstruct the events of that day in order to help you remember?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
34.	Do you use such aids for memory as notebooks or putting things in certain places more or less often today compared to 5 - 10 years ago?	1. Much less often 2. Less often 3. No difference 4. More often 5. Much more often
35.	When you want to remember an event that took place when you were a child, is it important for you to remember it as perfectly as possible?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
36.	Do you use letters as cues (in other words, go through the alphabet) when you want to remember the name of a person, a city, or something else?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always

37.	Do you put in effort when you want to remember the time of an important meeting?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
38.	When you want to remember something do you try to relate it to something else you know well in order to remember it better?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
39.	If you want to remember a funny story is it important to you to remember it perfectly?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
40.	Do you use mental images or pictures to remember some types of information?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always
41.	Do you put in effort and concentrate to remember important things more or less often today compared to 5 - 10 years ago?	1. Much more often 2. More often 3. No difference 4. Less often 5. Much less often
42.	Is it important for you to remember things perfectly (as verbatim as possible)?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always

43.	Do you repeat important appointments to yourself in order to remember them as well as possible?	1. Always 2. Often 3. Sometimes 4. Seldom 5. Never
44.	Is it more or less important to you to remember things perfectly today compared to 5 - 10 years ago?	1. Much more important 2. More important 3. No difference 4. Less important 5. Much less important
45.	Do you use memory tricks such as repeating things to yourself or grouping things in categories more or less often today compared to 5 - 10 years ago?	1. Much less often 2. Less often 3. No difference 4. More often 5. Much more often