CLARIFYING PERCEPTIONS OF COGNITIVE FUNCTIONING IN NORMAL AGING AND AFTER MILD TRAUMATIC BRAIN INJURY

A thesis presented in partial fulfilment of the requirements for the degree of

Doctor of Clinical Psychology

at Massey University, Albany, New Zealand

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2021

Abstract

The cognitive symptoms reported more than 3 months after a mild traumatic brain injury (mTBI) are often found to have no association with objective cognitive functioning as evaluated by formal assessment measures. They are believed to relate more to physical symptoms such as pain or fatigue, psychological factors such as affective distress, and misattributions regarding the causes of ongoing subjective difficulties. This is similar to normal aging where for similar reasons, subjective complaints of worsening of cognitive function are also often not supported by objective assessment.

The present research aimed to explore factors which have been suggested in the literature as potentially contributing to the development of subjective cognitive complaints (SCCs) in both populations. These factors included level of awareness of age-related change in cognition, affective distress, processing speed (PS), cognitive reserve (CR), and use of compensatory strategies.

The present research consisted of two parts. In Part A, secondary analyses of two databases were conducted to inform development of a survey and model in Part B. The results supported inclusion of CR, PS, and compensatory strategies in the survey, and indicated the need for inclusion of a measure of psychological stress.

Part B consisted of two studies which examined the hypothesized model of factors that influence reporting of SCCs. Data from a total of 659 individuals recruited from the New Zealand population was split into two groups - normal aging (n=436) and mTBI (n=223). Structural equation modelling (SEM) was employed to assess the relationships between the identified factors and SCCs in each of these groups. The results provided support for the hypothesized model in that this model explained 47.6% of variance in reporting of SCCs in normal aging, and 62.5% of variance in reporting of SCCs in mTBI. Psychoeducation-based interventions, compensatory strategy training, and in some instances individual psychological assessment and therapy are recommended as potentially helpful in reducing the reporting of SCCs.

Acknowledgements

This thesis would not have been possible without the support and guidance from my primary supervisor Professor Janet Leathem. Thank you for being the most patient, wise, and generous supervisor I could have ever wished for. Thank you for trusting in me and allowing me to stay true to myself throughout this process. I feel incredibly privileged and grateful to have shared this journey with you.

To my co-supervisor Associate Professor Paul Merrick, thank you for supporting my research from day one - your guidance and advice have been invaluable. You have contributed greatly to my academic and professional development and for that I will always be grateful.

I would like to thank Dr Matt Williams for his kindness, support, and expert advice throughout this process. You have contributed a significant amount of time to this research and for that I cannot thank you enough.

To Malcolm Loudon, thank you for your expertise and assistance in early stages of research - your role in development of the survey has been crucial. Also, to Harvey Jones for further support with the survey software.

I warmly acknowledge and thank all research participants – your gift of time and sharing of personal experiences have been vital to this research.

To my colleagues and peers – thank you for your patience and words of encouragement. In particular to Dr Susan Page – you have supported and encouraged me for years. Your selflessness, kindness, and generosity continue to amaze me every day.

To my beautiful family in Poland, thank you for your infinite love and support. Mum, thank you for always believing in me - even when I did not believe in myself.

Finally, to my husband Michal. You have been there for me through thick and thin and I could not have done any of this without you. I am thrilled to be sharing this achievement with you, and for all that our future together will bring.

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List of Abbreviations

AARC	Awareness of Age-Related Change
ACCQ	Awareness of Change in Cognition Questionnaire
ANOVA	Analysis of Variance
BR	Brain Reserve
CFQ	Cognitive Failures Questionnaire
CR	Cognitive Reserve
CRT	Choice Reaction Time
DASS	Depression Anxiety and Stress Scales
D-L	Deary-Liewald
EF	Executive Function
FIML	Full Information Maximum Likelihood
GCS	Glasgow Coma Scale
MCAR	Missing Completely at Random
MAR	Missing at Random
MNAR	Missing Not at Random
MCI	Mild Cognitive Impairment
PS	Processing Speed
RT	Reaction Time
SCD	Subjective Cognitive Decline
SEM	Structural Equation Model

SES	Socioeconomic Status
SCC	Subjective Cognitive Complaint
SMC	Subjective Memory Complaint
SRT	Simple Reaction Time
TBI	Traumatic Brain Injury
WM	Working Memory

Preface

The idea for the present research arose from an interest in mild Traumatic Brain Injury (mTBI), in particular, the cognitive and functional difficulties which can persist well beyond the expected recovery period. For a proportion of affected individuals, such difficulties are distressing and interfere with successful return to previous occupation and activities, leading to long-term use of health services and sometimes litigation (Kirsch et al., 2010).

The cognitive symptoms reported more than 3 months after a mTBI are often found to have no association with objective cognitive functioning as evaluated by formal assessment measures (Polster et al., 2018). They are thought to relate more to physical symptoms such as pain or fatigue (Prince & Bruhns, 2017), psychological factors such as personality traits and affective distress (Spencer, Drag, Walker & Bieliauskas, 2010), and biases and misattributions regarding the causes of ongoing subjective difficulties (Broshek, De Marco, & Freeman, 2015). This is similar to normal aging where for similar reasons, subjective complaints of worsening of cognitive function are also often not supported by objective assessment (Mendonça, Alves & Bugalho, 2016). These similarities became the central focus of literature review for this research and provided the theoretical basis for development of a model of influences on reporting subjective cognitive complaints (SCCs).

One idea that came from initial reading was that perhaps some perceived cognitive decline arises because people misattribute the changes that occur in the normal course of aging as due to mTBI or another neurological disorder. Inaccurate perceptions of what occurs to cognition as a result of aging and brain injury are likely to lead to false attributions, e.g., older people may incorrectly assume that they are developing dementia, and those who have sustained a mTBI may attribute changes in cognitive function entirely to the injury and overestimate the expected level of cognitive performance post-recovery. This could, in turn, contribute to ongoing SCCs and other persistent symptoms.

Other potential factors identified in the review of literature and requiring further investigation included age-related changes in Processing Speed (PS), the effects of Cognitive Reserve (CR), affective distress, and the degree to which people engage in different strategies to compensate for their difficulties. Clarifying the role of these factors, as well as awareness and attributions, in the development of SCCs became the aim of the current study. Such investigation would then inform intervention planning. Furthermore, while it is recognized that awareness of age-related changes (AARC) in cognition may have a significant role in reporting subjective difficulties, further research is required as the few existing studies focused exclusively on memory difficulties, and did not consider the possible interplay of SCCs with other cognitive domains (e.g., Begum et al., 2014; Edmonds, Delano-Wood, Galasko, Salmon & Bondi, 2014).

To bridge the identified gaps in research on the associations between these factors and SCCs, the idea of conducting a preliminary analysis of existing neuropsychology databases arose. It was hypothesized that the results would provide valuable insights and support for inclusion of these factors in the model of influences on reporting SCCs. Further, the results would contribute to the development of a New Zealand-based survey, the results of which would be used in analyses of a model influence on reporting SCCs in normal aging and mild-TBI populations.

Finally, the research aims to provide insights and recommendations for enhancing treatment of individuals from either of these two populations who struggle with chronic SCCs. The stages of thesis development are portrayed in Figure 1.

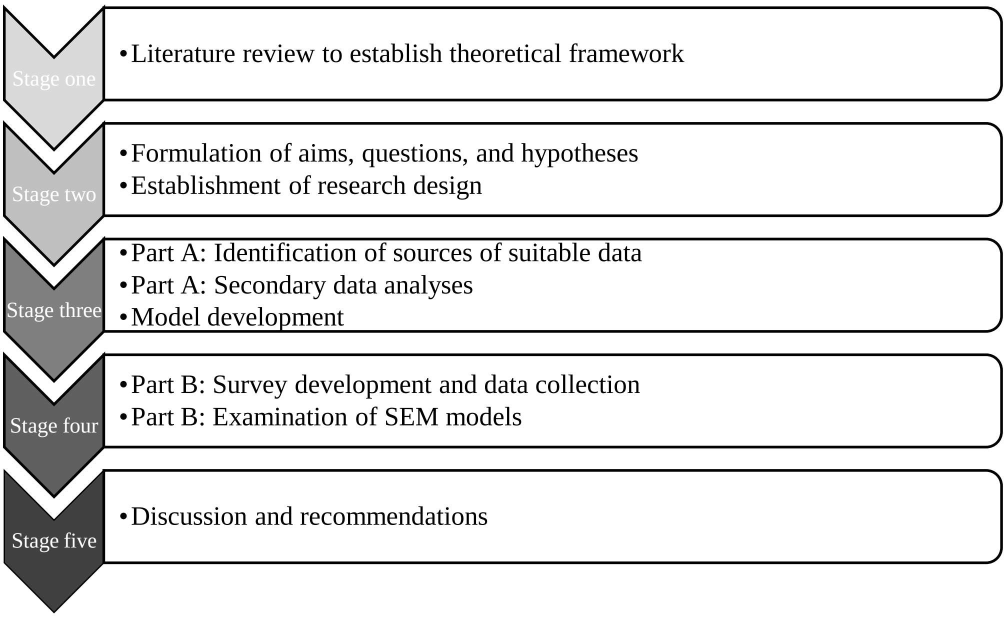


Figure 1. Stages of thesis development.

The structure of chapters in the thesis is intended to reflect the different stages of development of the research topic. Chapters 1 and 2 outline key concepts in the areas of cognitive aging and review research findings on the reporting of SCCs throughout the lifespan. Chapter 3 provides an overview of relevant literature in the area of mTBI and the SCCs reported by this population, and highlights similarities to the reporting of SCCs in normal aging. Chapter 4 summarises key findings from literature and outlines the research aims, questions, and hypotheses. Chapter 5 describes the research methodology and methods used in the two parts of the research, namely the secondary data analysis in Part A, and the Structural Equation Models (SEMs) of influence on reporting SCCs in normal aging and after mTBI in Part B.

Chapter 6 presents the results of Part A analyses in the two databases. Chapters 7 and 8 present the results for Part B – Study 1 normal aging (Chapter 7), and Study 2 mTBI (Chapter 8). These two chapters have a similar structure in that they begin with an outline of the process of data management, display demographic information of sample used in analyses, and outline results from analyses of select research hypotheses. Next, the measurement model is presented, and the model fit is assessed. Chapters conclude with presentation of the results from assessment of the structural model of influence on reporting of SCCs.

Finally, Chapter 9 discusses findings of the present research. This includes a discussion of limitations, note on unique contribution of research to the field of clinical psychology, treatment recommendations, and suggestions regarding the direction for future research in this area.

CHAPTER 1

THEORY AND RESEARCH ON COGNITIVE AGING

The current chapter provides an overview of key literature in the areas of aging and cognition. To emphasize why research in these areas is important, this chapter begins with a summary of the current population demographics worldwide and in New Zealand. This is followed by an overview of the theory of human cognitive abilities and changes that occur in cognition in the course of biological aging. Next, the relationship between subjective complaints of deterioration in cognitive function and objective cognitive functioning is examined. The chapter concludes with a detailed description of the cognitive abilities most often implicated in complaints of declining cognitive functioning.

Demographic Aging

The numbers of older adults in different populations worldwide began to steadily climb in the early 1950's, driven by increases in birth rates and simultaneous decreases in mortality rates (Lee & Mason, 2011). Shortly after that many countries around the world observed changes in family and social roles, the number of births slowed, and the population of working-age adults became larger than that of children and elderly (Lee & Mason, 2011). These adults are now transitioning into older adulthood, and it is estimated that the number of individuals in the older adult population increased from 205 million in 1950 to 962 million in 2017 (UN, 2017). As the life expectancy continues to increase due to improvements in health, social, and environmental factors, the total global population is projected to reach over 11 billion in 2100 with 3.1 billion of adults aged 60 years old and over, including 909 million of older adults aged over 80 years old (UN, 2017).

The life expectancy of New Zealanders has also significantly increased since 1950's when the average life expectancy was approximately 67 years for men and 71 years for women (Statistics New Zealand, 2014). In 2014 it was estimated that the average life expectancy was approximately 79 years for men and 83 years for women (Statistics New Zealand, 2014).

The most recent national census reported that in 2018, 14.3% of men and 16.1% of women residing in New Zealand were aged 65 years old and over (Statistics New Zealand, 2018). The United Nations World Population Prospects had reported in 2017 that 15.3% of total population of New Zealand were aged 65 years old or over (UN, 2017) and this was projected to sharply increase as the life expectancy rates continue to increase to 91.1 years for males, and 93.2 years for females (UN, 2017) by 2100. By then it is estimated that approximately 2 million individuals or 32% of New Zealand population will be aged 65 years old or over, while numbers of working-age adults and children will continue to decrease (UN, 2017). The debate about the likely implications of this demographic shift has included different public and private sectors, including health and workforce (Fuster, 2017; Hsu & Yamada, 2019). Due to this, the issues pertaining to functional and cognitive changes across the lifespan, and particularly in older age, continue to be a central topic of numerous studies.

Cognitive Aging

A decline in individuals' cognitive abilities that occurs throughout the lifespan has been well documented and is becoming an increasingly important focus for research due to an increasing number of people reaching older adulthood. Although there are multiple definitions of cognitive abilities (i.e., Cattell, 1963; McGrew, 2009; Sternberg, 1986), in the present research they are defined as mental abilities which enable performance in different domains of cognitive functioning, for example knowledge, reasoning, problem-solving, working memory, and speed of information processing.

Interest in the area of cognitive aging is often prompted by the need to establish fundamental differences between normal and abnormal aging as this information is deemed to be necessary for accurate screening and identification of pathological changes in cognitive functioning (Harada, Natelson-Love, & Triebel, 2013). Further, knowledge of factors beyond biological aging that may influence cognitive decline is crucial for the development of models used to predict the trajectory of decline in an individual (Vemuri et al., 2019). Lastly, identification of key factors in cognitive aging and specific periods of decline throughout the lifespan may assist in the development of interventions aimed at enhancing individual adaptiveness to such change or even mitigating the effects of such decline (Salthouse, 2009).

Historically, it was thought that decline in cognitive abilities became functionally significant around the age of 65 (Salthouse, 2004). This was based on observations that changes which occur during young and middle adulthood do not produce difficulties that interfere with functioning as much as those that occur in older age (Salthouse, 2009). Salthouse (2004) explained that the decline in earlier stages of life may not be as apparent for several reasons, including individual differences in motivation and personality, and that most situations do not require individuals to perform to the best of their abilities. He also noted that individuals, some more than others, are able to problem-solve the difficulty they are experiencing and engage in compensatory strategies which are continuously enhanced by accumulation of life experience.

More recent research has demonstrated that significant age-related decline in cognitive abilities begins shortly after biological maturity is reached, around the age of 30 (Salthouse, 2009; Salthouse, 2019). Abilities implicated in processing of information, reasoning, and memory deteriorate more markedly and faster compared to verbal abilities which appear to remain relatively stable throughout the lifespan (Park, 2000; Salthouse, 2001; Salthouse, 2019; Wechsler, 2008). The following trends were observed in the general population (Harada et al., 2013; Hedden & Gabrieli, 2004; Salthouse, 2004; Salthouse, 2019; Wechsler, 2008):

1. Decline in information processing speed appears nearly linear with age, beginning from early adulthood.
2. Compared to processing speed, decline in other fluid abilities such as working memory and reasoning abilities begin later in life, however these declines accelerate with increased age.
3. Verbal abilities are least affected by age and generally change little over time. It was observed that they may even improve with age up until mid-60's.

Furthermore, these abilities are frequently interrelated, meaning that changes in one cognitive domain may impact different cognitive abilities, including those that may not directly measure the domain of interest, for example memory (Harada et al., 2013). Changes that are highly pronounced and significantly interfere with the person's functioning may be associated with the emergence of subjective complaints, leading individuals to wonder whether they are developing a deteriorating illness.

Despite the findings related to a universal trajectory of cognitive decline, individual differences in the degree of decline were found, raising the possibility that certain biological or environmental factors may protect individuals from experiencing functional consequences of age-related decline. These factors as illustrated in the findings from study by Schaie and Willis (2010; see Figure 2) include good cardiovascular health; favourable social environment and high socioeconomic status; active involvement in cognitively stimulating environment; flexible personality style; high cognitive status of spouse; and relatively high levels of perceptual Processing Speed. Further findings related to protective factors in cognitive aging are outlined in Chapter 2.

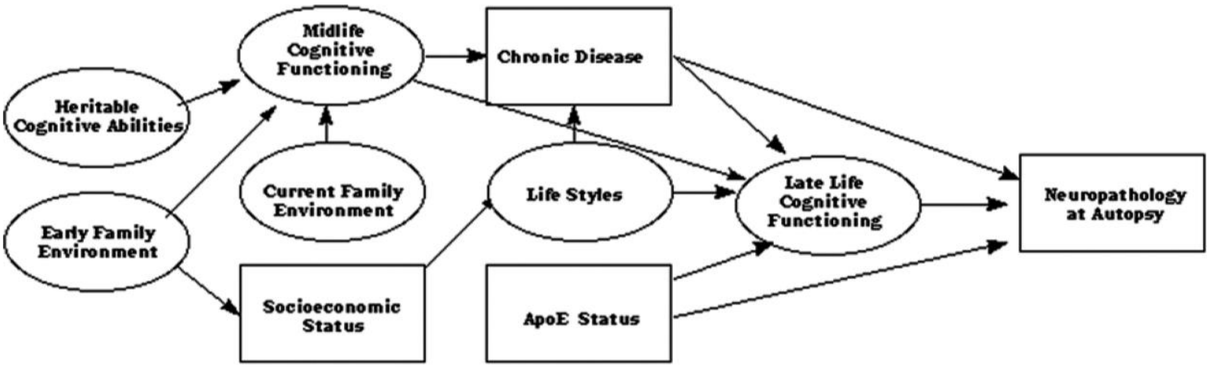


Figure 2. Individual differences in age-related cognitive change. Reproduced from *The Seattle Longitudinal Study of Adult Cognitive Development* by K. Schaie & S. Willis. Copyright 2010 by SAGE Publications.

Key Cognitive Domains in Aging

Processing speed. Processing Speed (PS) is defined as the speed at which mental input is recorded and processed, and the speed of motor responses to that input (Harada et al., 2013). It is typically estimated through timed tests of behaviour and thus assessment often involves other cognitive domains such as motor speed and language (Wechsler, 2008). Normal PS requires a structurally intact brain, and research found that any underlying abnormalities or physical trauma affecting the brain result in markedly reduced speed of mental processing (Draper & Ponsford, 2008; Mathias & Wheaton, 2007; Su, Wuang, Lin, & Su, 2015; Turken et al., 2008). Difficulties in PS can be observed in tasks which measure performance times and delayed reaction times, assuming that visual and motor functions are intact (Ebaid, Crewther, MacCalman, Brown, & Crewther, 2017; Wechsler, 2008).

PS is an important cognitive domain for several reasons. It is believed to facilitate the functioning of other cognitive abilities and as Salthouse (1996) observed, a decrease in PS leads to impairments in other cognitive functions due to slowed processing of sensory input and operations, and therefore reduced availability of information required for later processing (Salthouse, 1991; Salthouse, 1996). Consequently, performance on tasks intended to measure functioning of for example memory is likely to be affected by PS as memory tests involve processing and responding to visual or verbal information (Kail & Salthouse, 1994).

Slowing in PS appears to be a major contributor to memory lapses reported by individuals without any underlying brain changes (Lezak et al., 2012) in that slower PS may result in less efficient organization and encoding of incoming information (Salthouse, 1991). Further, difficulties in PS may indirectly influence memory functioning through its impact on attention (i.e., attending to stimuli and alternating between simultaneous stimuli) and comprehension through rates at which information is perceived, integrated, and accessed. Consequently, this may adversely affect higher-order cognitive processes such as abstraction and integration which are dependent on the effectiveness of earlier processing (Salthouse, 1991).

Lastly, PS is considered to be the most reliable marker of age-related change in cognition based on studies which demonstrated unique, moderate to large relations between PS and age (Salthouse, 2000; Whiting, Baranova, & Hamm, 2006). Further, in older populations PS was found to be a significant predictor of functional independence (Wahl, Schmitt, Danner & Coppin, 2010). PS was also found to be sensitive to structural changes in the brain, and therefore it is considered to be the most reliable marker of age-related change (Madden et al., 2012).

Executive functions. Executive functions (EF) are “higher level” abilities which are believed to control more fundamental, “lower level” cognitive abilities such as attention and perception, and regulate behaviour (Alvarez & Emory, 2006). Diamond (2013) noted three core functions of EFs:

1. Inhibitory control – ability to control one’s behaviour, thoughts, attention, and emotions. This mean that rather than acting on impulse, individuals are able to respond to stimuli in a careful manner. It also enables one to simultaneously focus attention and inhibit irrelevant stimuli.
2. Working memory – holding and manipulating information mentally. Can be verbal (i.e., words) and nonverbal (i.e., visual images).
3. Cognitive flexibility – ability to adapt to changing demands and circumstances or influx of new information, take perspectives, and express oneself creatively.

In research, impairments in EFs were associated with a number of psychiatric disorders, for instance substance abuse, schizophrenia, and depression (Diamond, 2013). They are also frequently observed sequelae of brain trauma and neurodegenerative conditions (Lezak et al., 2012).

The prefrontal-executive theory of cognitive aging described by West (1996) represents an early synthesis of research in the areas of structural brain changes that occur with age and theoretical constructs of EF. It postulates that changes in frontal brain regions that are out of proportion to chronological age may lead to impairment in EFs, and therefore interfere with functioning of other cognitive abilities such as working memory and attention. Links between these regions of the brain and EF have been well documented in research. First, cognitive processes involving EFs are correlated with activation of frontal regions of the brain (Chang et al., 2010; Kinnunen et al., 2010; Sasson, Doniger, Pasternak, Tarrasch, & Assaf, 2012), and therefore are widely used in assessment of frontal lobe dysfunctions (Keil & Kaszniak, 2002). Age-related structural changes in the frontal cortex were found to be more extensive and begin earlier in lifespan compared to other parts of the brain (Grieve, Williams, Paul, Clark, & Gordon, 2007; Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003; West, 1996). Furthermore, reduced complexity of white matter and reduced age-appropriate microstructural development in the prefrontal cortex, as well as EF deficits were found in adolescents diagnosed with Attention Deficit/Hyperactivity Disorder (Helpern et al., 2011). Lastly, Reuter-Lorenz et al. (2001) found higher activation of prefrontal regions during performance of working memory task in older adults, suggesting a possible existence of an innate compensatory mechanism where additional brain regions are recruited with the intention of improving performance and simultaneous lessening of the effects of age on EF.

However, it has been argued that many of the observed age differences in EF may be mediated by underlying changes in PS (Salthouse & Babcock, 1991). For example, Albinet, Boucard, Bouquet, and Audiffren (2012) found that the measures used to validate the prefrontal-executive theory and the processing speed theory share mutual variances, with the later theory explaining 85% of the age-related variance in EF components. More recently Nguyen et al. (2017) found that in a sample of individuals with Parkinson’s Disease, performance on measures of EF was correlated with PS but not chronological age. Research into other types of dementing conditions has further highlighted the need for caution with attribution of performance on tests associated with EF to a specific region in the brain.

Specifically, Stopford, Thompson, Neary, Richardson, and Snowden (2012) found that individuals diagnosed with frontotemporal dementia performed lower on tasks of attention, response inhibition, and set shifting, but not working memory, compared to individuals with Alzheimer's Disease (AD). This is because performance on tests of EF places demands on a number of different cognitive abilities and as a result, impaired performance may be more related to a difficulty with those more fundamental cognitive abilities. Therefore, it may not be appropriate to attribute it to a single brain region, in this case the frontal lobes (Delis, Kaplan, & Kramer, 2001).

To summarize, the PS and prefrontal-executive theories may be considered as complimentary, rather than contradictory, in explaining age-related decline in cognition.

Subjective Cognitive Complaints

Complaints of a subjectively perceived decline in cognitive performance can arise at any point throughout the lifespan (Lachman, 2004). The aetiology of these subjective cognitive complaints (SCCs) has often been attributed to clinical insight that cognitive decline has occurred, however some researchers questioned the validity of this theory as their studies found weak or no associations between subjective complaints and objective cognitive functioning (Baliga, Kamath, & Kedare, 2020; Crumley, Stetler, & Horhota, 2014; Mendonça et al., 2016; Sellwood et al., 2013; Vogel et al., 2004). Despite the lack of clarity regarding the origin of SCCs, they remain an important focus for research due to their consistent associations with poorer mental and physical health, and disability across different areas of functioning, including social, occupational, and functional independence (Aasvik, 2017; Al-Sari, Tobias, Archer, & Clark, 2017; Langlois & Belleville, 2013).

Typically, SCCs are measured through structured questionnaires assessing presence of symptoms, and these can include a rating scale for frequency of experiencing a particular symptom. Another way of assessing SCCs is through recording of spontaneous reports without providing categorical cues. Method of assessment may influence the reporting of SCCs which could explain discrepancies in findings between research which utilised a questionnaire as opposed to uncued recall. Specifically, prompted questioning is limited only to symptoms listed on the questionnaire and can lead to over-reporting of symptoms (Apolinario et al., 2012). In contrast, Burmester et al. (2017) found that unprompted reporting of SCCs can result in reporting of more severe and troubling complaints. Furtermore, Mattos et al. (2003) argued that compared to questionnaires, unprompted reporting is more accurate in predicting actual underlying cognitive decline. However, it is possible that this could lead to less accurate reporting of difficulties as individuals may struggle to identify their SCCs, or that they may provide responses that are not specific enough, for example attributing their difficulty to “memory” while in reality this may be related to another cognitive domain.

The purpose of assessing SCCs has typically been to aid a diagnosis of Mild Cognitive Impairment (MCI) and early stages of dementia (Winblad et al., 2004) as it was found that SCCs are positively associated with biomarkers of abnormal cognitive decline in the absence of structural brain damage (Amariglio et al., 2012; Lam, Lui, Tam, & Chiu, 2005). Individuals reporting SCCs were also found to be more likely to develop MCI or dementia later in life (Mitchell, Beaumont, Ferguson, Yadegarfar, & Stubbs, 2014). For example, an earlier study in this area found that in individuals with a diagnosis of MCI and those of higher educational attainment, SCCs may predict later abnormal cognitive decline (Jonker, Geerlings, & Schmand, 2000). Greater self-reporting of SCCs was also linked to lower performance on tasks of EF and memory, and greater depressive symptomatology (Nicholas et al., 2017). A more recent meta-analysis by Mendonça et al. (2016) found that reporting of SCCs was associated with risk of developing a neurodegenerative disorder but at the same time highlighted that the majority of individuals who report SCCs do not develop dementia later in life. Lee et al. (2020) reported that in a large cohort of older adults in South Korea, those who reported a subjective decline in memory functioning over a 1-year period were at higher risk for subsequent dementia, particularly those who also reported concurrent depressive symptoms. However, it was noted that subjective cognitive decline (SCD) was assessed using a single question pertaining to subjective memory functioning and the study did not include objective means of assessment of cognitive functions. Lastly, Slot et al. (2019) found that in individuals who reported SCD, the incidence rates of dementia were 17.7%, compared to 14.2% for controls. Furthermore, this study reported that individuals referred to memory clinics by a physician or via self-referral were identified to be at an increased risk of dementia compared to individuals based in the community.

Other research focused on improving the prognostic value of SCCs, for example Van Harten et al. (2018) suggested inclusion of re-test measures of SCCs to assess for symptom congruence and querying perceived worry about cognitive decline. However, as these associations have not been found consistently across research for all individuals, this led to advocating against the use of SCCs as a predictor of later cognitive impairment and raising the possibility that using SCCs for such purposes may even hinder an accurate clinical diagnosis (Edmonds et al., 2014).

Over time a small amount of research examined the utility of SCCs as a subtle marker of normal age-related cognitive decline, with promising results. An analysis of existing studies by Stewart (2012) concluded that older adults may, in fact, be more aware of the underlying age-related decline in cognition than previously thought, and that SCCs may be a demonstration of this awareness. Support for this hypothesis comes from Hohman, Beason-Held, Lamar, and Resnick (2011) who found that in their sample of adults without underlying brain impairments, SCCs as assessed by the Cognitive Failures Questionnaire (CFQ) predicted expected longitudinal declines in performance on tasks of verbal memory. The second identified study, a cross-sectional analysis by Snitz et al. (2015) found that preclinical markers of brain aging were associated with SCCs, however this effect was not found uniformly across different measures of SCCs, including the CFQ. The difficulty in replicating results may, therefore, be related to a lack of consistency in measures used to assess SCCs (Rabin et al., 2015). This was further evidenced by Burmester, Leathem, and Merrick (2017) who found significant differences in frequency and severity of subjective memory complaints (SMCs) reported by middle and older adults between two different assessment methods (i.e., prompted questionnaire and unprompted interview). Further research corroborating SCCs with expected trajectories of cognitive decline is warranted, and careful consideration should be given to measures used to assess SCCs.

Comparatively less research has looked at reporting of SCCs in cognitively intact adults of younger age. This is mainly due to the common observation that the frequency of cognitive complaints increases with age (Salem, Vogel, Ebstrup, Linneberg, & Waldemar, 2015), and their attribution to worry about one’s ability to compensate for incremental age-related decline rather than diagnostically significant impairment (Lachman, 2004). However, Begum et al. (2014) demonstrated that SCCs have the tendency to increase up until middle adulthood after which they decrease and re-emerge in older adulthood. Other relevant research focused on exploring hypotheses from studies with older populations on the ability of SCCs to predict future pathological brain degeneration in middle-aged adults (Dumas et al., 2013; Schultz et al., 2015). Limited attention has been given to specific populations of younger adults such as mental health (Salem et al., 2015) and physical health service consumers (Gagnon et al., 2014).

The limited research on SCCs in early and middle adulthood is concerning as experiencing SCCs at a young age may interfere with functioning in different areas of one's life. Furthermore, the lack of disseminated knowledge on the incidence of SCCs in early to middle adulthood could act as a barrier for such individuals to access help. Further, there is some evidence that reporting of SCCs in working-age adults has strong links to depression, poor sleep, and stress (Stenfors, Marklund, Magnusson-Hanson, Theorell, & Nilsson, 2014). However, it appears that there is no published research which explores other factors that may contribute to reporting of SCCs in younger adults, for example the degree of awareness of age-related decline and ability to compensate for any perceived difficulties. It appears that while SCCs in older adults are often explored for their hypothesized ability to predict future neurodegeneration, for the rest of population they may be more related to other factors such as affective distress, stress-inducing environmental demands, ability to cope with emerging difficulties in cognitive abilities, or simply noticing that a slight, age-related decline has occurred. Further research is required to explore these factors.

Common Subjective Cognitive Complaints

It appears that across all age groups, the most frequently reported SCCs pertain to memory errors and lapses of concentration (Begum et al., 2014; Ruocco, Lam, & McMain, 2014; Slavin et al., 2015).

Memory. Memory difficulties are the most commonly reported area of concern for individuals across the lifespan. In the most basic terms, memory is an individual's ability to retain and recall information (Salthouse, 1991). However, what is now considered to be memory is a function of multiple different systems which are dependent on a number of more fundamental cognitive abilities such as PS, WM, and EF (Tulving, 1995). Theories of memory include constructs which depict memory systems, and those that describe memory processing as outlined in Table 1.

Table 1

Memory Systems

System	Other terms	Subsystems	Retrieval
Procedural	Nondeclarative	Motor skills Cognitive skills Simple conditioning Simple associative learning	Implicit
PRS	Priming	Structural description Visual word form Auditory word form	Implicit
Semantic	Generic Factual Knowledge	Spatial Relational	Implicit
Primary	Working Short-Term	Visual Auditory	Explicit
Episodic	Personal Autobiographical Event memory		Explicit

Note. Adapted from *Organization of Memory: Quo Vadis?* by E. Tulving in *The Cognitive Neurosciences*. Copyright 1995 by The MIT Press.

Research has produced numerous theories of memory systems, with the most common being the dual system conceptualization which divides memory into declarative and nondeclarative memory, and these are further divided into more specific subsystems (Tulving, 1995; Clark, 2018). *Declarative memory* includes semantic and episodic memory, otherwise called fact and autobiographic memory; and *nondeclarative memory* consists of item-specific and procedural memory (Lezak et al., 2012). Declarative memory requires a conscious intention to recall specific information, and therefore complaints of worsening memory are most often related to this type of memory.

The three-stage model of memory processing is helpful in understanding how the declarative and nondeclarative memory systems work together, and how difficulties in memory functioning may arise from deficient information processing (Lezak et al., 2012; Salthouse, 1991):

1. Sensory registration – bordering between perceptual and memory functions, this refers to the brief, initial reception of incoming auditory or visual information. Sensory registration corresponds to the procedural and PRS memory systems. Determining which information will be processed further requires attention.

2. Short-term memory (STM) – information held in STM is estimated to last 30 seconds during which the most relevant information is selected for more permanent storing. Information held in STM is typically brief, consisting of five plus minus two bits of information, and requires conscious effort to maintain. In STM, information is categorized based on sensory properties. Further processing to more permanent memory store can be achieved through for instance rehearsal of information.
3. Long-term memory (LTM) – this refers to learning and consolidation of information which results in more permanent storing of information. Learning of information requires attention, and in individuals with intact memory this occurs with and without conscious effort. Storing of different information involves different brain systems, and information is often structured based on meaning and associations.

Forgetfulness is one of the most frequently reported cognitive complaints among cognitively intact adults. Current research hypothesizes that well-assimilated information becomes forgotten through a process of autonomous decay resulting from neurometabolic processes (Davis & Zhong, 2017). However, forgetting can also be a result of difficulties in other cognitive functions and other biological or environmental factors, for example inappropriate attending to information; difficulties with retrieval; presence of interference; or it could be due to pathological brain changes related to dementing conditions (DeBettencourt, Norman, & Turk-Browne, 2018; Hugo & Ganguli, 2014; Storm & Bui, 2016).

To summarize, memory is a complex ability which is largely dependent on a number of different processes and individual cognitive abilities. Memory difficulties are frequently reported throughout the lifespan, and these reports appear to increase with age. Difficulties attributed by lay-people to memory functioning may, however, have their origin in other, more fundamental cognitive abilities, for example PS, WM, and EF.

Attention and concentration. Complaints of worsening attention and concentration are also frequently reported in the course of normal aging. In its broad definition, attention refers to the ability of the brain to become receptive to sensory stimuli and maintain it for the time required to complete a given task (Scott, 2011). It is not the responsibility of a single region in the brain; but rather, on the concerted interaction of several different regions which initiate and sustain attention (Mirsky, 2018). Attention is commonly divided into three interrelated abilities, namely the ability to *focus* on incoming stimuli, *sustain* this focus for a required period of time, and *shift* focus between stimuli. (Mirsky, 2018). The ability to focus on stimuli further involves abilities to select target stimuli whilst suppressing other, non-relevant stimuli (Scott, 2011). Lastly, attention is believed to be comprised of different stages of information processing; operate in an automatic or controlled way; and that it has limited capacity (see Figure 3; Scott, 2011).

Initial Attention	➔➔➔	Selective Attention	➔➔➔	Concentration
Automatic or voluntary orientation to sensory stimuli		Selection of stimuli from array of competing sensory stimuli		Maintenance of focus on stimuli to complete task

Figure 3. Cognitive model of attention and concentration. Reproduced from *Attention/Concentration: The Distractible Patient* by J. Scott in *The Little Black Book of Neuropsychology: A Syndrome-Based Approach*. Copyright 2011 by Springer.

Concentration is closely related to attention in that it is the capacity of attention to focus on select stimuli while suppressing awareness of other input in a controlled, effortful manner (Spikman, 2010). It can be affected by external factors such as time pressure or level of difficulty of tasks, and internal factors such as level of motivation (Sörqvist & Marsh, 2015). Therefore, concentration is often linked to task performance in that it facilitates attention to significant stimuli and safeguards against external and internal distractions.

Attention is highly sensitive to the effects of psychiatric disorders, for example anxiety, and any changes in brain structure and physiology, particularly when the frontal lobes are affected (Hedges, Farrer, Bigler, & Hopkins, 2019; Hoffmann, 2016). It can also be affected by other internal and external factors such as sleep deprivation and fatigue, pain, medication, and substance use (Lezak et al., 2012). Difficulties in attention may indirectly affect performance of other cognitive abilities through deficient attending to information, however it is possible to test for the performance of other cognitive areas if adequate attentional capacity is exercised during assessment (Scott, 2011). Lastly, among those abilities, deficits in information processing speed are most frequently reported as attentional difficulties (McAuley, Crosbie, Charach, & Schachar., 2014).

Summary

In summary, as more people live into older adulthood, the demographic profiles of populations across the globe undergo a significant transformation. On average, people live longer and actively participate in the workforce for longer which translates to an increased need for research in all areas pertaining to aging, including cognitive functioning. Despite research demonstrating that cognitive decline begins in early adulthood, and that individuals of all ages may report difficulties related to their cognitive functioning, the focus of studies in this area has been mainly on neurodegenerative conditions in older adulthood. An overview of existing models of cognitive aging indicated that among all cognitive abilities, PS may be the most fundamental ability in that it appears to be responsible for optimal functioning of other primary and more complex abilities, and that slowing in PS may prompt subjective reports of difficulties in memory, concentration, and attention. It also appears that PS is likely to underlie abilities involved in EF. Certain socioeconomic, lifestyle, and health factors were indicated to affect the rate at which cognitive decline occurs, and research has further indicated the potential impact of affective distress on cognitive performance. It was also highlighted that individuals of any age may report subjective concerns pertaining to their cognitive functioning, however more research is required in younger adults. At present it is unclear whether such complaints reliably reflect insight into actual age-related cognitive decline, or if they could be related to other psychological, physical, and social factors. Overall, all such factors should be carefully considered in future research in the area of changes in cognition across the lifespan.

CHAPTER 2

CORRELATES OF SUBJECTIVE COGNITIVE COMPLAINTS

As described in Chapter 1, the past two decades have seen a proliferation of research in the area of cognitive aging. Some studies touched on the associations between SCCs and biological, cognitive, and psychosocial factors, indicating that these play a significant role in clarifying the origins of SCCs, early identification of at-risk individuals, and in highlighting potential targets for interventions. Some of these hypothesized associations appear to have not been formally tested, and other studies0020in this area focused on individual factors rather than the relationships between them.

The present chapter will examine literature which explores factors associated with reporting of SCCs. It will begin with a descriptive overview of each factor, discuss significant findings in relation to SCCs, and highlight areas that require further empirical query.

Awareness of Age-Related Change in Cognition

Awareness of change in cognitive functioning has recently become a topic of discussion due to its potential influence on one’s perceptions of own illness and wellness. In the context of the present research, awareness refers to general knowledge about typical age or illness-triggered changes in cognition, and the likely consequences of such changes. This kind of awareness is different from personal experience of age-related changes as these are subject to interpretation through the prism of social stereotypes and cultural beliefs and do not always reflect actual underlying cognitive changes (i.e., when attributing slowing in PS to memory; Diehl & Wahl, 2009). Furthermore, as discussed in Chapter 1, change in cognition involves both declines in fluid abilities such as PS or EF, and improvements in crystallised abilities, for example general knowledge (Wechsler, 2008). Thus, in theory, awareness of age-related change in cognition (AARC) pertains to all underlying cognitive abilities and includes the ability to explicitly verbalise these changes.

AARC has most frequently been explored in the context of associations between SCCs, objective cognitive functioning, and risk of future pathological decline. Several studies have demonstrated that awareness of decline is positively associated with reporting of SCCs, and it has been proposed that accurate perceptions of change and concurrent reporting of SCCs could be a subtle indicator of on-going progression of neurodegenerative disorders

(Lehrner et al., 2015; Schouws, Comijs, Stek, & Beekman, 2012). For example, in individuals who had been diagnosed with MCI, SCCs were found to accurately reflect their objective cognitive challenges (Piras, Piras, Orfei, Caltagirone, & Spalletta, 2016). Other studies have considered fluctuations in awareness as an early marker for future development of AD, especially when observed in individuals who are at risk of development of AD but who have not yet declined in cognition as evidenced by objective testing (Dubois, Padovani, Scheltens, Rossi, & Dell'Agnello, 2016). Lastly, one of the few existing studies in this field found that in their sample, approximately 19% of individuals reported more SCCs compared to information obtained from their primary caregiver which demonstrates that not all indiviudals who report SCCs appear to have appropriately developed knowledge of the actual changes which occurred in their cognition (Cacciamani et al., 2020).

Significantly less attention has been given to awareness of normal age-related change. One of the earliest studies in this area proposed that SCCs reported in the absence of objective cognitive impairment may be a sign of limited awareness that an age-related change has occurred (Geerlings, Jonker, Bouter, Ader, & Schmand, 1999). More recently Burmester et al. (2017) offered another explanation for reporting of SCCs where normal age-related decline in PS becomes subjectively evident when the attention to cognitive difficulties is enhanced, as in the case of heightened affective distress.

Other studies provide further insights on the association between awareness and SCCs. For example, reporting of SCCs related to memory functioning was associated with lower awareness regarding normal memory decline (Tang, Yang, Huang, Jiang, & Wang, 2018). In another study, this type of awareness was linked to stereotype threat which, in turn, was linked to lower performance on tasks measuring explicit memory in individuals aged under 75 years (Eich, Murayama, Castel, & Knowlton, 2014). Lastly, a recent meta-analysis by Mendonça et al., (2016) found that on their own, SCCs do not predict future progression to a neurodegenerative condition; however, the salient awareness of and preoccupation with complaints, and concurrent experience of affective symptoms may help identify at-risk individuals. This indicates that while SCCs could indicate insight regarding the occurrence of age-related change, it cannot be assumed that all individuals are able to accurately pinpoint the specific reason for their difficulties.

Awareness has also been linked to other factors relevant to SCCs. Awareness of age-related health and cognitive decline across different domains of life in middle to late adulthood was associated with increased depressive symptoms (Dutt, Gabrian, & Wahl, 2016). Similar findings were reported from a recent meta-analysis by Sabatini et al. (2019) in that awareness was associated with poorer emotional outcomes. However, it was noted that these studies included mainly individuals aged 40 years and above. There appear to be few published studies regarding awareness in groups of adults younger than 40 years, and this is surprising given the lifespan trajectories of cognitive decline. A lack of awareness of how cognition changes in the course of normal aging may, in some people, result in attributing cognitive changes or difficulties to another, more sinister condition. For instance, Mendonça et al., (2016) noted that a large proportion of individuals who report SCCs are also worried about developing a neurocognitive disorder. Catastrophic reactions to noted difficulties and symptom misattributions may lead to increased psychological distress, i.e., symptoms of depression and anxiety, which may perpetuate the problem as both depression and anxiety are associated with poor concentration and memory functioning (Naismith, Longley, Scott, & Hickie, 2007; Robinson, Vytal, Cornwell, & Grillon, 2013; Trivedi & Greer 2014).

Attributions

The theory of attributions was formulated based on observations that humans strive to obtain a plausible explanation of causes that led to certain significant consequences (Försterling, 1986). Attributions are made based on individuals' arbitrary perceptions that an external event is linked to a specific outcome, and their purpose is to better understand and predict behaviour and events (Shaver, 2016). As attributions are intrinsically subjective, they are influenced by societal stereotypes, acquired knowledge and experience, personality traits, and cultural context relevant to the person. Attributions can be divided into two broad categories based on individual differences in locus of control such that individuals tend to attribute causality for observed phenomena to either internal (dispositional) or external (situational) factors (Shaver, 2016). To illustrate, the belief that one's good exam performance was due to own ability is an example of internal attribution, whereas the belief that good performance was a result of favourable exam questions corresponds to external attribution. In general, internal attributions for positive events have been associated with positive coping and enhanced self-efficacy (Kok, Den Boer, De Vries, Gerards, & Mudde, 2014; Mark & Smith, 2012; Salanova, Martinez, & Llorens, 2012), whereas for negative events it is frequently linked to heightened psychological distress (Sanjuán, Pérez, Rueda, & Ruiz, 2008).

Existing research highlights potential links between reporting of SCCs and attributions that people make about the cause of these complaints. However, relatively few empirical studies have explored these in detail, and most studies focused on attributions made for memory complaints. For instance, the memory difficulties reported by middle aged women were most frequently attributed to heightened stress and deteriorating physical health (Mitchell & Woods, 2001). Some women attributed SMCs to normal aging, however no significant links were found between their chronological age and frequency of reported SMCs which suggests that these complaints are likely related to other factors (Mitchell & Woods, 2001). Hurt, Burns, and Barrowclough (2011) found that their sample of adults attributed SMCs predominantly to stress, worry, and difficulties in attention control; significantly fewer participants endorsed attributions to underlying affective disorders or the use of substances. Interestingly, it was found that attributing memory difficulties to a disruption in blood supply in the brain was a significant predictor of anxiety (Hurt et al., 2011) which could indicate presence of worry about the potential for development of a neurodegenerative disorder.

A follow-up study by Hurt, Burns, Brown, and Barrowclough (2012) found that attributions may play a significant role in help-seeking behaviour in healthy individuals who report SMCs. Compared to individuals who attributed SMCs to “a lack of blood supply in the brain” (Hurt et al., 2012, p. 396), those who attributed SMCs to loneliness were less likely to seek help for their difficulties. Furthermore, it was noted that individuals who sought help for their SMCs were more likely to have a family history of dementia (Hurt et al., 2012). These results highlight that people are not always correct in their causal attributions of perceived memory difficulties, and that accuracy of such attributions may moderate the experience of psychological distress.

Another study suggested that attributions regarding cognitive abilities involved in memory processes may be key in explaining the observed discrepancies between subjective and objective memory performance (Helmstaedter & Elger, 2000). It could, therefore, be argued that knowledge of human cognitive abilities and changes that occur across the lifespan is essential for making accurate attributions regarding the origin of any noted changes. However, this hypothesis has not yet been empirically tested. The last reviewed study found that over-reporting of SMCs in middle-aged adults was linked to affective symptoms and that these symptoms may lead to bias towards negative attributions of memory performance (Paradise, Glozier, Naismith, Davenport, & Hickie, 2011). But while this may be true for some, there is no evidence to show that this occurs uniformly across all individuals who report SCCs. No studies exploring attributions of decline in other cognitive domains in normal populations were identified, highlighting the need for further research in this area.

Cognitive Reserve

Individuals vary in their levels of cognitive ability across the lifespan (Wechsler, 2008), with some appearing to be more resistant to age or disease-related decline in cognitive functioning than others (Barulli & Stern, 2013; Stern, Gazes, Razlighi, Steffener, & Habeck, 2018). Such individuals are frequently more highly educated, employed in more cognitively demanding occupations, and have a better physical health status than those whose decline occurs at the expected pace (Rindermann, Becker, & Coyle, 2016). These observations prompted research into the construct of CR which is hypothesized to be the degree of damage that the brain can tolerate before the threshold for clinical expression of pathological changes is reached (Stern, 2002). According to the CR model, the brain attempts to cope with age or trauma-induced degeneration through employment of pre-existing cognitive processing strategies and compensatory techniques (Cosentino & Stern, 2019). This means that the same amount of brain damage would have varying effects on cognitive functioning of different people regardless of their brain size, and in individuals with higher CR it would result in a lesser degree of deficits and fewer symptoms compared to individuals with lower CR (Cosentino & Stern, 2019).

It is important to note a distinction between CR and the construct of brain reserve (BR). While CR is often thought to represent the *functional* properties of the brain related to its functional network organisation, BR is believed to represent the *structural* properties related to specific parts of the central nervous system, specifically the size of the brain and neuronal count (Medaglia, Pasqualetti, Hamilton, Thompson-Schill, & Bassett, 2017; Stern, 2014). Therefore, it is assumed that while CR can be enhanced through lifetime exposure to cognitively challenging situations, BR is largely determined by genes and influenced by experiences in early neurodevelopmental stages (Reiss, Abrams, Singer, Ross, & Denckla, 1996). Stern (2002) provided a further explanation of the difference between CR and BR through an analogy of the brain as a computer where BR is the computer's physical components or *hardware* such as the processor or graphics card, and CR is akin to *software* which facilitates performance of different functions, for example the operating system and applications. Therefore, factors which influence BR and CR have a low degree of cross-over, and the protective effects of BR and CR on individual ability to cope with brain pathology are unique (Stern, 2013; Sumowski et al., 2013).

The results from several studies indicate that CR mediates the effects of normal and pathological aging, and other brain pathology on cognitive abilities, and therefore those with low CR seem to display symptoms of cognitive decline at a younger age than those with higher CR (Haussmann, von Lieres und Wilkau, Sauer, Niles, & Donix, 2020; Mazzeo et al., 2019; Stern, 2002; Stern, 2009; Stern, 2012; Tucker-Drob, Johnson, & Jones, 2009). It was suggested that aspects of life experience and innate intelligence may influence individual differences in CR, and that when considered together, they can be used to indirectly estimate the level of one’s CR (Barulli & Stern, 2013; Stern, 2003).

Factors frequently correlated with CR and therefore used as proxy measures include educational and occupational attainment, frequency of engagement in social and intellectual leisure activities, and combined childhood and adult socioeconomic status (Cosentino & Stern, 2019). For example, individuals with eight or more years of education; in a cognitively demanding occupation (i.e., higher management and professional positions); with frequent participation in cognitively stimulating leisure activities; good health status; and an overall higher standard of living were found to have higher CR (Deary et al., 2009; Scarmeas & Stern, 2003; Stern, 2013). Recent research also indicated that exposure to socially and cognitively stimulating, favourable environments in early developmental period has the ability to enhance CR and therefore provides a degree of protection from the effects of aging (Schoentgen, Gagliardi, & Defontaines, 2020).

Education. Education is the most widely researched proxy measure of CR, and several studies have demonstrated that in individuals with higher educational attainment, clinical manifestation of brain pathology was delayed (Alexander et al., 1997; Qiu, Bäckman, Winblad, Aguero-Torres, & Fratiglioni, 2001; Stern et al., 1995; Stern et al., 2018). Compared to their less educated peers, these individuals do not differ in the timeline of the development of a neurocognitive disease. However, they display fewer symptoms until the late stage of their condition, and their cognitive decline progresses significantly faster following the expression of early signs (Meng & D’Arcy, 2012). Further support for this theory comes from Mungas et al. (2018) who reported that higher education was associated with lower cognitive decline in individuals with a lesser degree of brain atrophy, and faster cognitive decline in individuals with greater brain atrophy.

In general, however, higher educational attainment, particularly when combined with higher occupational attainment, is associated with better cognitive functioning in older age in the absence of an underlying neurodegenerative process (Darwish, Farran, Assaad, & Chaaya, 2018). Other research pointed out that access to education at a young age may be of significance, hypothesizing that the aforementioned attainment of up to 8 years of education falls within the critical period for cognitive and neural development (Zahodne, Stern, & Manly, 2015). Education as a proxy measure of CR was also found to have a protective effect on retrieval of common nouns, but not proper nouns such as names of people and places which are frequently reported as memory-related complaints in older age (Delazer et al., 2020). Lastly, in a recent study of men undergoing residential treatment for substance-related disorders, education as a proxy measure of CR was positively associated with scores a on cognitive screening measure and an EF task (Toledo-Fernández et al., 2020).

Occupation. The associations between occupational attainment and CR appear to be less clear. While some researchers argue that higher occupational complexity at mid-life is significantly associated with improved late-life cognitive outcomes and lower risk of developing dementia (Andel, Silverstein, & Kåreholt, 2014; Stern, 2012), other studies suggested basing the assessment of CR only on the most recently held occupation (Richards & Sacker, 2003). However, both methods appear narrow as they do not account for all individual circumstances, for example situations where an individual is retired or temporarily unemployed. It is now common to see research which queries both the most recently held occupation and the highest occupational attainment in order to enhance the accuracy of estimated occupational attainment (e.g., Darwish et al., 2018). Therefore, it appears that using only the most recent occupation are insufficient in estimating one's CR; rather, two or more measures are preferable.

Leisure activities. Engagement in leisure activities is also believed to enhance CR. These are commonly divided into cognitive activities such as reading, solving problems, and playing games; and non-cognitive activities including socialising and physical exercise (Cheng, 2016; Cosentino & Stern, 2019). Several studies observed that compared to their peers, individuals who frequently engaged in any kind of leisure activities during early and middle adulthood were less likely to develop a neurocognitive disorder later in life (Friedland et al., 2001; Sauter, Widmer, Ihle, & Kliegel, 2019; Scarmeas, Levy, Tang, Manly, & Stern, 2001). Another study looking at associations between CR and biomarkers for AD found that in their sample of cognitively intact individuals, CR was associated with white matter hyperintensities but not other studied biomarkers (Pettigrew et al., 2020). As these changes in white matter are often presumed to be of vascular origin, these results seem to indicate that improved lifestyle and environmental factors that contribute to higher CR may be important protective factors. Further, Wang, MacDonald, Dekhtyar, and Fratiglioni (2017) found that frequent engagement in any kind of stimulating activities over the course of the lifespan was associated with a lower risk of developing dementia regardless of any pre-existing genetic risk factors. The most frequently documented associations between leisure activities and reduced risk of developing a neurocognitive condition were for intellectually stimulating leisure activities (Andel et al., 2014; Crowe, Andel, Gatz, Pedersen, & Johansson, 2003; Kareholt, Lennartsson, Gatz, & Parker, 2011). However, other non-cognitive leisure activities were also linked to a lowered risk of developing dementia and a higher level of CR, notably physical exercise and social engagement (Sauter et al., 2019; Scarmeas & Stern, 2003).

Socioeconomic factors. Socioeconomic Status (SES) refers to a hypothesized economic and social standing of an individual, and it is frequently linked to the quality of health and wellbeing (Adler, 2013). Individual SES can be subjective (i.e., self-reported perception of own SES) or objective (Präg, Mills, & Wittek, 2016), with the latter commonly derived from information such as occupational and educational attainment, and income status (Sirin, 2005). Early-life SES is largely dependent on the SES of the family of upbringing which influences one’s access to and quality of education, leisure, and health services (Swaab, 1991). Consequently, adult SES may often be similar to childhood SES as, for instance, reduced access to education due to lower parental SES frequently results in lower adult SES (Davis-Kean, 2005; Erola, Jalonen, & Lehti, 2016; Sirin, 2005). Low SES is associated with reduced educational achievements and lower health status through fewer opportunities to engage in exercise and poorer health-related behaviour (Adler & Ostrove, 1999). In contrast, higher SES of family of origin is linked to better health status and educational outcomes, adult financial earnings, and consequently higher adult SES (Currie & Goodman, 2020).

There is some uncertainty regarding the role of SES in CR due to sparse amount of research directly measuring the relationship between the two, and the overlap in their proxy measures e.g., education and occupation (Gold et al., 1995). For instance, Fotenos, Mintun, Snyder, Morris, and Buckner (2008) observed reduced brain volume and acceleration in volume loss in non-demented older males of higher SES in the absence of clinical expression of brain pathology, however this study did not control for the effects of educational attainment. A recent study by Yasuno, Minami, and Hattori (2020) found that in their participant sample, SES derived from information on educational attainment and occupation was not protective of future development of dementia; however, educational attainment as a stand-alone factor was found to be protective. Only one study demonstrating the unique effect of SES on reduced risk of developing dementia was identified (Sattler, Toro, Schonknecht, & Schroder, 2012).

Further research is required to clarify the relationship between SES and CR. This, however, is outside of the scope of the present research. Due to significant overlap between factors of CR and SES, the decision was made to include only one factor with the least degree of overlap. Therefore, parental occupational attainment was selected and intended to serve a proxy measure of childhood SES.

In summary, factors including educational attainment, occupational attainment, engagement in leisure activities, and factors associated with socioeconomic status appear to contribute to the level of CR in individuals.

Effects on cognitive and emotional functioning. The relationship between CR and specific cognitive abilities is not yet fully understood. A meta-analysis by Opdebeeck, Martyr, and Clare (2016) concluded that when assessed together, proxy measures of CR were significantly related to overall cognitive functioning; however, these associations varied greatly for different proxy measures when these were considered individually. Among all proxy measures, educational attainment was shown to have a small to moderate size relationship with all of the cognitive domains, with age being a significant moderator in the relationship between education and working memory, executive function, and language, but not memory and visuospatial ability (Opdebeeck et al., 2016). Smaller significant associations were also found for occupational attainment and cognitive leisure activities (Opdebeeck et al., 2016).

A more recent study by Szepietowska and Kuzaka (2020) reported that individuals with higher CR were approximately 14% less likely to obtain lower scores on measures of general cognitive functioning, and also that CR demonstrated no significant interactions with age. This appears consistent with theory that the protective effects of CR apply not only in instances where underlying brain pathology is present, but also in general aging. Further, McKenzie et al. (2020) found that CR predicted slower decline in EF in individuals grouped as positive for biomarkers for AD, but not in individuals in the biomarker-negative group. Lastly, O'Shea et al. (2015) found that in their sample of older adults, higher CR was associated with larger declines across different domains of cognitive ability at higher levels of depressive symptoms. It was suggested that individuals with higher CR may be more aware of the negative impact that depressive symptoms have on their functioning (O'Shea et al., 2015). This is consistent with conclusions from previously discussed Sabatini et al. (2019) who found significant associations between awareness of negative changes in cognitive functioning and worse emotional outcomes.

Another recent study looked at links between CR and WM using reaction time (RT) tasks in cognitively intact individuals aged 20-80 years (Zarantonello, Schiff, Amodio, & Bisiachhi, 2020). RT tasks involved temporarily holding the image of target stimuli and observing a computer screen, then pressing a keyboard button as fast as possible when the target stimulus was presented. Performance on RT tasks require not only engagement of WM, but is reliant on optimal functioning of PS. The study found that CR was positively associated with task accuracy but not speed, and it was noted that RTs increased with age, indicating that the speed of responding slowed with age (Zarantonello et al., 2020). Of interest was also a finding that educational attainment of 15 years or more had a positive effect on RTs in that such individuals responded faster to stimuli. To conclude, the results appear to indicate that CR may have a limited protective effect on WM. However, it also appears that this may not be the case for information PS which may explain the lack of significant results for RT speed.

Other studies explored the role of CR in attenuating the impact of affective distress on cognitive functioning. Evans et al. (2019) explored the associations between perceived social isolation and performance on tasks related to different cognitive domains in older adults with symptoms of depression and anxiety. It was found that this relationship was significant at baseline, however not at 2-year follow-up. Furthermore, a moderation analysis found that CR did not have a significant effect on this relationship at baseline or follow-up, although no significant differences were observed between performance on cognitive tests at baseline and follow-up (Evans et al., 2019). These findings appear consistent with other studies which demonstrated significant links between symptoms of depression and anxiety, and cognitive performance in the absence of any underlying cognitive change (e.g., Beaudreau & O'Hara, 2009; Yochim, Mueller, & Segal, 2013).

Therefore, it appears that individuals who experience psychological symptoms may be less able to benefit from any potential protective effects of CR. However, as the study by Evans et al. (2019) focused mainly on social isolation, further research looking at other affective symptoms is required to assess the accuracy of these assumptions. Another study found that in their sample of community-dwelling older adults, lower performance on cognitive tests was related to lower perceived psychological and physical well-being, and that this relationship was attenuated by higher CR and social factors (Ihle et al., 2020).

Cognitive reserve and reporting of subjective cognitive complaints. Five relevant studies exploring the relationship between CR and reporting of SCCs were identified and reviewed. The earliest of these studies found a significant association between individual level of CR and reporting of SCCs, however this association was moderated by personality traits (Comijs, Deeg, Dik, Twisk, & Jonker, 2002). The next study found that reporting of SCCs by cognitively intact individuals with high educational attainment was associated with a higher risk of developing AD (Van Oijen, Jan de Jong, Hofman, Koudstaal, & Breteler, 2007). This finding could be explained by the threshold theory of CR according to which individuals with higher CR do not exhibit symptoms of underlying brain pathology until a late stage of the development of pathology is reached (Stern, 2002). It also appears that in individuals with higher levels of CR, SCCs could arise in place of other clinical symptoms and serve as early signs of underlying pathological changes. The third study by Perquin et al. (2015) found that in older adults, higher CR was associated with lower prevalence of cognitive complaints. The results of these two studies appear to contradict, however it is likely that participants in the Van Oijen et al. (2007) study were more advanced in the development of underlying pathology than participants in the Perquin et al. (2015) study. The last two studies examined middle aged individuals who reported persistent SCCs and it was found that in these samples, CR was positively associated with better episodic memory, working memory, and general cognitive performance (Ferreira et al., 2017; Lojo-Seoane, Facal, Guardia-Olmos, & Juncos-Rabadan, 2014).

In summary, CR is a relatively new construct which emerged from observations of individual differences in the progression of neurodegenerative disorders. It is believed to be influenced by exposure to experiential resources throughout the lifespan. The underlying theorem of CR continues to undergo verification and modification as new research in this area is published, mainly in the area of potential protective properties of CR and factors which may influence the level of CR in individuals. In regard to these factors, the strongest evidence is for education, occupation, and choice of leisure activities. SES has also been highlighted, however there is a significant overlap between factors that are hypothesized to constitute SES and general CR factors such as education. However, research implies that the protective effect of CR may be difficult to tease out, or even be inapplicable depending on the individual cognitive status and the investigated cognitive domain. It may also not be practical to consider the different proxy measures of CR in isolation when conducting research in this area, and thus they all require careful consideration. Lastly, emerging research suggests links between CR and reporting of SCCs in aging, and more research is required to assess whether the protective properties of CR extend to include individuals who experience symptoms of affective distress.

Processing Speed

As discussed in Chapter 1, PS is one of key cognitive abilities that facilitate the functioning of other abilities. Regarding the link between PS and SCCs related to memory, a study by Burmester et al. (2017) demonstrated that the number of reported SMCs increased proportionally to depressive symptoms, and that SMCs were inversely related to PS scores at higher levels of depressive symptoms. Two explanations to this effect were offered. First, it was suggested that while PS underlies difficulties in objective memory, it is only subjectively evident when sufficient attention is paid to memory problems – for instance when depressive symptoms are highly pronounced. Second, it was suggested that depression may cause PS to decline, and that this decline becomes unmanageable at higher levels of symptom severity, leading to negative consequences in functioning of other cognitive abilities. This explanation is consistent with research that found significant differences in performance on tasks measuring PS, EF, and memory in individuals affected by unipolar depression, with measures taken during a depressive episode and after six weeks of treatment (Xu et al., 2012). The study also explored whether this effect would be observed with other higher-order cognitive abilities, and it was found that EF was not a significant predictor of SMCs (Xu et al., 2012). These findings appear consistent with Salthouse’s (1996) PS theory of cognitive aging in which decline in PS underlies changes in other cognitive domains.

The protective effect of CR was suggested to apply to a number of cognitive domains, for example WM, verbal, and perceptual abilities, but not for PS (e.g., Lojo-Seoane et al., 2014; Ferreira et al., 2017). This is not surprising considering that CR proxies are believed to reflect attainment, whereas PS tasks are intended to measure ability. A lack of protective effect of CR on PS may negatively affect other cognitive domains and potentially result in difficulties being expressed as SCCs. It also indicates that compared to other cognitive domains, PS more accurately reflects age-related neurobiological changes. These ideas appear to be supported by research which demonstrated that PS had the weakest relations to proxy measures of CR (Morin & Midlarsky, 2017; Tucker-Drob et al., 2009) and strongest to age (Hergert, Pulsipher, Halaand, & Sadek, 2020). Further evidence comes from study by Lavrenic, Churches, and Keage (2018) who found that CR was associated with performance on measures of different cognitive domains such as attention and EF, but not PS.

Affective Distress

Affective distress refers to self-reported symptoms that could be attributed to depression, anxiety, and stress in general. The co-occurrence of SCCs and symptoms of affective distress has been well documented, with SCCs being more frequently correlated with depression than objective cognitive functioning (Edmonds et al., 2014; Zlatar, Moore, Palmer, & Jeste, 2014). For instance, Santangelo et al. (2014) found that in their sample of participants with comparable level of cognitive ability, those with subclinical and clinical depression reported more SCCs than non-depressed participants (Santangelo et al., 2014). In cognitively healthy older adults, reporting of SCCs was also associated with depressive symptoms as assessed using the Geriatric Depression Scale (Markova et al., 2017). Similar results were found by Lehrner et al. (2013) who found that higher severity of depressive symptoms was associated with a larger number of reported SMCs regardless of cognitive status. Also, Gelonch, Garolera, Valls, Rossello and Pifarre (2017) found that in their sample of women with fibromyalgia, reporting of SCCs was significantly linked to depressive symptoms. Lastly, a study of individuals undergoing cardiac surgery found that reporting of SCCs was associated with depressive symptoms, and furthermore, that the majority of individuals with objective cognitive decline did not report any SCCs (Deiner et al., 2019).

However, several studies showed that symptoms of depression may be unrelated to reports of SCCs. Gallassi et al. (2010) found no significant differences in symptoms of psychological distress between cognitively intact individuals who reported SCCs and those who were later diagnosed with MCI. Another study found that discrepancies between subjective and objective cognitive performance were unrelated to the severity of depressive symptoms (Liik, Vahter, Gross-Paju, & Haldre, 2009). Lastly, Hollands et al. (2015) found that individuals with high and low amyloid-B biomarkers for AD did not differ in objective and subjective reports of cognitive decline and symptoms of psychological distress.

The role of anxiety in reporting SCCs is even more uncertain due to the lack of conclusive research in this area. Yates, Clare, and Woods (2017) found a significant positive association between SMCs and anxiety, but only when symptoms of anxiety were measured together with those of depression. Two further studies found that symptoms of anxiety were uniquely associated with reports of SMCs (Balash et al., 2013; Aasvik et al., 2015). However, a New-Zealand based study found that anxiety was not significantly related to SMCs (Burmester et al., 2017).

Lastly, while the incidence of mood disorders in those who report SCCs has been well documented (Chu et al., 2017; Jungwirth et al., 2004; Seo, Kim, Choi, Lee, & Choo, 2017; Yates et al., 2017), the direction of the relationship between the two remains unclear and may vary between individuals. No research to date has unequivocally evidenced the direction of the relationship between symptoms of depression and SCCs, and therefore it is not plausible to assume a causal role of affective distress in emergence of SCCs. Specifically, symptoms of depression and anxiety could have been pre-existing in those who later develop SCCs, or the experience of subjective decline could increase one's levels of stress, and therefore render them vulnerable to the development of depression and anxiety (Gotlib & Joormann, 2010). Therefore, the direction of this relationship appears to be largely dependent on individual circumstances.

To conclude, it is plausible that depression and anxiety may not be directly related to reporting of SCCs. However, the high incidence of affective symptoms in those who report SCCs warrants an inclusion of those factors in future research.

Compensatory Strategies

Use of cognitive and environmental strategies to compensate for subjective declines in cognitive performance, and their effect on general functioning has been widely researched.

Examples of such strategies include physical and digital diaries, picture or intstruction cards displayed in visible places, minimising environmental distractions, or asking family and friends for reminders (Wilson, Winegardner, Van Heugten, & Ownsworth, 2017). Studies demonstrated that use of strategies, particularly related to memory, is linked to better objective memory performance (e.g., Aronov et al., 2015) and overall higher perceived wellbeing (Dixon, de Frias, & Bäckman, 2001). However, research also noted that while use of compensatory strategies can improve performance on specific tasks, individuals with greater cognitive and functional difficulties are less likely to employ such strategies (Weakley, 2018) or experience more difficulty in effective use of strategies (Fechner, Pachur, & Schooler, 2019). Greater reporting of SCCs was also linked to more difficulties in completing instrumental activities of daily living and lower use of compensatory strategies (McAlister & Schmitter-Edgecombe, 2016).

Less is known about active engagement of strategies to compensate for cognitive decline and its relationship with reporting of SCCs. One study found that individuals who experienced more stress, reported more subjective memory errors, and those with lower educational attainment relative to their intelligence quotient reported using more compensatory strategies (Garrett, Grady & Hasher, 2010). Another study hypothesized that individuals of higher educational and health status may report fewer SCCs due to more successful engagement in compensatory strategies, however no empirical evidence was offered to support this (Langlois & Belleville, 2014). Two further studies found that the use of accommodative strategies in response to self-perceived difficulties was associated with overall lower report of memory difficulties (Hahn & Lachman, 2015; Robinson, Rickenbach, & Lachman, 2015).

These results seem to suggest that higher engagement in compensatory strategies may lead to lower reporting of SCCs. The previously mentioned Burmester et al. (2017) study was the first to suggest a compensatory aetiology of SCCs proposing that SCCs arise when no attempt is made to compensate for cognitive difficulties, or when these attempts are unsuccessful. It was further suggested that lack of engagement in compensatory strategies may significantly impact the association between SCCs, affective symptoms, and EF performance (Burmester et al., 2017). The use of compensatory strategies was not, however, explicitly assessed in that study, and this warrants further research in this area. Contrasting results were obtained from another recent study exploring strategy use and incidence of

SMCs in older adults. Individuals who reported more SMCs used more compensatory strategies than those who did not report any memory difficulties, and that number of reported SMCs was positively correlated with use of compensatory strategies (Frankenmolen et al., 2018). It could be hypothesised that becoming aware that cognitive decline has occurred may prompt individuals to try to compensate for the more disruptive deficits. Without sufficient knowledge about the links between cognitive abilities and observed changes they may, however, adopt inadequate strategies, resulting in higher volume of reported SCCs and possibly experience more distress related to this.

Conclusion

This chapter reviewed studies which explored variables that appear to influence reporting of SCCs in normal and pathological aging. Results discussed in this chapter provide evidence that there is no single cause of SCCs, and therefore all of the relevant factors should be considered together as potential contributors to the emergence of SCCs. It was highlighted that this area of research is relatively under-developed, which warrants further empirical exploration as accurate identification of influences on reporting of SCCs is essential for development of interventions aimed at reducing SCCs, and alleviating psychological distress related to experiencing them.

CHAPTER 3

MILD TRAUMATIC BRAIN INJURY

The initial focus of the present research was exclusively on SCCs reported after mTBI. However, the relative lack of research in this area prompted a comprehensive review of literature on SCCs in other populations, and it was noted that complaints reported after mTBI resemble those reported by the general population in normal aging. The factors hypothesized to influence SCCs in normal aging also appeared similar to those implicated in aetiology of SCCs after mTBI. Research pertaining to SCCs in normal aging was covered in Chapters 1-2.

The current chapter refers back to the original research idea of exploring the reporting of SCCs after mTBI. It starts with an overview of prevalence and classification of traumatic brain injury (TBI), and later focuses on symptoms, outcomes, and treatment of mTBI. Emphasis is then placed on exploration of subjective complaints of worsening in cognitive functioning which are frequently reported in all phases of recovery from mTBI, and in some cases continue to be reported for months after initial injury. Factors identified as likely contributing to reporting of these complaints will be examined, and lastly, comparisons will be drawn to SCCs reported in the general population.

Traumatic Brain Injury

TBI is a highly prevalent neurotrauma across all ages worldwide which leads to short and long-term complications and death (Langlois, Rutland-Brown, & Wald, 2006; Roozenbeek, Mass, & Menon, 2010). Every year approximately 69 million people across the globe sustain a TBI, with higher severity of injury (Dewan et al., 2018) and older age (Yamagami et al., 2019) associated with poorer outcomes. The consequences of TBI vary depending on the circumstances of the injury and personal traits, and often include cognitive, functional, and mental health difficulties (Forslund et al., 2017; Juengst et al., 2015; Whiteneck, Cuthbert, Corrigan, & Bogner, 2016). TBI can occur in a closed-head injury initiated by a mechanical impact, usually a direct blow to the head or sudden movement of the body, or an open-head injury where the skull becomes fractured or penetrated by an external object (Lezak et al., 2012). Either of these mechanisms of injury trigger pathological physiological and biochemical changes, and these may lead to secondary complications with delayed clinical manifestation (Werner & Engelhard, 2007). Following the injury, cells in the affected brain regions may become irreversibly damaged, with some cells dying and others becoming vulnerable to the effects of future pathology (Glenn, Sutton, & Hovda, 2017).

The classification of severity of TBI is based on the acuity of disruption of brain function, and includes mild, moderate, and severe categories (Teasdale & Jennett, 1974). In clinical settings, the initial assessment of severity of TBI is made based on the Glasgow Coma Scale (GCS) score assigned at the time of the injury which is derived from observations of best eye opening, and best verbal and motor responses (Teasdale & Jennett, 1974). The GCS grading for TBI is outlined in Table 2.

Table 2

GCS Diagnostic Criteria for TBI

TBI severity	GCS Range
Mild	13-15
Moderate	9-12
Severe	≤ 8

Note. Reproduced from *Assessment of Coma and Impaired Consciousness: A Practical Scale* by G. Teasdale & B. Jennett. Copyright 1974 by The Lancet.

Traumatic brain injury in New Zealand. New Zealand-based studies revealed that the incidence rates and causes of TBI vary depending on age and gender. In general, the most commonly reported cause of TBI in New Zealand are falls (Feigin et al., 2013). Overall, the highest incidence rates were reported in males aged 15-25 years old, and most frequent mechanisms of injury in this group include motor vehicle accidents, sport-related incidents, and assaults (McKinlay et al., 2008). The group with second high incidence rates consists of children aged 14 years and below, and in particular those aged 0 to 4 years (Feigin et al., 2013). Incidence rates for Māori are higher than other ethnic groups and are estimated to be 1200 per 100,000 persons compared to 975 per 100,000 persons of New Zealand European ethnicity, and 245 per 100,00 persons of other ethnicities, with rates for individuals aged 35 to over 65 years being double compared to individuals of same age from other ethnic groups (Feigin et al., 2013).

Mild Traumatic Brain Injury

MTBI is the most prevalent type of brain injury, with over 90% of all annual cases of TBI being classified as mild (Dewan et al., 2018; Iverson & Lange, 2011). It is a highly variable injury in that the cause (i.e., motor vehicle accident, sport-related, assault), the symptoms, and recovery can be vastly different among individuals diagnosed with mTBI. As with all TBIs, the impact of initial injury causes onset of disturbances in cellular physiology which then prompt alterations to neural cells (Belanger, Tate, & Vanderploeg, 2018; Rabinowitz & Levin, 2014) and may result in an array of symptoms including loss of consciousness, altered mental state, short-term memory impairment, and physical symptoms such as vomiting (Iverson & Lange, 2011; Jennett, 2005). The commonly used diagnostic criteria in assessment of mTBI were developed by the American Congress of Rehabilitation Medicine (see Table 3).

Table 3

Diagnostic Criteria for mTBI

A traumatically induced physiological disruption of brain function, as manifested by *at least one* of the following:
    Any loss of consciousness
    Any loss of memory for events immediately before or after the accident
    Any alteration in mental state at the time of the accident (e.g., feeling dazed, disoriented, or confused) *and*
    Focal neurologic deficit(s) that may or may not be transient
But where the severity of the injury *does not exceed* the following:
    Loss of consciousness of approximately 30 min or less
    After 30 min, an initial Glasgow Coma Scale score of 13-15 *and*
    Post-Traumatic amnesia not greater than 24 hr

Note. Reproduced from *Definition of Mild Traumatic Brain Injury* by Mild Traumatic Brain Injury Committee, American Congress of Rehabilitation Medicine. Copyright 1993 by Foundation for Rehabilitation Information.

More recently, Baxendale, Heaney, Rugg-Gunn, and Friedland (2019) distinguished underlying structural brain damage, premorbid characteristics, neuropsychological reserve, and other non-neurological factors, both psychosocial and environmental, as important assessment information for enhancing accuracy of prognosis after mTBI. Furthermore, consideration of these factors provides a pragmatic framework for discussing mTBI experiences with affected individuals and their families and allow for development of collaborative recovery plans.

Concussion and mild traumatic brain injury. MTBI is also frequently referred to as concussion, however there is currently no universal agreement regarding the definition of concussion which complicates its official classification in relation to mTBI. Two opposing views on this matter include consideration of concussion and mTBI as homogenous constructs, and separation of the two as mutually incompatible terms.

The majority of research reports use the terms *concussion* and *mTBI* interchangeably, and some presuppose that *concussion* was a term used prior to the classification of TBIs based on severity (Belanger et al., 2018; Sharp & Jenkins, 2015) The mechanism of injury, symptoms, and long-term outcomes associated with concussion appear the same as mTBI; the absence of distinct pathophysiology indicates that currently there is little known basis for separation of the two entities (Sharp & Jenkins, 2015). Furthermore, it has been argued that in medical and legal settings, categorising an injury as a *concussion* in place of *mTBI* puts individuals at a disadvantage as it may be misunderstood as indicating a transient nature of their symptoms which appears to not always hold true for all individuals (Sharp & Jenkins, 2015).

Others supported maintaining separate nomenclature on the basis that the two terms represent distinct injury constructs (McCrory et al., 2013). However, the arguments cited to support this distinction often vary between different research groups. For example, Chancellor, Franz, Minaeva, and Goldstein (2019) argued that the term *concussion* corresponds to a neurological syndrome (i.e., cluster of cognitive, somatic, and functional symptoms), while *mTBI* relates only to the neurological event at the time of injury. They also pointed to differences in findings of neuroimaging studies where mTBI was associated predominantly with metabolic disturbances, and concussion with diffuse white matter changes. However, the literature cited in this review included data from assessments conducted more than 1-month post-event and where the injury was classified as mTBI with observed symptoms described interchangeably as “post-concussive” and “post-mTBI” (Westfall et al., 2015). In contrast, the Concussion in Sport Group consensus statement omitted the categorical distinction of injury and syndrome, and rather emphasized a difference based on the absence of overt structural brain damage or a significantly lesser degree of diffuse damage in concussion compared to mTBI (McCrory et al., 2017). However, a comprehensive review by Shin, Bales, Dixon, and Hwang (2017) concluded that in most cases of mTBI with different injury aetiologies, overt structural damage is rare and possibly related to limitations of present imaging techniques, and instead they were associated with metabolic and functional abnormalities.

To summarize, further research is needed to enhance the current understanding of concussion in order to discern its most appropriate nosology. At present the evidence for consideration of the two as the same entity appears convincing and therefore for the purpose of maintaining consistency in nomenclature, the term *mTBI* will be used in the current research. However, as majority of research refers to *Post-Concussion Syndrome* (PCS) when describing a cluster of persistent post-traumatic symptoms, this term will also be used. In cases where subjective self-report of persistent cognitive symptom is discussed, the term *Subjective Cognitive Complaint* (SCC) will be used.

Mild traumatic brain injury statistics in New Zealand. In 2013 the incidence of mTBI in New Zealand was estimated at 749 cases per 100,000 people per year (Feigin et al., 2013). This number is likely to have significantly changed since the publication of the study due to number of new reported cases of TBI estimated to increase from 11,301 in 2010 to 13,591 in 2020 (Te Ao et al., 2014). However, these figures are still likely to be an underestimation as the latest Accident Compensation Corporation (ACC) claim report revealed over 35,000 new mTBI-related claims between 2018 and 2019, compared to over 25,000 claims between 2013 and 2014 (ACC, 2019). However, it is difficult to ascertain whether this increase is due to an increase in the number of sustained injuries in the population, or an improvement in screening and identification of injury in affected individuals. Precise statistics may be nearly impossible to obtain as many individuals who sustain a mTBI do not seek medical attention for their symptoms (Iverson & Lange, 2011).

Outcomes of mild traumatic brain injury. The outcomes of mTBI are commonly divided into cognitive and noncognitive, and these can be reported at all stages of injury, including the acute, sub-acute, and chronic stages (Dikmen, Machamer, & Temkin, 2017; Halstead & Walter, 2010; Belanger et al., 2018; Prince & Bruhns, 2017). Table 4 provides a summary of symptoms commonly reported in mTBI in children and adolescents, and these are also applicable to adults and older adults.

Table 4

Signs and Symptoms of mTBI.

Physical	Cognitive	Emotional	Sleep
Headache Nausea Vomiting Balance problems	Feeling mentally “foggy” Feeling slowed down	Irritability Sadness More emotional Nervousness	Drowsiness Sleeping more than usual

Visual problems	Difficulty concentrating		Sleeping less than usual
Sensitivity to light	Difficulty remembering		Difficulty falling asleep
Sensitivity to noise	Forgetful of recent information		
Dazed	Confused about recent events		
Stunned	Answers questions slowly		
	Repeats questions		

Note. Reproduced from *Sports-Related Concussion in Children and Adolescents* by M. Halstead & K. Walter. Copyright 2010 by American Academy of Pediatrics.

Cognitive symptoms are commonly reported and include impairments in different cognitive domains. Slowed speed of information processing is frequent and usually presents as attentional difficulties, i.e., impaired concentration, distractibility, and confusion (Carroll et al., 2014; Karr, Areshenkoff, & Garcia-Barrera, 2014; McCauley et al., 2013). Difficulties with verbal retrieval are frequently reported and thought to be related to deficits in PS, for example difficulties with recall of known names of objects, people, and places, and misnaming. Likewise, complaints of deficits in short-term memory are also frequently reported and are believed to stem from deficits in PS through impaired concentration at information acquisition and issues with verbal retrieval (Malojcic, Mubrin, Coric, Susnic, & Spilich, 2008). Complaints of difficulties in cognitive domains related to EF are also common (Donders, Oh, & Gable, 2015). Other cognitive symptoms include perceptual and motor difficulties, for instance impaired coordination, dizziness, light sensitivity and altered vision, and slowing in speed of motor responses to stimuli (McCauley et al., 2013; Rabinowitz & Levin, 2014).

Noncognitive symptoms are highly variable and frequently include physical and sleep complaints, and psychological distress. Commonly reported symptoms include headaches, fatigue, disrupted sleep patterns, chronic pain, and irritability (Cooksley et al., 2018; Grandhi, Tavakoli, Ortega, & Simmonds, 2017; McMahon et al., 2014). These symptoms are frequently linked to one another, for instance poor sleep often contributes to an increase in physical and mental fatigue, and this may increase irritability. Mood symptoms are also frequently reported throughout all stages of recovery, with individuals whose cognitive and physiological symptoms persist beyond the usual recovery period identified to be at risk of developing depression and anxiety disorders (Gould, Ponsford, Johnston, & Schönberger, 2011; Whelan-Goodinson, Ponsford, Johnston, & Grant, 2009).

Predicting the trajectory of recovery from mTBI for any individual appears difficult due to the complex interplay between injury-specific and individual factors. Generally, the severity and duration of symptoms of mTBI is associated with three main factors related to the injury, including initial GCS score, presence of structural brain abnormalities, and time since injury (Dikmen et al., 2017). It is important to note that these factors should be considered in conjunction with one another rather than individually as for example Panenka et al. (2015) found that presence of neuroimaging abnormalities alone did not predict worse outcomes at 6-8 weeks after initial injury. Similarly, Veeramuthu et al. (2017) compared recovery progress 6-months after mTBI and found that individuals whose neuromimaging results indicated presence of structural abnormalities demonstrated greater rates of improvement compared to those without such difficulties. Timely access to interventions post-injury may also improve the outcomes, with psychoeducation, access to multidisciplinary treatment, and reassurance being associated with reporting of fewer symptoms at 3-month post-injury (Iverson & Lange, 2011).

Individual differences were found to also affect the recovery after mTBI. Factors linked to poorer outcomes include presence of psychological distress and negative perceptions regarding the injury (Hou et al., 2012), female gender (Bazarian, Blyth, Mookerjee, He, & McDermott, 2010), lower socioeconomic status (De Silva et al., 2009), maladaptive coping (Van der Naalt et al., 2017), and premorbid personality traits (Williams, Potter, & Ryland, 2010). Lower educational attainment has also been associated with poorer outcomes, specifically longer duration of symptoms and slower return to work (i.e., Barker-Collo et al., 2015; Wäljas et al., 2014), however other studies found poorer outcomes in individuals with higher educational who had more negative perceptions of the injury (Snell, Siegert, Hay-Smith, & Surgenor, 2011). Other potential risk factors for poorer outcomes may include alcohol use (Yue et al., 2017) and older age (Van deer Nalt et al., 2017). Lastly, sustaining repeated mTBIs may have a cumulative effect which was associated with axonal damage, increased vulnerability to future brain trauma, longer duration of symptoms, and larger extent of functional deficits (Eisenberg, Andrea, Meehan, & Mannix, 2013; Fehily & Fitzgerald, 2017).

In approximately 80% of individuals with no previous history of brain injury, symptoms gradually resolve within three months post-injury, with progressively fewer cognitive and physical symptoms reported at six months (McCrea et al., 2009; Rabinowitz &

Levin, 2014). Likewise, any objective cognitive deficits noted post-injury appear to resolve by the 3-month mark (Rohling et al., 2011). By 12 months post-injury, the majority of affected individuals report no impairments in functioning across different life domains or quality of life (Losoi et al., 2016). However, some researchers found that up to a quarter of studied individuals continued to report persistent symptoms of mTBI after the expected recovery period of 3 to 6 months (e.g., McMahon et al., 2014; Levin & Diaz-Arrastia, 2015). These estimates depend largely on diagnostic criteria used, time since injury, and the studied population, for example research indicated prevalence of 11.1% in a sports setting (Rose, Fischer, & Heyer, 2015), 11.8% in pediatrics (Barlow, Crawford, Brooks, Turley, & Mikrogianakis, 2015), and 8% in young adults (Balakrishnan, Rus, Chan, Martin, & Awang, 2019). It is not entirely clear why this occurs, with factors such as psychological distress and more severe injury quoted as potential contributing factors (Iverson & Lange, 2011).

Post-Concussion Syndrome

PCS is commonly defined as a cluster of symptoms associated with mTBI which persist beyond the expected recovery period of 3 months in the absence of neuroimaging evidence of structural brain changes (see Table 4; Iverson & Lange, 2011; Wäljas et al., 2015). It is believed that injury-related anatomic, physiologic, and neurometabolic changes may influence the development and chronic course of PCS, but that these changes are mostly transient and subtle, and therefore they are difficult to be reliably detected in the course of standard diagnostic investigation (Kurča, Sivák, & Kučera, 2006; Leddy, Sandhu, Sodhi, Baker, & Willer, 2012). However, detection of such changes more than 3 months post-injury has been documented through the use of diffusion tensor imaging (DTI; Yuh et al., 2014), prompting the need for further research in this area.

PCS has been a subject of debate for many years due to overlap with other physical and psychological conditions, and difficulties with reliability of diagnostic criteria (Evans, 2010). For example, nearly a third of healthy controls in a study by Wäljas et al. (2015) met ICD-10 criteria for a diagnosis of PCS, indicating low specificity of these criteria. In regard to the physical symptoms, Leddy et al. (2012) hypothesized that the cell vulnerability triggered by mTBI may facilitate clinical expression of underlying conditions, for instance migraine headaches, which would explain the chronicity of symptoms. In another study, Stubbs et al. (2020) found that a significant proportion of somatic symptoms reported in PCS were not typically classed as related to mTBI, and hypothesized that this may indicate the presence of other conditions which confound perceptions of recovery from symptoms after mTBI. Other well-documented examples of complicating conditions include depressive disorders and anxiety (Broshek et al., 2015; Stazyk, DeMatteo, Moll, & Missiuna, 2017; Stein et al., 2017), and elevated levels of non-specific psychological distress (Edmed & Sullivan, 2012[a]; Ho, Hall, Noseworthy, & DeMatteo, 2020).

Research exploring risk factors for development of PCS has largely replicated findings of research into outcomes of mTBI, reinforcing the argument that they are most likely describing the same phenomenon. Factors such as premorbid personality traits, history of psychiatric disorders, heightened stress at the time of the accident, negative perceptions regarding head injury, premorbid cognitive reserve, and any residual deficits in brain functioning have been indicated as useful in identifying individuals at risk of developing PCS (Broshek et al., 2015; Hou et al., 2012; King, 2003; Oldenburg, Lundin, Edman, Nygren-de-Boussard, & Bartfai, 2016). Other factors unrelated to the injury were also proposed as significant, including misattribution of the causes and exaggeration of severity of symptoms, and underestimation/overestimation of premorbid factors often related to what Iverson, Lange, Brooks and Rennison (2009) coined the *good old days* bias. A small proportion of individuals may also be motivated to report subjective complaints by potential for litigation claims and obtaining time off work (Polinder et al., 2018).

Subjective Cognitive Complaints

Reporting of SCCs is common in PCS, and this sometimes persists for months after injury (Belanger, Spiegel, & Vanderploeg, 2010). In individuals who do not recover within the first 3-months, the period between 6 and 12 months appears to yield the largest decreases in SCCs, however in some cases they are still reported more than 12 months post-injury (Barker-Collo et al., 2015). The most frequently reported persistent symptoms are related to memory functioning, concentration, attention, and cognitive slowing (French, Lange, & Brickell, 2014; Prince & Bruhns, 2017), and research has hypothesized that these might be due to an underlying difficulty in PS (Barker-Collo et al., 2015).

Reporting of SCCs may be further influenced by assessment measures. Research found that self-reported questionnaires elicit reporting of more SCCs compared to open-ended interviews (Edmed & Sullivan, 2012[b]; Iverson et al., 2010), and that the most frequent complaints are related to memory functioning (Nolin, Villemure, & Heroux, 2006). This is similar to findings from studies in older adults where the use of a self-report questionnaire resulted in higher number of reported SCCs, and spontaneous, unprompted reporting resulted in fewer complaints of higher severity (Burmester et al., 2017). However, a study by Kondiles, Starr, Larson and Zollman (2015) reported that their participants endorsed fewer physical and cognitive symptoms on a self-report questionnaire compared to a face-to-face interview which may indicate that prompting of any kind leads to overreporting of symptoms.

Psychological factors. The debate regarding the likely causes of reporting SCCs after mTBI is ongoing, with the majority of research indicating an apparent absence of underlying neurocognitive impairment that would explain the presence of such difficulties (Broglio, Eckner, Surma, & Kutcher, 2011; Polster et al., 2018). One possibility is that reporting of SCCs is at least partially related to experiencing heightened psychological distress and premorbid personality factors, for example neuroticism, conscientiousness, and agreeableness, as they were often found to have a positive association with symptoms of affective distress and somatic complaints (Comijs et al., 2002; Donelly, Donelly, Warner, Kittleson, & King, 2018; Forrest, Henry, McGarry, & Marshall, 2018; Pearman & Storandt, 2004; Schiehser et al., 2011; Snitz et al., 2015; Stocker, Khan, Henry & Germain, 2017). An example of this is a recent study by Stillman, Madigan, Torres, Swan and Alexander (2020) which found that reporting of SCCs was more related to the presence of symptoms of affective distress and premorbid psychiatric history than objective cognitive functioning. Similarly, Clarke, Genat, and Anderson (2012) found positive associations between reporting of SCCs and symptoms of depression and anxiety. Furthermore, an earlier study by Stulemeijer, Vos, Bleijenberg, and van der Werf (2007) identified symptom hypervigilance, lower level of education, posttraumatic stress, affective symptoms, and fatigue as significantly associated with self-perceived decline in cognitive performance. The severity of injury, premorbid health status, and performance on neuropsychological measures did not appear to be linked to reporting of SCCs (Stulemeijer et al., 2007). Lastly, reporting of persistent cognitive difficulties has also been associated with fear and avoidance of mental exertion as this is often perceived by laypeople as effective in reducing the occurrence of headaches (Silverberg, Iverson, & Panenka, 2017).

Cognitive factors. Results from studies using diffusion tensor imaging (DTI) in individuals who sustained a mTBI have opened up another possibility where injury-related axonal damage leads to subtle cognitive changes and therefore is the underlying cause of SCCs (Dean, Sato, Vieira, McNamara, & Sterr, 2015; Khong, Odenwald, Hashim, & Cusimano, 2016; Yuh et al., 2014). However, research in this area is still developing. Results from existing research into performance on cognitive tests and persistent SCCs suggest that this may also require further exploration as for example one study found that SCCs were associated with lower performance on assessment measures (Clarke et al., 2012). In a New Zealand-based study, presence of persistent SCCs was associated with significantly lower scores on assessment measures of PS and EF (Barker-Collo et al., 2015), but others found that reporting of persistent and severe SCCs was most strongly linked to poor testing effort (Spencer et al., 2017). Lastly, Su et al. (2017) reported that in their sample, persistent symptoms were linked to lower scores on tasks measuring information PS, but the study included only a small sample of participants, reported “normal neuro-imaging” findings, and did not control for the potential effects of psychiatric difficulties.

Cognitive reserve. Another factor which may influence the frequency of reporting persistent symptoms post-mTBI is CR (for a detailed overview of CR, see Chapter 2). Research on the effect of CR on reporting symptoms after mTBI in children (Fay et al., 2010), adults (Kesler, Adams, Blasey, & Bigler, 2003) and even in TBIs of higher severity (Menardi, Bertagnoni, Sartori, Pastore, & Mondini, 2020; Schneider et al., 2014) mirror results found in aging in the general population. Specifically, it was found that similar to individuals affected by a neurodegenerative condition, higher educational attainment delayed the expression of cognitive deficits following a brain injury, or significantly reduced reporting of symptoms. Recent research by Stenberg et al. (2020) also suggested that CR may influence outcomes after mTBI as they found that in their study sample, CR moderated reporting of cognitive difficulties after mTBI. Yet empirical research on the effect of CR on reporting SCCs after mTBI appears sparse at present. One study was retrieved which examined the relationship between CR, performance on tests of cognitive ability, and PCS with associated subjective complaints (Oldenburg et al., 2016). It was found that in a group of 102 recruited individuals, those with lower CR were approximately 4 times more likely to continue reporting subjective cognitive and non-cognitive complaints as assessed 3-months post-injury (Oldenburg et al., 2016).

Attributions. Attributions which people make about the cause of their daily life difficulties are also an important factor in reporting of SCCs. As discussed in earlier sections, this is because the commonly reported persistent symptoms after mTBI are also observed in other conditions and are sometimes reported by individuals who have never experienced a brain injury. Furthermore, research found that those who attributed their symptoms to mTBI, as opposed to other potential causes, were found to report greater severity of complaints (Belanger, Barwick, Kip, Kretzmer, & Vanderploeg, 2013; Larson, Kondiles, Starr, and Zollman, 2013). Greater symptom reporting was also associated with an externalising bias in causal attributions (Ownsworth, Fleming, & Hardwick, 2006). Lastly, there is potential for significant influence of externalising bias in the attribution of symptoms to either concussion or mTBI, however this requires further clarification (McKinlay, Bishop, & McLellan, 2011).

Compensatory strategies. The extent to which individuals who have sustained a mTBI utilise compensatory strategies is unclear, however research has demonstrated that engagement of such strategies post-injury may contribute to symptom improvement. For example, Caplan et al. (2015) found that a psychoeducation-based programme in conjunction with cognitive compensatory strategy training in mild to moderate TBI led to significant improvements in persistent symptoms and perceived quality of life. Another review by Barman, Chatterjee, and Bhide (2016) found that training and enhancement of cognitive compensatory strategies was found to alleviate the severity of persistent symptoms after mild to severe TBI. Similarly, compensatory strategy training for cognitive and functional difficulties was also recommended by Prince and Bruhns (2017). Lastly, training in external (i.e., use of alarms and diaries) and internal (i.e., use of mnemonics and errorless learning) compensatory strategies for cognitive difficulties is recommended as a part of rehabilitation following TBI of any severity (Velikonja et al., 2014).

Similarities to research on aging. It appears that there are significant similarities between SCCs reported in the general population and persistent SCCs reported after mTBI. In both cases, these complaints are reported in the presence of affective difficulties (Edmonds et al., 2014; Gotlib & Joormann, 2010; Levin & Diaz-Arrastia, 2015), and both are associated with a slowing in PS (Carroll et al., 2014; Iverson, Gaetz, Lovell, & Collins, 2004; Iverson, Lovell, & Collins, 2005). It was also found that individuals who report difficulties often do not differ in their level of ability compared to their age-matched peers (Mitchell et al., 2014; Levin et al., 1987), and reporting of SCCs appears to be unrelated to objective cognitive functioning (Brands, Verlinden, & Ribbers, 2019). Furthermore, research demonstrated that the persistent symptoms reported at 6 and 12-months post-mTBI are also frequently endorsed by healthy controls and outpatients for unrelated conditions (Barker-Collo et al., 2019). It is possible that similar to SCCs in normal populations, persistent cognitive symptoms after mTBI may be a manifestation of limited awareness that a decline in cognitive functioning has occurred (Broshek et al., 2015). Individuals who sustain a mTBI may be unaware of changes that have occurred to their cognitive abilities as a consequence of normal aging and/or that they can only recover to the level of ability immediately preceding the injury. They may, therefore, hold unrealistic expectations regarding their recovery and attribute their persistent difficulties to the event itself, rather than aging, and struggle to accept that their abilities have naturally declined. Lastly, these beliefs may not be readily accessible as it has been shown that individuals usually begin to report SCCs when they find themselves unable to meet the demands of their environment, for instance upon return to premorbid occupation.

Treatment after Mild Traumatic Brain Injury

The recommended treatment for symptoms of mTBI depends on the phase of recovery. In the acute phase, the most common recommendations include very brief period of physical and cognitive rest, followed by gradual return to activities, and temporary cessation of activities which may increase the risk of sustaining a consecutive injury (Brown et al., 2014; Silverberg & Iverson, 2013). Individuals are also advised to abstain from use of alcohol or any perception-altering substances (Marshall et al., 2015). It was previously believed that symptoms reported in the post-acute phase would spontaneously diminish over time, however more recently it has been recognised that psychoeducation-based interventions implemented in the acute phase of injury may help prevent these symptoms from becoming chronic in the future (Mott, Connon, & Rieger, 2012). Promising results of such an intervention was obtained from a sample of adolescents who received access a to an online, self-guided psychoeducation resource as it was reported that all participants engaged with the material and made a full recovery within 4 weeks (Kurowski et al., 2016). Generally, access to psychoeducation regarding the injury and its consequences, knowledge of treatment expectations, reassurance, and compensatory strategies training was associated with better outcomes at 3-month post-injury (Iverson & Lange, 2011; Leddy et al., 2012).

Interventions aimed at alleviating persistent symptoms largely depend on specific areas of difficulty. In individuals who report persistent difficulties in memory and abilities related to EF, the recommended treatment may include neuropsychological rehabilitation with focus on selecting and trialling appropriate compensatory strategies such as the use of memory aids (Management of Concussion-mild Traumatic Brain Injury Working Group, 2016). For difficulties related to attention control, social skills deficits, and sleep difficulties, interventions may take the shape of targeted training (Cicerone et al., 2011; Mott et al., 2012; Potter & Brown, 2012). Talking therapies are recommended to tackle affective distress and other psychological factors that may perpetuate the symptoms, and often focus on maladaptive cognitions and behaviour, enhancement of self-efficacy, and explore symptom attributions (Belanger et al., 2013; Marshall et al., 2015). Treatment may also include involvement of other multidisciplinary professions, for example physiotherapists, to address headaches and pain, and occupational therapists to address functional limitations (Marshall et al., 2015). There is also emerging evidence supporting efficacy of light therapy in treatment of fatigue (Bajaj, Vanuk, Smith, Dailey, & Killgore, 2017; Raikes et al., 2020)

Conclusion

To summarise, mTBI is a highly prevalent injury both worldwide and in New Zealand. In mTBI, the mechanism of injury, symptoms reported, and outcomes can be highly variable between individuals. While most individuals recover within the first 3 months, some continue to report persistent symptoms at 6 months and beyond, and these can often result in significant subjective distress and functional impairment. In the case of cognitive complaints reported after the expected recovery period, these appear to be unrelated to objective cognitive functioning and are often linked to the presence of affective symptoms. The possibility of underlying structural brain changes remains an important consideration, although this is not always apparent except when DTI is used in assessment. Given the similarities between reporting of SCCs after mTBI and in the general population, it may be plausible that such symptoms indicate limited insight into changes that occur in the course of normal cognitive aging. This has not, however, been explored by research and requires further clarification.

CHAPTER 4

RESEARCH FORMULATION

The present chapter provides a succinct synthesis of key findings from the literature presented in previous chapters and presents the rationale for present research. It then outlines the research aims, questions, and hypotheses.

Summary of Literature

The preface introduced the topics of interest and outlined the development process of the present research which centres around a proposed theoretical model of SCCs in normal aging and after mTBI. Chapter 1 outlined key concepts in the areas of aging and cognition which are essential for understanding the concept of SCCs and the most frequently reported complaints. Chapter 2 focused on hypothesized aetiological factors of SCCs and highlighted gaps in research in this area. Finally, Chapter 3 provided an overview of topics related to mTBI with an emphasis on persistent SCCs which are reported by a small number of people for months after the expected recovery period.

Based on literature it could be concluded that there are multiple factors which influence the reporting of SCCs in normal aging and after mTBI. Chapters 2 and 3 discussed individual differences that had been demonstrated to influence reporting of SCCs in both normal aging and after mTBI, including awareness and attributions of change in cognition, use of compensatory strategies, PS, CR, and affective distress. It was also highlighted that these factors appear to be frequently associated. For example, research linked affective distress to performance on tasks measuring PS, awareness of own cognitive decline, and use of strategies to compensate for cognitive difficulties, and in turn, these factors were suggested to be related to education and socioeconomic factors, both of which constitute the construct of CR. However, the associations between these different factors and CR, and their role in reporting SCCs in normal aging and after mTBI have not been explored through empirical research and thus require further assessment.

Research Aims

The overarching aim of the present research was to contribute to understanding of the phenomenon of SCCs that arise in normal aging, and after mTBI. Literature review identified five potential factors of interest which included awareness of age-related change in cognition, affective distress, CR, PS, and use of compensatory strategies. However, there is little research to-date that demonstrates significant associations between several of these factors, including awareness, CR, and PS, and SCCs. One area in which there had been limited research concerns the awareness of change in cognition in normal aging, and the attributions that people make to any noticeable changes. Another area pertained to CR and whether the level of CR influences the reporting of SCCs and PS performance. The above questions gave rise to an aim to clarify links between these factors and SCCs, and in particular to explore a novel idea that awareness is a significant contributing factor to the development of SCCs in normal aging and after mTBI.

Clarifying these relations is highly important as this could contribute to enhancement of interventions targeting SCCs, and therefore help lessen the psychological and economic burden experienced by individuals who report SCCs. Therefore, the first step towards achieving this research aim was to explore the links between the above factors and SCCs in existing databases. These initial analyses were intended to help inform the hypothesized model and guide data collection. Next, the research aimed to use that information to refine the hypothesized model of SCCs. The final aims were to assess this model in normal aging and after mTBI, provide recommendations for practitioners, and indicate the direction for future research in this area. To the knowledge of the researcher, at the time of writing the present thesis there were no existing studies that proposed this model of SCCs.

Research Questions and Hypotheses

Question 1. What effect does CR have on reporting SCCs in the general population?

The relationship between CR and reporting of SCCs is unclear as it has not been well researched, and existing research often provides contrasting views. On one hand, it would be expected that individuals with higher CR report fewer SCCs as the CR theory presupposes that lifetime attainment of an individual protects them from an early expression of cognitive decline (Cosentino & Stern, 2019; Stern, 2002). However, in the general population the protective effect of CR does not appear to apply equally to all cognitive abilities (Opdebeeck et al., 2016), and therefore functioning in a cognitively demanding environment may mean that even the slightest decline is brought to the attention of the individual, prompting the emergence of SCCs. Existing research also highlighted that in individuals diagnosed with

MCI, higher education (education being considered a proxy measure of CR) is linked to higher awareness of current deficits and therefore higher reporting of SCCs (Chary et al., 2013). It is not clear, however, if this is also true for individuals in the general population who report SCCs without this diagnosis, and if they perceive their reported SCCs as more distressing compared to individuals with lower CR.

Hypothesis 1. Individuals with higher level of CR will report more SCCs than those with lower level of CR.

Hypothesis 2. Individuals with higher level of CR will report higher severity of their experienced SCCs.

Hypothesis 3. In individuals who report SCCs, those appraised as high CR will report experiencing more affective distress than those with low CR.

Question 2: What effect does CR have on PS?

This question first arose in 2016 at the planning stage of current research, and refers to a hypothesis that the protective effects of CR may not apply to PS. As discussed in Chapters 1, 2, and 3, the literature suggests that among all cognitive abilities, PS is the most vulnerable to the effects of aging and brain pathology, and consequently best reflects age-related changes in cognition. Certain personal characteristics such as educational and occupational attainment have been cited as protective factors against decline in several cognitive domains, and yet there appears to have been no published research exploring whether this is also the case for PS. Furthermore, recent research demonstrated links between lower PS scores and higher reporting of memory-specific SCCs. It is therefore plausible that if CR is not protective of PS then age-related changes in PS may be expressed in reporting of SCCs.

Hypothesis 4. CR is not protective of PS. Specifically, there will be no differences in scores on information PS between individuals of varying levels of CR.

Question 3: What is the impact of CR on use of compensatory strategies in individuals who report SCCs?

Research suggests that the use of compensatory strategies may demonstrate limited awareness that a change in cognitive ability has occurred, and this is based on assumption that people modify their behaviour in response to any experienced difficulties (Burmester et al., 2017). However, they may not always have explicit knowledge that their behavioural adjustments can be classified as compensatory strategies (Saczynski, Rebok, Whitefield, & Plude, 2007). As discussed in Chapter 2, research suggests that the ability to self-generate compensatory strategies for any perceived cognitive deficits is related to one's educational attainment, however it also indicates that such strategies may not always be effective. This could be due to incorrect assumptions regarding the cognitive ability responsible for a given difficulty, and possibly indicating that their awareness of change is limited. As the present research aimed to further explore the role of CR as a significant factor in reporting SCCs, the first of these two suggestions needed to be explored.

Hypothesis 5. Among individuals who report SCCs, those with higher level of CR will endorse using a larger number of compensatory strategies than those with low CR.

Hypothesis 6. There is a linear relationship between AARC scores and use of compensatory strategies. Specifically, use of compensatory strategies will be higher at higher levels of AARC.

Question 4. To what extent are people in the general population aware of what happens to cognition across the lifespan, and what attributions do they make about the cause of their experienced SCCs?

The influence of perceptions that lay-people hold of cognitive aging on reporting of SCCs is not well understood. Existing research has mainly focused on metacognitive awareness of deficits (i.e., the knowledge about one's own thinking processes), in particular the accuracy of this kind of awareness when compared against results from standardised assessment, and its potential utility in predicting later neurocognitive decline (Bertrand et al., 2018; Edmonds et al., 2014; Roberts, Clare, & Woods, 2009). In contrast, the effects of awareness of own cognitive functioning, in the context of what typically occurs to cognition in normal aging, on reporting SCCs remains unclear (Helmstaedter & Elger, 2000). This type of awareness may further be linked to attributions people make regarding the cause of any experienced difficulties, and consequently those who are less informed regarding cognitive change across the lifespan may make less accurate attributions. Clarifying this question is important as making incorrect attributions may lead to increased worry and distress about one's own cognitive functioning, or prevent individuals from engaging appropriate resources to mitigate the effects of any underlying difficulties.

Hypothesis 7. AARC scores will have an inverse relationship with SCCs in that lower AARC scores will be related to higher reporting of SCCs.

Hypothesis 8. In the general population, cognitive difficulties will be more frequently attributed to affective symptoms, attention, or memory functioning than normal aging.

Hypothesis 9. The severity of reported affective distress will be greater at lower levels of AARC.

Hypothesis 10. In the mTBI population, cognitive difficulties will be most frequently attributed to the injury, and less often to the process of normal aging.

Question 5: Is reporting of SCCs influenced by factors including awareness of age-related change in cognition, affective distress, CR, PS, and use of compensatory strategies?

The final question of this research pertains to validation of a proposed SEM model of SCCs where factors including awareness of age-related change in cognition, affective distress, CR, PS, and use of compensatory strategies influence reporting of SCCs in normal aging. The research also postulates that there are significant similarities between SCCs reported in normal aging and complaints reported after mTBI, and therefore the present study also aims to validate this model for mTBI population.

Hypothesis 11. The level of AARC, affective distress, CR, PS, and use of compensatory strategies will have a direct effect on reporting SCCs in the general population of New Zealand.

Hypothesis 12. The level of AARC, affective distress, CR, PS, and use of compensatory strategies will have a direct effect on reporting SCCs in individuals who experienced a mTBI.

CHAPTER 5

RESEARCH METHODOLOGY

This chapter outlines the methodology and methods of the present research. It outlines the research design, and then progresses to a detailed description of methods employed in each of the two parts of this research.

Research Design

The present research employed a quantitative design. It was comprised of two parts.

Part A: Secondary data analyses. This part of research focused on bridging gaps in the literature pertaining to associations between different factors and reporting of SCCs in normal aging. The purpose of secondary analyses of two existing databases in Part A was to provide empirical support for inclusion of individual factors in the theoretical model of SCCs in Part B. These preliminary analyses were also used to inform collection of data in the survey in Part B.

Part B: Examination of theoretical models of subjective cognitive complaints. This part of the study focused on evaluating a theoretical model of SCCs using Structural Equation Modeling (SEM). Participants were recruited through an online survey and were later split into two distinct populations - normal aging (Study 1) and mTBI (Study 2).

Part B also included testing of the remaining hypotheses (Hypotheses 6-9) which could not be addressed through analyses of existing databases in Part A. Linear regression was used to test hypotheses of linear relationships between pairs of continuous variables. The remaining two hypotheses (Hypothesis 8 and Hypothesis 10) were tested using frequency counts.

Table 5 provides a summary of relevant variables from each study and how they were utilised to test each hypothesis. The grey shading highlights hypotheses addressed in Part A, and white shading highlights hypotheses addressed in Part B.

Table 5

Variables used in Part A (Grey) and Part B (White)

Questions		Hypotheses		Comparison Measure 1	Comparison Measure 2
1	Effect of CR on reporting of SCCs	1	High CR *more* SCCs than low CR.	Educational Attainment - Database 1 Educational Attainment - Database 1 Educational Attainment - Database 2	Memory Difficulties Questionnaire No. of spontaneously reported difficulties Cognitive Failures Questionnaire score
		2	High CR *higher* severity of SCCs than low CR	Educational Attainment - Database 1	Memory Difficulties Questionnaire
		3	High CR *more* affective distress than low CR	Educational Attainment - Database 1 Educational Attainment - Database 1 Educational Attainment - Database 2	Distress ratings spontaneous/prompted SCCs BDI; BAI; STAI; subjective mood/stress ratings Subjective mood/stress ratings
2	Effect of CR on PS	4	CR not related to PS scores	Educational Attainment - Database 1	WAIS-IV Coding and Symbol Search scores
3	Impact of CR on use of compensatory strategies for SCCs	5	High CR *more* compensatory strategies than low CR.	Educational Attainment - Database 2	Memory Compensation Questionnaire score
		6	Lower AARC *fewer* compensatory strategies than high AARC	Awareness of Age-Related Change Questionnaire score	Compensatory Strategies Questionnaire score
4	General awareness of cognition across the lifespan, and attributions made about the cause of experienced SCCs	7	Lower AARC *more* SCCs	Awareness of Age-Related Change Questionnaire score	Cognitive Failures Questionnaire score
		8	Cognitive difficulties *more* frequently attributed to affective symptoms, attention, or memory functioning than normal aging.	Attributions (Question 44)	
		9	Severity of reported affective distress *higher* at lower levels of AARC.	Awareness of Age-Related Change Questionnaire score	Depression Anxiety Stress Scales score
		10	In the mTBI population, cognitive difficulties most frequently attributed to the injury, and less often to the process of normal aging.	Attributions (Question 44)	
5	Influence of AARC, affective distress, CR, PS, and compensatory strategies on SCCs	11	Level of AARC, affective distress, CR, PS, and use of compensatory strategies have a direct effect on reporting SCCs in *NZ general population*	Awareness of Age-Related Change Questionnaire score Depression Anxiety Stress Scales scores Educational attainment, occupational attainment, caregiver occupational attainment, leisure activities Simple Reaction Time and Choice Reaction Time scores Compensatory Strategies Questionnaire score Cognitive Failures Questionnaire score	
		12	Level of AARC, affective distress, CR, PS, and use of compensatory strategies have a direct effect on reporting SCCs in individuals *after mTBI.*	Awareness of Age-Related Change Questionnaire score Depression Anxiety Stress Scales scores Educational attainment, occupational attainment, caregiver occupational attainment, leisure activities Simple Reaction Time and Choice Reaction Time scores Compensatory Strategies Questionnaire score Cognitive Failures Questionnaire score	

Part A: Secondary Data Analyses

Sources of data. Selection of suitable databases was driven by research questions and followed several criteria. The data had to be drawn from cognitively intact individuals in the general population of New Zealand and include as many variables of interest (or their proxy measures) as possible. It was also important that the use of information was permissible and not in violation of the consent obtained for the original study.

Two databases from existing doctoral research projects at Massey University, New Zealand were identified as containing variables relevant to the present study. There was a degree of overlap in variables that each database included (e.g., a measure of SCCs, questions pertaining to affective distress, and a proxy measure of CR). It was also noted that participants in both databases reported experiencing SCCs. However, each database also contained unique variables – the Memory Difficulties Survey included PS data and a comprehensive assessment of affective distress, and the Memory Performance Survey included information on engagement in compensatory strategies. In order to test as many hypotheses as possible, and therefore lay the foundations for the development of model of influence on reporting SCCs, the decision was made to utilise both databases in analyses in Part A. As the information in these two databases was cross-sectional, collected four years apart, derived from different participants, and utilised different measures, these databases were kept separate and analysed independently of each other. The selection and data screening process for both databases is depicted in Figure 4.

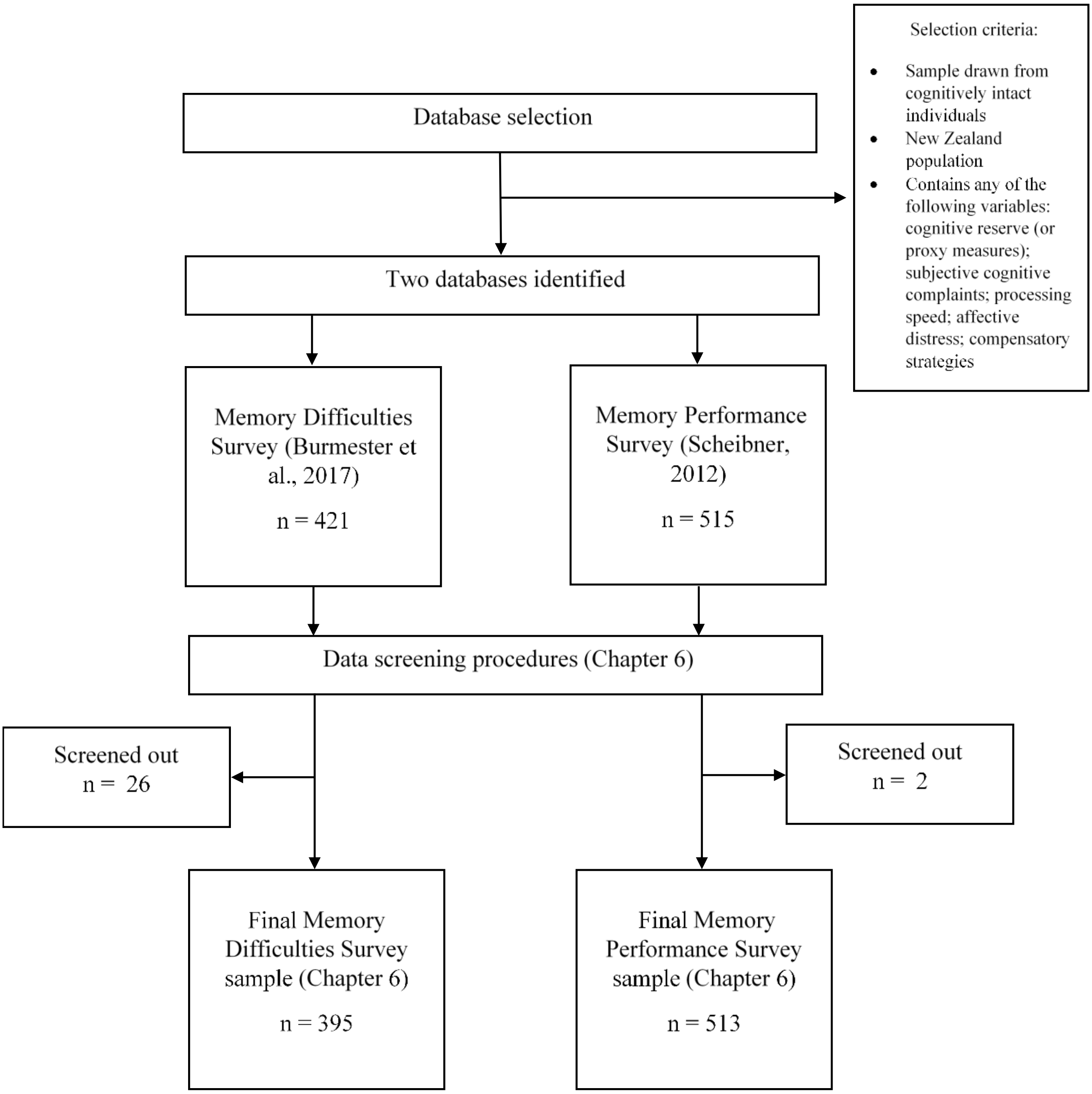


Figure 4. Existing databases analysed in part A (chapter 6).

Database 1 - The Memory Difficulties Survey.

This database was created for the purpose of conducting a doctoral-level research in Psychology at Massey University in Wellington, New Zealand (Burmester et al., 2017). The aim of that research had been to examine a hypothesized aetiological model of SMCs as arising from interaction between age-related change in cognition and affective symptoms of anxiety and depression. The database was created from responses to a survey which was distributed online between June and July 2013, and data derived from face-to-face neuropsychological testing conducted from February to May 2014. Survey participants were aged between 40 and 85+ years and were recruited from the general population of New Zealand via snowball sampling and public advertising. Responses from individuals younger than 40 years old were not present in the database based on observations that SMCs begin to increase in middle adulthood (Burmester et al., 2017).

The cross-sectional data set obtained included responses from 421 individuals of diverse cultural backgrounds who provided responses to demographic questions regarding their age, gender, ethnicity, location, and educational attainment. In this survey, presence and severity of different SMCs was examined using the Memory Difficulties Questionnaire which was developed through selection and consolidation of items from existing measures of SMCs. It also included an assessment of spontaneous (unprompted) SMCs. Severity of reported SMCs (prompted and spontaneous) was assessed using a 7-point Likert scale ranging from 1 (Not a problem at all) to 7 (One of my biggest problems).

Out of 421 survey respondets, 94 individuals completed further face-to-face testing which included an assessment of cognitive domains of memory, EF, and PS; test of motor speed; and a test of premorbid intelligence. PS subtest scores were derived from age-normed Wechsler Adult Intelligence Scale 4th Edition (WAIS-IV) Coding and Symbol Search (Wechsler, 2008). Affective symptoms were assessed using the Beck Depression Inventory-II (Beck, Steer, & Brown, 1996) and State-Trait Anxiety Inventory (Spielberger, 1983).

As indicated on Table 5, the following variables available in this database were used in analyses in Part A:

Spontaneous subjective cognitive complaints. Spontaneous reporting of SCCs was reported to have been elicited through an open-ended questionnaire (*When you think about your memory in everyday life, what is the biggest difficulty, if any, that you have? Please try* *to be as clear and specific as you can.)* that included severity ratings for each reported SCC on a scale from 1 – 7 where 1 = Not a problem at all, and 7 = One of my biggest problems.

Prompted subjective cognitive complaints. The database contained responses from a 24-item structured Memory Difficulties Questionnaire which assessed the presence and frequency of experiencing problematic SCCs, predominantly pertaining to memory, on a 7-point scale where 1 = Not a problem at all, 4 = Sometimes a problem, and 7 = One of my biggest problems. Each questionnaire item was carefully inspected, and the original manuscript of this study was consulted to ensure that it is fit for the purpose of analyses in Part A of this research. The reliability of this scale was assessed by Cronbach's alpha coefficient and the calculated alpha value was $\alpha=0.93$, indicating good internal consistency. Items endorsed with a rating of 2 or above were counted for each individual to provide a total number of prompted SCCs. Ratings of 1 were excluded on the assumption that such a rating indicates that the prompt area was not a difficulty for the respondent. Mean distress ratings were calculated for all endorsed items for each respondent, with higher scores indicating higher severity of endorsed SCCs.

Affective distress. Four different variables corresponding to affective distress were available in the database.

Mood. Participant's general sense of mood over the past 6 months was assessed using a single question on a 4-point Likert scale (*How has your mood generally been over the last 6 months?*) where 1 = excellent, 2 = good, 3 = fair, and 4 = poor/bad.

Stress. Subjective experience of stress was assessed using a single question on a 4-point Likert scale (*How stressed have you been over the last 6 months*) where 1 = not stressed at all, 2 = a little stressed, 3 = quite stressed, and 4 = very stressed.

Beck Depression Inventory-II. The BDI-II (Beck, Steer, & Brown, 1996) is a 21-item self-report instrument measuring the severity of depressive symptoms in individuals aged 13 years old and above. Each item is rated on a 4-point Likert scale where 0 indicates no presence of symptom, and 3 indicates high prevalence of symptom. Scores on each item are summed, with higher total scores indicating higher severity of depressive symptoms.

State Trait Anxiety Inventory. The STAI (Spielberger, 1983) is a 40-item self-report questionnaire which measures the severity of current anxiety symptoms, and a generalised propensity to be anxious. It is comprised of two sub-scales: the state anxiety which measures current symptoms of anxiety, and trait anxiety which evaluates relatively stable aspects of “anxiety proneness” by measuring general states of calmness, confidence, and security. Scores are summed separately for each sub-scale, with higher scores indicating higher state or trait anxiety.

Processing speed. Scores from Coding and Symbol Search subtests of the PS index on WAIS-IV were used in analyses. Raw scores were converted into scaled scores based on the WAIS-IV age norms.

Proxy measure of cognitive reserve. As database 1 did not include information on CR this was derived using educational attainment as a proxy measure of CR. To compare means of individuals hypothesized as high CR and low CR, data was re-coded based on highest achieved level of education:

High CR included those with a tertiary certificate or a diploma (not a degree), Bachelor’s degree (e.g., BA, BSc, BComm), or Postgraduate qualification (Honours, Masters, PhD or postgraduate diploma).

Low CR included those with High School Entrance, School Certificate or NCEA level 1, or University Entrance, Bursary, or NCEA level 3.

Database 2 - The Memory Performance Survey.

This database was developed in 2010 also as part of doctoral research in Clinical Psychology at Massey University in Wellington, New Zealand (Scheibner, 2012). Cross-sectional data was derived from a survey which examined the theory of Selective Optimisation with Compensation (Baltes & Baltes, 1990) in the context of everyday memory functioning and age-related cognitive decline. The survey was distributed through several means: online via e-mail and social media advertising, chain referral, and through advertisement in two local newspapers. A total of 515 individuals aged 18 to 85 years from the general population of New Zealand responded to the survey which included demographic items regarding age, gender, occupational status, and educational attainment, and a query of subjective mood rating. The survey also elicited reports of SCCs through inclusion of the Cognitive Failures Questionnaire (CFQ) and assessed use of compensatory strategies on the Memory Compensation Questionnaire (MCQ).

The following variables were available in the databases:

Subjective cognitive complaints. The present database included response scores on the 25-item Cognitive Failures Questionnaire (CFQ; see Measures section below for a detailed description of this measure) as a measure of prompted SCCs. The CFQ total score was used for analyses.

Compensatory strategies. Scores from the Memory Compensation Questionnaire (MCQ; Dixon et al., 2001) were available in the present database. The MCQ assesses use of everyday memory strategies across five different kinds of memory compensation strategies. The MCQ in this database was reported to include 34 items on a 4-point Likert scale where 1= Never, 2 = Sometimes, 3 = Often, and 4 = Always. Total scores for this MCQ range between 34 and 136. Scores derived from the MCQ include the following:

Internal sub-scale. The internal sub-scale includes engagement of internal strategies intended to enhance one’s remembering, for example mnemonics.

External sub-scale. This sub-scale includes engagement of external strategies, for example calendars and reminders.

Effort sub-scale. This sub-scale includes strategies that involve increased effort into remembering information (i.e., concentrating a lot to learn information).

Time sub-scale. This sub-scale includes memory strategies which involve a larger investment of time into tasks (i.e., reading a story more than once).

Reliance sub-scale. This sub-scale includes memory strategies which include a degree of reliance on other people (i.e., asking someone to remind oneself).

MCQ Total score. The total MCQ score was computed by summing scores of five sub-scales of the MCQ (values for each sub-scale were available in the database but not the total score). The obtained values were checked to ensure that the values are within the minimum and maximum range indicated by the MCQ guidelines (i.e., between 0 and 136).

Affective distress. Two variables corresponding to affective distress were identified in this database:

Mood status. Scores representing a general sense of mood over the past 6 months were used in analyses. These scores were reported to have been derived from a single question on a 4-point Likert scale (*Please indicate how has your mood generally been within the last 6 months?*) where 1 = excellent, 2 = good, 3 = fair, and 4 = poor/bad.

Stress status. Scores representing subjective experience of stress were used in analyses. The scores were reported to have been derived from a single question on a *4-point Likert scale (Please indicate how your stress levels have been over the last six months*) where 1 = very low, 2 = low, 3 = high, and 4 = very high.

Data transformation procedures were applied to other information in the database in order to derive further two variables for analyses:

Proxy measure of cognitive reserve. Levels of educational attainment was used as a proxy measure of CR. For comparisons of group means, data was re-coded into two groups (Low CR and High CR) based on responses to questions regarding educational status:

High CR included those with undergraduate or postgraduate education.

Low CR included those with primary school or secondary school education.

Data analysis. Data in this part of research was analysed using IBM SPSS version 25 for Windows. Independent samples t-tests were used to compare group means and assess bivariate relationships. In addition, analysis of variance (ANOVA) models were utilised to assess group differences in further detail. Descriptive statistics were used to derive information about samples.

Ethics. Ethical approval for data collection for the Memory Difficulties Survey was obtained from the Massey University Human Ethics Committee (HEC: Southern A Application – 13/26).

The collection of data for the Memory Performance Survey had been reviewed and approved by the Massey University Human Ethics Committee (HEC: Southern B. Application - 09/23).

Part B: Examination of theoretical models of SCCs

Survey design. The survey was developed specifically for the current study in consultation with research supervisors who specialise in the areas of aging and TBI, and refined through review and feedback from peers from the School of Psychology, Massey University. Item development and selection of relevant questionnaires was guided by review of relevant literature as outlined in previous chapters, and results from Part A (see Chapter 5). Specifically, the survey was designed to provide data that corresponds to variables in the SEM model of influence on reporting SCCs in the general population, and in mTBI population. Figure 5 depicts the hypothesized model.

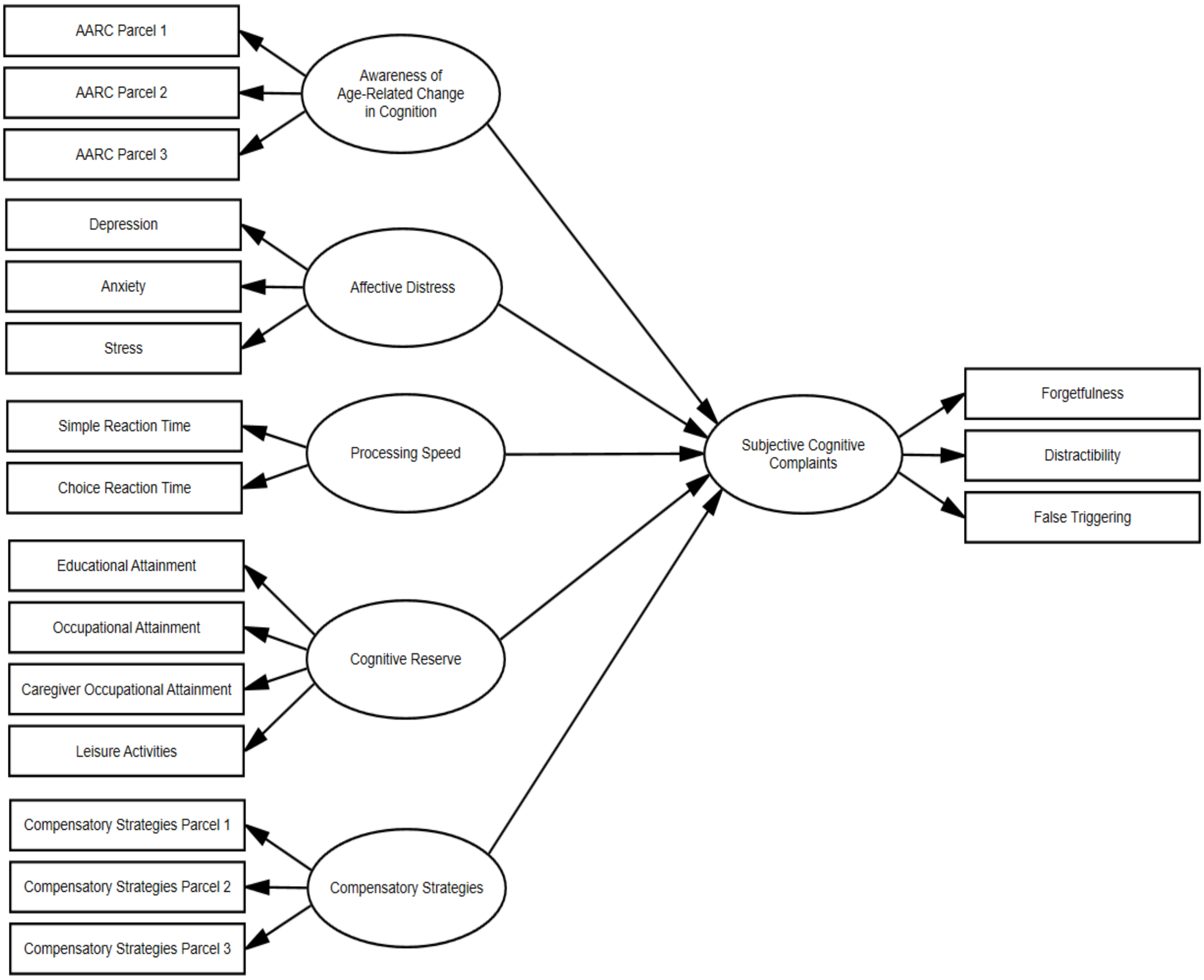


Figure 5. Hypothesized model of influence on reporting SCCs.

The survey was preceded by three screening questions in line with established exclusion criteria of age and residency status. Items of the survey were divided in three distinct sections:

1. In section one, participants were asked to provide their demographic information and indicate any previous experiences of TBI or other neurological events. Information in this section was used to derive an estimate of CR.
2. Section two contained measures assessing AARC, symptoms of affective distress, and SCCs. It also contained a questionnaire which queried engagement in leisure activities and use of compensatory strategies for age-related difficulties in cognition.
3. Section three consisted of an interactive task which measured reaction time (RT). The task was programmed by a Massey University programmer based on instructions outlined in Deary, Liewald, and Nissan (2011).

Sections one and two were estimated to take up to 20 minutes to complete, and section three approximately 5 minutes to complete. Qualtrics survey software was selected to host sections one and two of the survey. However, as the Qualtrics platform was not able to support section three (RT task), this was hosted on a private Massey University server. Progression through these sections was automatic. In order to simplify the survey link and highlight the affiliation of this research with Massey University, the survey was accessible via http://psylab.massey.ac.nz/cognitive-aging. The survey can be viewed in Appendix B.

Recruitment. Recruitment took place from July 2019 to March 2020, and participants eligible for the study were drawn from the general population of New Zealand. Initially recruitment was based on snowballing or chain referral where individuals known to researchers were invited to participate, and upon completion of the survey they had the option to share the study details with family and acquaintances and invite them to participate. No incentive was offered for the referrals. However, due to difficulties with recruiting a sufficient number of participants, in January 2020 recruitment through public online advertising was also implemented. The advertising poster used in recruitment included an overview of the study and website address (see Appendix A). Upon entering the website participants were presented with a detailed information sheet which identified the chief researcher, criteria for participation, types of questions asked, description of interactive task, time commitment, and consent and confidentiality of collected data (see Appendix B). It also outlined contact details of the researcher and supervisors, ethics approval for research, and provided information about the compatibility limitations of the interactive task.

Sample size. A minimum sample size of 200 for normal aging group, and 200 for mTBI group was calculated in order to detect a medium size effect at 0.8 power in the hypothesized model (Soper, 2020; Westland, 2010).

Consent. Individuals interested in the study were advised through the information sheet that participation in the survey implied consent for collection of responses provided by them (see Appendix B). They were also advised of their right to decline to answer any particular question.

Inclusion criteria. Participation was open to all New Zealand citizens and long-term residents who were aged at least 18 years at the time the survey was advertised. There was no upper age limit.

Exclusion criteria. Individuals younger than 18 years, and non-New Zealand citizens or long-term residents were excluded from the present research. *Long-term residents* were defined as individuals who have resided in New Zealand for a period of at least five years. All potential participants had to complete screening questions at the beginning of the survey after which they either progressed to the rest of the survey or were screened out and thanked for their interest in the study.

Participant koha. To compensate participants for their time, upon completion of the survey they were invited to register their interest in a draw of one of ten $40 gift vouchers.

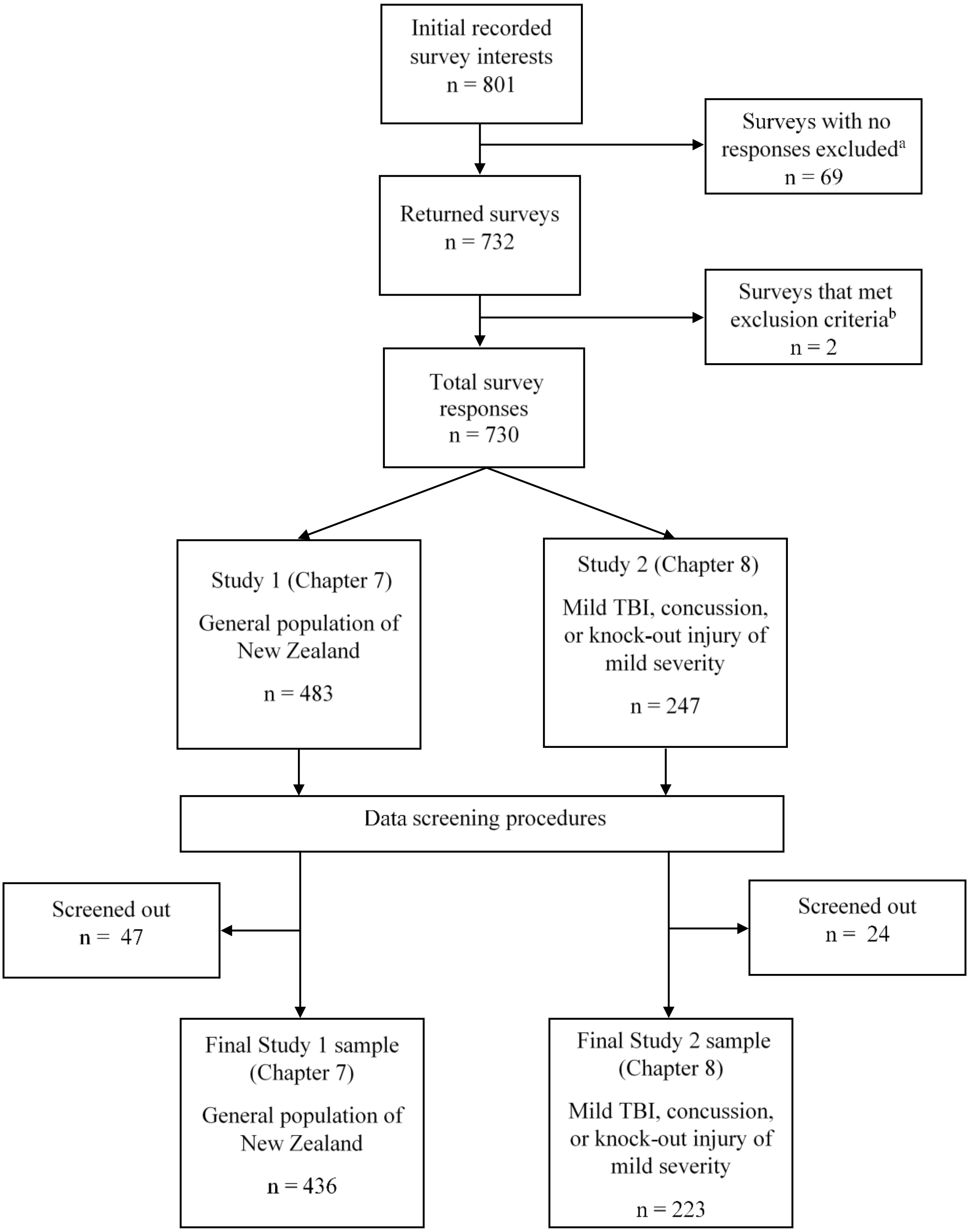
Participants

A total of 801 initial survey interests were recorded. Out of those, 69 respondents were removed due to noncompletion of any of the survey questions, and further two respondents were screened out in-line with established exclusion criteria. The total dataset prior to application of formal data screening procedures consisted of 730 respondents of which 79.5% were female, 20.5% were male, and 1% did not identify a gender. Of these, 82.9% were New Zealand European, 5.3% Other European, 2.3% Māori, 1.1% South African, 1% Indian, and 0.4% Chinese. Further 6.8% respondents indicated their ethnicity as Other, and 0.1% did not respond. In this sample, 21.6% respondents reported to have experienced a mild TBI or concussion, and 7% reported to have had a TBI. A total of 25.9% indicated to have experienced a knock-out injury. The mean age of respondents was 59.97 years old (*SD* =15.958, range 18-90 years old). This Part B dataset was split into two samples.

Study 1 sample – general population of New Zealand. This sample included data from individuals whose responses indicated no past experience of mTBI. The sample consisted of 483 responses of which 81% were female, 18% were male, and 1% did not identify a gender. In this sample, 82.8% of respondents were New Zealand European, 6.8% Other, 5.4% Other European, 2.3% Māori, 1% South African, 1% Indian, and 0.6% Chinese. The mean age of respondents in this sample was 61.32 years (*SD* = 15.93, range 19-90).

Study 2 sample – mild traumatic brain injury. This sample included data from individuals who reported to have had one or more of the following: a TBI of mild severity, a concussion, or have been knocked out in the past. Any responses that indicated TBI of moderate or severe degree of severity were not included in the sample as this was deemed likely to introduce bias to analyses. A total 247 responses were included in this sample, of which 74.5% were female, 24.7% were male, and 0.8% did not identify a gender. Of these, 83% were New Zealand European, 6.9% Other, 5.3% Other European, 2.4% Māori, 1.2% South African, 0.8% Indian, and 0.4% did not respond to this question. The mean age of respondents in this sample was 57.15 years (*SD* = 15.68, range 18-83).

Both samples underwent data screening procedures prior to analyses (see Chapters 7 and 8 for details). The final samples used in analyses are depicted in Figure 6.



[a] This includes respondents that viewed the survey information sheet and proceeded to the next page but did not respond to any survey questions

[b] This includes respondents younger than 18 years old or non-citizens/long-term residents of New Zealand

Figure 6. Samples analysed in part B (chapters 7 and 8).

Measures

Affective distress. The **Depression Anxiety and Stress Scales** (DASS; Lovibond & Lovibond, 1995) was used in the current study as a measure of affective distress. The full questionnaire consisted of 42 self-report items assessing the presence symptoms of affective distress across three factors: Depression (DASS-D), Anxiety (DASS-A), and Stress (DASS-S). Each scale consisted of 14 questions grouped into individual subscales as summarised in Table 6. Items were delivered on a 4-point Likert scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much, most of the time) referring to presence of symptoms over the past week, with higher scores representing greater severity of symptoms.

Table 6

DASS Subscales

Scale	Subscales
Depression	Dysphoria Hopelessness Devaluation of life Self-depreciation Lack of interest/involvement Anhedonia Inertia
Anxiety	Autonomic arousal Skeletal musculature effects Situational anxiety Subjective experience of anxious affect
Stress	Difficulty relaxing Nervous arousal Easily upset/agitated Irritable/over-reactive Impatient

Note. Reproduced from *The Structure of Negative Emotional States: Comparison of the Depression Anxiety and Stress Scales (DASS) with the Beck Depression and Anxiety Inventories* by P. Lovibond & S. Lovibond. Copyright 1995 by Elsevier.

The full version of DASS was selected for the present study as it has been shown to have excellent psychometric properties in both clinical and non-clinical samples (Antony, Bieling, Cox, Enns, & Swinson, 1998; Brown, Chorpita, Korotitsch, & Barlow, 1996; Clara, Cox, & Enns, 2001; Lovibond & Lovibond, 1995), and in mTBI (Dahm, Wong, & Ponsford, 2013). The Depression and Anxiety scales were also found to be strongly correlated with other existing measures of affective distress such as the Beck Depression Inventory-II and Beck Anxiety Inventory, providing evidence of convergent validity (Lovibond & Lovibond, 1995). The reported test-retest reliability for this measure was reported as high, ranging from approximately 0.7 to 0.8 depending on the scale (Brown et al., 1996). The choice of DASS was further motivated by presence of the Stress scale which reflects states of general negative affect, and the symptoms of which were demonstrated to be separate from those in depression and anxiety (Brown et al., 1997). Other advantages of using DASS included short administration time, and availability in the public domain. Lastly, while a short, 21-item version of the DASS questionnaire was also available, it was not used in the present research due to issues with construct validity in the TBI population (Wong, Dahm, & Ponsford, 2013).

Processing speed. The **Deary-Liewald Task** (D-L Task; Deary et al., 2011) was selected for the study as an appropriate internet-based proxy measure of PS. It is a 5-minute task measuring RT to simple and choice stimuli. RT tasks are viewed as capturing the capacity of PS with some involvement of motor speed and had been shown to decline with age starting from young adulthood (Der & Deary, 2006; Woods, Wyma, Yund, Herron, & Reed, 2015). Research demonstrated that the D-L task was significantly correlated with scores obtained on traditional pen-and-paper tests of PS, and it was also noted that lower scores were associated with older age and lower occupational attainment (Deary et al., 2011).

The D-L Task consists of two separate RT tasks which were administered as a set (see Appendix B).

1. In the simple reaction time (SRT) task, participants were asked to observe a box displayed in the centre of the screen on their computer. They were instructed to press the space bar as fast as they could when a target stimulus “X” appeared in the box. SRT consisted of 8 test trials and 20 test trials.
2. In the choice reaction time (CRT) task, participants were asked to observe four separate boxes which corresponded to four different keyboard keys. They were instructed to press the key that corresponded to the box where a target stimulus “X” appeared. CRT consisted of 8 practice trials and 40 test trials, and the location of stimulus and time interval between two stimuli was randomly generated.

The advantages of using the D-L Task include its good validity and reliability, particularly for the CRT (Deary et al., 2011). The test-retest reliability varied for the two tasks, with moderate reliability for the SRT, and good reliability for the CRT condition (0.64 and 0.83 respectively; Deary et al., 2011). Furthermore, the task required no additional software, its' specifications were available in public domain which means that it could be adapted and embedded into an internet-based survey, and the data was collected in an easy to download spreadsheet. However, the relative disadvantage of using the DL-Task was that it has not been standardised on devices other than a computer with a keyboard. This means that the task could not be completed on other electronic devices, for example mobile phone or tablet.

Awareness of age-related change in cognition. The questionnaire exploring people's AARC was developed specifically for the present study. This was motivated by the lack of a suitable questionnaire for use at the time of planning the present research which explicitly queried perceptions of change in cognition over time. A *suitable questionnaire* was defined as an instrument that was brief, reliable, validated for use in English speaking populations, and accessible to the public.

Initial item pool. A total of 12 items were initially developed based on findings from the literature review pertaining to awareness of continuous changes (both improvements and declines) that occur in cognition across the lifespan as outlined in Chapters 1 and 2. They were intended to query laypersons' awareness of change in cognition through reflective questions related to their subjective experiences of cognition in both general and specific cognitive domains, including memory, complex attention, and PS. The items asked participants to compare their present cognitive functioning with how they perceived themselves in the past. The advantage of this approach was that by subjectively comparing themselves to when they were younger, participants became their own reference group. For some items, 10-year comparison intervals were adapted in line with research demonstrating that age-related changes in cognition occur throughout the lifespan (Wechsler, 2008), while keeping in mind that capturing any functionally significant changes is difficult as these may not become apparent until years later.

Item response options and scoring. A five-point Likert scale was selected to enhance the ability of the measure to capture variability in awareness between subjects. When completing the questionnaire, participants were prompted to choose one of the following response options based on their subjective opinion of the question: “very true”, “true”, “neither true nor untrue”, “not true”, “not true at all”. The questionnaire included a combination of standard and reverse-scored items. Inclusion of reverse-scored items was intended to assist in detection of unengaged responding. Scores for individual items were summed to derive parcel scores and a total questionnaire score.

Pilot. The survey was piloted on a group of 10 participants recruited through chain referral sampling. The sample consisted of equal number of men and women, and their mean age was 40.3 (*SD* = 17.01). Seven participants identified themselves to be of New Zealand European descent, and the remaining three participants were Māori, South African, and Middle Eastern. The purpose of the pilot was to assess the reliability of items and to identify and remove any items with problematic psychometric properties.

Face validity. The initial item pool was reviewed by research supervisors. It was then piloted, and feedback from participants regarding the measure and individual items was reviewed. The final questionnaire was reviewed by research supervisors and School of Psychology peers during a doctoral confirmation event at Massey University, Albany, New Zealand.

Internal consistency. The internal consistency of the questionnaire was assessed by Cronbach’s alpha coefficient. Values ranging from .65 to .9 are universally considered to be acceptable as the alpha coefficient is affected by the total number of items in a scale and average inter-item correlation, with lesser number of items producing a lower value and higher inter-item correlation contributing to a higher value (Field, 2019; Nunnally, 1994). The inter-item correlation matrix was also consulted to assess the degree to which individual items were able to be a part of a coherent measure. Cronbach’s alpha value for the initial 12-item questionnaire was calculated at α=0.673. This increased to α=0.727 after item 12 “*I am able to identify the cause of my cognitive difficulties”* was removed from the questionnaire. This decision was further motivated by low response rate to the item and feedback from participants of the pilot that this question was not always relevant to them. The internal consistency of the final questionnaire was deemed to be acceptable.

Final questionnaire. The final Awareness of Cognitive Change Questionnaire (ACCQ) consisted of 11 questions on a 5-point Likert scale pertaining to subjective perceptions of changes in cognitive ability over the past 10 years, and the lifespan in general.

There were six items scored from 5 to 1 point, and five reverse items scored from 1 to 5 points. The scores were then summed, with higher scores representing a higher AARC, and lower scores corresponding to lower AARC. The ACCQ is presented in Table 7.

Table 7
The ACCQ

Item	Very True	True	Neither True nor Untrue	Not True	Not True At All
1. My cognitive abilities are not much different now than they were 10 years ago.	1	2	3	4	5
2. I regularly think about how much these abilities have changed over the past 10 years.	5	4	3	2	1
3. I regularly compare my current cognitive ability to what it used to be when I was younger.	5	4	3	2	1
4. I can identify a point in time when my cognitive abilities were at their peak.	5	4	3	2	1
5. My memory is not much different now than it was 10 years ago.	1	2	3	4	5
6. The speed at which I complete tasks (i.e., at work or leisure) is not much different now than it was 10 years ago.	1	2	3	4	5
7. My ability to make quick decisions is not much different now than it was 10 years ago.	1	2	3	4	5
8. My ability to concentrate on tasks and ignore distractions is not much different now than it was 10 years ago.	1	2	3	4	5
9. I find multitasking more challenging than 10 years ago.	5	4	3	2	1
10. I have sought or plan on seeking ways to remedy my cognitive difficulties (examples: discussion with GP, use of self-help materials).	5	4	3	2	1
11. My difficulties make me concerned that I may be developing a more serious condition.	5	4	3	2	1

Item parcelling. Using parcels of items as indicator variables of constructs is a frequent practice in SEM (Little, Cunningham, Shahar, & Widaman, 2002). Item parcelling is commonly done through creation of groupings (parcels) and assigning each scale item to a single group at random and deriving parcel score from a sum of item scores (Little et al., 2002). The advantages of item parcelling in SEM include psychometric merits of parcels relative to single items and the need for fewer parameters to define a construct (Little et al., 2002). For the purpose of analyses in Part B of the present research, all 11 items were randomly assigned to one of three indicator scales using random number generator without replacement. This resulted in creation of two parcels containing four ACCQ items, and one parcel with three ACCQ items.

Cognitive reserve. Four proxy measures (indicators) of CR were utilised in the present part of research.

Educational attainment. Participants were asked to indicate their highest obtained qualification by selecting one of five response options (1 = intermediate school attendance and below, 2 = high school attendance, 3 = certificate or diploma, 4 = bachelor's degree, and 5 = post-graduate qualification including master's and doctoral degrees).

Occupational attainment. Participants were asked to identify their current and past occupations. Qualitative responses were manually assessed and assigned to one of five skill level groups according to the Australian and New Zealand Standard Classification of Occupations, Version 1.3 (ANZSCO; Statistics New Zealand, 2019). The ACC work type details sheet (ACC, 2020) was also consulted in ensuring accuracy of assessments. As ANZSCO does not formally classify certain unpaid occupations, these were provided with ratings for occupations which included similar responsibilities, for example response "I care for my father in his home" was rated the same as "Personal Care Assistant", and "homemaker" was rated the same as "Hostel Parent". The median rating of present and past occupation was used in the analyses. The following category descriptions were derived from the ANZSCO:

Skill level 1. Occupations at this skill level correspond to attainment of a Bachelor's Degree and above, and in some instances at least 5 years of relevant experience may substitute for formal qualification. Specialist vocational training may further be required in addition to formal qualifications. Occupations typically involve tasks that require a high level of problem-solving, decision-making, and an extensive specialist knowledge. Examples of occupations in this classification include doctors, lecturers, higher level managers, and professionals.

Skill level 2. Occupations at this skill level correspond to attainment of NZ Register Diploma, and in some instances at least 3 years of relevant experience may substitute for formal qualification. Specialised on-the-job training may further be required. Occupations involve performance of complex technical and practical tasks that require a high degree of specialist knowledge. Such occupations may involve supervisory roles, coordination, and performing technical functions in support of professionals. Examples of such occupations include laboratory technicians, civil engineers, retail managers, and financial brokers.

Skill level 3. Occupations at this skill level correspond to attainment of NZ Register Level 4 qualification, and in some instances at least 3 years of relevant experience may substitute for formal qualification. Specific on-the-job training may further be required. Examples of such occupations include trades workers (i.e., plumber, electrician, carpet layer), horticultural trades workers, and insurance brokers.

Skill level 4. Occupations at this skill level correspond to attainment of NZ Register level 2 or 3 qualification, or one year of relevant experience. Occupations typically involve operating and/or maintenance of machinery, driving, and retail assistance. Occupations in this area may require literacy and numeracy skills, manual dexterity, and interpersonal skills. Examples of occupations in this classification include drivers, secretaries, retail assistants, and motor vehicle mechanics.

Skill level 5. Occupations at this skill level correspond to attainment of NZ Register level 1 qualification or secondary school qualification. Occupations usually involve performing simple and routine physical or manual tasks which require mainly physical strength. Literacy and numeracy skills are generally not a major part of the work, and competent performance at this level often does not require a formal qualification or training. Examples of occupations in this classification include cleaners, freight handlers, and labourers.

For the purpose of SEM analyses, these categories were recoded in reverse in congruence with categories of the educational attainment variable.

Caregiver occupational attainment. The caregiver occupational attainment was used as a proxy measure of childhood SES (i.e., economic living standard) of participants. Responses were assigned into one of five ANZSCO skill level groups in line with criteria described in the previous sub-section.

Leisure activities. Engagement in leisure activities was assessed through 10 individual self-report questions, and each question corresponded to different type of activity. Participants were asked to rate their engagement in each activity on a 5-point scale where 0 = Never, 1 = A few times a month or less, 2 = Once a week, 3 = Two to three times a week, and 5 = More than four times a week. Item 10 was an open-ended item where participants were able to report any leisure activity not listed in the previous 9 items.

Use of compensatory strategies. The degree to which participants engaged in behaviour intended to compensate for any perceived cognitive difficulties was assessed using a 15-item self-report questionnaire. Items were generated based on literature in the area of neuropsychological rehabilitation and existing memory questionnaires (de Frias, Dixon, & Bäckman, 2001; Wilson et al., 2017). Five frequency categories for each item were available which yielded a different score (i.e., Never = 0, Sometimes = 1, About half the time = 2, Most of the time = 3, and Always = 4). Participants were asked to indicate how often do they engage in each listed compensatory strategy. Item 15 did not list a specific strategy; rather, participants had the opportunity to name any other strategy that they may be familiar with.

For the purpose of analyses in Part B of the present research, all 15 items were randomly assigned to one of three indicator scales using random number generator. This produced three parcels, each containing five items.

Subjective cognitive complaints. The **Cognitive Failures Questionnaire** (CFQ; Broadbent, Cooper, Fitzgerald, & Parkes, 1982) was selected for the present study as a measure of SCCs. It is a self-report measure consisting of 25 items pertaining to failures in everyday cognitive functioning experienced in the past 6 months across three factors: Forgetfulness, Distractibility, and False Triggering (Rast, Zimprich, Boxtel, & Jolles, 2009). The response format was based on a 5-point Likert scale representing five response options (i.e., never, very rarely, occasionally, quite often, and very often) which were scored from 0 to 4. Scores were summed and yielded a score ranging from 0 to 100, with higher scores representing higher frequency of cognitive failures. Lastly, CFQ has been widely used as a measure of SCCs in research with different populations including aging (Hohman et al., 2011; Snitz et al., 2015) and TBI (Barker-Collo et al., 2015; Hart, Whyte, Kim, & Vaccaro, 2005; Theadom et al., 2013). Overall CFQ has been demonstrated to be a reliable and valid measure (Broadbent et al., 1982; Merckelbach, Muris, Nijman, & de Jong, 1996; Rast et al., 2009; Wallace, 2004).

Data Analysis

Data was screened for missing values prior to computing scores from survey measures (see Chapter 7 and Chapter 8 for details of how screening procedures were conducted). Scoring criteria for psychometric measures were used in accordance with their respective manuals to calculate subscale and total scores. Scores were then entered into the dataset and checked at random for accuracy. As section three of the survey (interactive task) was hosted on a platform separate from sections one and two, the data obtained from both host platforms were manually merged in IBM SPSS 27 using recorded response identification codes (IP addresses were not recorded in order to maintain anonymity of survey participants). The two SEM models were analysed using IBM AMOS 27. Remaining quantitative research hypotheses were analysed using linear regression in IBM SPSS 27.

Structural Equation Modeling (SEM) was utilised in the present study as this methodology takes a confirmatory approach to testing of hypothesized relations between observed and latent variables (Byrne, 2016). Specifically, it assesses how sets of variables define larger constructs, and how these constructs are related to one another (Schumacker, Lomax, & Randall, 2016). It was deemed the most suitable for the purpose of the present study as it facilitated a clear visual representation of the relationship between different studied factors and SCCs, and a simultaneous analysis of all variables in the model to assess the fit of the model to collected data (i.e., whether data supports the hypothesized relations amongst variables). Lastly, SEM accounts for measurement error which is intended to safeguard the user from making erroneous inferences (Byrne, 2016).

Content analysis was also utilised in Part B was utilised to address hypotheses pertaining to causal attributions of perceived cognitive complaints. In content analysis, qualitative responses are examined to identify themes which are then converted to quantitative data (Krippendorff, 2019). Development of coding systems was inductive, e.g., coding categories were derived from the data, separately for each sample (i.e., normal aging and mTBI; Hsieh & Shannon, 2005). This was deemed the most appropriate as it was recognized that a pre-determined coding system could fail to encompass differences in responses between the two study samples. However, it was also acknowledged that the researcher had prior knowledge of different kinds of reported cognitive complaints both in normal aging and after mTBI which had the potential to influence the data analysis to be deductive. The codes and organisation of data into coding categories were systematically reviewed and refined in order to minimise any potential bias related to knowledge of pre-existing theory, enhance accuracy of assignment of data to codes, and to ensure absence of clerical errors (Bengtsson, 2016).

Ethics

The proposed research was reviewed and granted ethical approval by the Massey University Human Ethics Committee: Southern A (Application SOA 18/70).

Confidentiality of data. Several ethical considerations were identified as relevant to the present study. First, the confidentiality of data used in Part A, and data collected through an online survey in Part B was maintained by exclusion of any responses or questions that could potentially lead to identification of individuals. Once data collection in Part B was completed, the responses stored on the online survey platform were downloaded to a secure laptop and permanently deleted from the platform. All data was stored in a secure location and relevant files were password-protected so that they were accessible only by the main researcher, main supervisor, and co-supervisor.

Disclosure of health information. Consideration was given to items in the survey in Part B which queried experiences of TBI and presence of symptoms of affective distress. It was deemed appropriate that the survey should provide affected participants with a comprehensive list of New Zealand-based support services relevant to the reported experience or difficulty. Therefore, positive responses to such questions and scores on measure of affective distress above the cut-off point were programmed to trigger the survey platform to display an additional page containing a list of relevant support services. Participants were also informed prior to completion of the survey that they have the option to decline to answer any particular question. Lastly, contact details of researchers were also provided on the survey information sheet in case of any queries from potential participants.

Dissemination of research findings. At the end of the survey in Part B, participants had the option to register their interest in obtaining a summary of research findings. To register, participants had to click a link which re-directed them to a new survey form. Once there, they were asked to provide their e-mail address. To ensure anonymity of data, this form was entirely separate from the main survey and did not record IP addresses of page visitors. Interested participants were then e-mailed an overview of research findings.

CHAPTER 6

PART A RESULTS

The present chapter outlines secondary analyses of two databases - The Memory Difficulties Survey and The Memory Performance Survey – the purpose of which was to answer several research questions. Addressing these questions was important to enhance the understanding of the aetiology of SCCs, and to provide further justification for the SEM model studied in Part B of the present research. As the two selected databases were independent of each other, they will be introduced and analysed in separate sections of the current chapter, beginning with Database 1 – The Memory Difficulties Survey, and then progressing to Database 2 – The Memory Performance Survey. Each results section begins with an outline of data screening procedures and descriptive statistics of each sample, and then progresses to an outline of results which are arranged in the order of research hypotheses under investigation as presented in Chapter 4.

Database 1 - The Memory Difficulties Survey

Data screening.

Missing data. Missing data can be categorised in three distinct groups, including data missing completely at random (MCAR), data missing at random (MAR), or data missing not at random (MNAR; Schafer, 1997). In MCAR, missing data is hypothesized to be random and unrelated to other variables in the dataset, and MAR implies that missing data is related to other variables. In contrast, data is MNAR when the missingness is related to the value of that variable itself whilst controlling for other variables (Randall, Richard, & Randall, 2016). Identification of which of these three types of missingness is most likely to apply to present data is important in order to select the appropriate method of handling any missing data.

Variables relevant to the hypotheses under investigation were screened for missing data. A total of 6 missing data points (1.4%) were identified for the question regarding educational attainment, 3 data points (0.7%) were missing for mood, and 1 data point (0.2%) was missing for stress. Little’s method (Little, 1988) was used to assess if data is MCAR, and the result was significant ($\chi 2 = 14.40$, $df = 6$, $p = 0.027$) which indicates that the missing data may not be MCAR. Significance tests of missingness were conducted using independent samples t-tests of dummy coded variables. None of the missingness tests were significant for the mood variable, however the test indicated that individuals who did not respond to the education question reported lower levels of stress (*M* = 1.67) than individuals who responded to this question (*M* = 2.26), and this difference was significant (*t*(5.28) = -2.78, *p* = 0.037, *g* = 0.71). Further Chi-square tests of independence were conducted to explore the relations between these variables and no significant relationships were found.

Given the above results and a small number of missing data relative to the total sample, the decision was made to apply listwise deletion to cases missing data on educational attainment. This is because without information on educational attainment, cases were unable to be assigned to analysed groups. It was also reasonable to conclude that removing these cases would not result in a significant loss of power or introduce bias to present analyses. To cases missing responses on the stress and mood variables, pairwise deletion was applied to retain their data on other variables of interest (Schumacker & Lomax, 2016).

For spontaneously reported SCCs (assessed through unprompted, open-ended questions), data from 20 respondents was missing in the dataset, and 18 mean distress ratings for these SCCs were also identified as missing. As this was a secondary analysis of this dataset, follow-up with the survey respondents was not an option. The manuscript of the original study was consulted, and it transpired that these data points were intentionally removed from the sample as these respondents did not meet the inclusion criteria of having experienced SCCs. It was further identified that 2 individuals who did not respond to the question on spontaneous SCCs (i.e., left the question box blank) provided a presumably random response to the “distress associated with SCC” question. Therefore, a listwise deletion of these two cases was applied.

Outliers. Cases are identified as potential outliers when the value of observation falls outside the value of interquartile range multiplied by 3. All relevant continuous variables were analysed using normal box plots, and no significant outliers were identified. The values for skewness and kurtosis, and PP plots were consulted for each variable, producing no significant evidence of a non-normal distribution of data.

Database sub-set. BDI-II scores for two respondents, and STAI scores for one respondent were missing in the dataset. Little’s MCAR was not significant for either of these variables ($\chi 2 = 0.37$, *df* = 3, *p* = 0.952), indicating that the missingness of this data is likely to be random. An analysis of normal QQ plots indicated no significant outliers in this data. The values for skewness and kurtosis, and PP plots were assessed and indicated no significant evidence of a non-normal distribution of data in this sub-set.

Descriptive statistics. After conducting data screening procedures, The Memory Difficulties Survey dataset contained a total of 395 responses from individuals aged 40 years and over. A summary of demographic data for this database is presented in Table 8.

Table 8

Demographic Information – The Memory Performance Survey

	Category	Frequency (%)
Age in Years	40 - 44 years	57 (14.4%)
	45 - 49 years	64 (16.2%)
	50 - 54 years	61 (15.4%)
	55 - 59 years	39 (9.9%)
	60 – 64 years	42 (10.6%)
	65 – 69 years	34 (8.6%)
	70 – 74 years	33 (8.4%)
	74 – 79 years	31 (7.8%)
	80 – 84 years	27 (6.8%)
	85 years or older	7 (1.8%)
Gender	Female	285 (72.2%)
	Male	108 (27.3%)
	Missing	2 (0.5%)
Ethnicity	New Zealand European/Pakeha	315 (79.7%)
	New Zealand Māori	21 (5.3%)
	Pacific Islander	8 (2%)
	Asian	4 (1.0%)
	Other	44 (11.1%)
	Missing	3 (0.8%)
Educational attainment	High school attendance	32 (8.1%)
	School certificate or NCEA level 1	47 (11.9%)
	University Entrance, Bursary, or NCEA level 3	28 (7.1%)
	Tertiary certificate or diploma (not a degree)	96 (24.3%)
	Bachelor’s degree – for example: BA, BSc	80 (20.3%)
	Postgraduate – for example: Honours, Masters, PhD, or postgraduate diploma	112 (28.4%)

Analyses. This section describes the results from bivariate analyses. Independent samples t-tests and one-way ANOVAs were used to test hypotheses related to educational attainment as a proxy measure of CR and variables related to SCCs, affective distress, and information PS.

Hypothesis 1. Individuals with higher level of CR will report more SCCs than those with lower level of CR.

Independent samples t-tests were conducted to compare the number of reported SCCs through spontaneous self-report and questionnaire prompts between two groups of individuals who were hypothesized as high CR and low CR (using educational attainment as proxy). A significant difference was found between respondents with high CR (M = 2.86, SD = 1.45) and low CR (M = 2.44, SD = 1.35) in that individuals with high CR spontaneously reported, on average, more SCCs ($t(393) = 2.67$, $p = 0.008$, $g = 0.31$) than respondents with low CR. No statistically significant differences were found in the number of endorsed SCCs on a prompted questionnaire were found between respondents with high CR and low CR (Welch's $t(180.47) = 1.49$, $p = 0.137$).

Means of the six individual groups that constitute the educational attainment variable were also compared using one-way ANOVAs. Levene's tests for spontaneous and prompted reporting of SCCs were non-significant, indicating no evidence to reject the hypotheses of homogeneity of variances in analysed groups. Although the results indicated that there is a significant difference for spontaneous SCCs ($F(5, 389) = 2.54$, $p = 0.028$), Tukey's post-hoc tests showed no significant differences between the groups. No significant differences between groups were found for prompted SCCs ($F(5, 389) = 0.98$, $p = 0.433$).

Hypothesis 2. Individuals with higher level of CR will report higher severity of experienced SCCs.

Independent samples t-tests found no significant differences between individuals with high CR and low CR on reported severity of spontaneous SCCs ($t(172.58) = -0.32$, $p = 0.746$), or prompted SCCs ($t(393) = -1.18$, $p = 0.239$).

Differences between six educational attainment groups were also analysed using one-way ANOVA. Levene's test was found to be significant for distress ratings of spontaneous SCCs, but not prompted SCCs. A significant Levene's test indicates that these is evidence to reject the null hypothesis of homogeneity of variances in analyses groups. Significant difference was found in reported severity of SCCs as reported on a prompted questionnaire (*F*(5, 389) = 2.32, *p* = 0.042). Tukey's post-hoc procedure showed that respondents with high school attendance (*M* = 3.59, *SD* = 1.03) differed from individuals with school certificate/NCEA level 1 (*M* = 3.06, *SD* = 0.67) and those with a tertiary diploma (*M* = 3.11, *SD* = 0.73) in mean severity ratings for prompted SCCs (*p* = 0.042, *d* = 0.03). However, the size of this effect was near negligible. No significant differences between groups were found for spontaneously reported SCCs (*F*(5, 389) = 0.57, *p* = 0.726).

Hypothesis 3. In individuals who report SCCs, those appraised as high CR will report experiencing more affective distress than those with low CR.

Independent samples t-test was carried out to explore differences in reported affective distress between the two CR groups. The only significant difference between individuals with high CR (*M* = 2.31, *SD* = 0.72) and low CR (*M* = 2.09, *SD* = 0.64) emerged for stress in that individuals with high CR reported higher levels of experienced stress (*t*(392) = 2.74, *p* = 0.006, *g* = 0.31) than those with low CR. No significant differences were found for mood (t(202.70) = -0.19, *p* = 0.857), BDI-II scores (*t*(35.19) = -0.55, *p* = 0.586), State Anxiety scores (*t*(39.34) = 0.28, *p* = 0.779) and Trait Anxiety scores (*t*(40.11) = -0.20, *p* = 0.841). One-way ANOVAs also found no significant differences between groups of different educational attainment on mood (*F*(5, 386) = 0.12, *p* = 0.988), stress (*F*(5, 388) = 1.86, *p* = 0.100), BDI-II scores (*F*(5, 86) = 0.99, *p* = 0.428), State Anxiety scores (*F*(5, 87) = 1.45, *p* = 0.214), and Trait Anxiety scores (*F*(5, 87) = 1.63, *p* = 0.160).

Hypothesis 4. CR is not protective of PS. Specifically, there will be no differences in scores on information PS between individuals of varying levels of CR.

An independent samples t-test was conducted to compare Coding and Symbol Search subtest scores between individuals appraised as low CR and high CR. The test showed no significant differences in scores between these two groups on Coding (*t*(33.01) = -1.46, *p* = 0.154) or Symbol Search (*t*(34.2) = -1.34, *p* = 0.188). The results from one-way ANOVAs also demonstrated no significant differences in scores between groups of respondents of different level of educational attainment on Coding (*F*(5, 88) = 0.94, *p* = 0.458) and Symbol Search (*F*(5, 88) = 0.83, *p* = 0.532). As Coding and Symbol Search constitute the information

PS subtest of the WAIS-IV, no evidence was found that CR measured through proxy of educational attainment has a protective effect on PS.

The results of all tests reported above are presented in Table 24 and Table 25 of Appendix C.

Database 2 - The Memory Performance Survey

Data screening.

Missing data. Out of 515 respondents, two did not respond to the question on educational attainment which constitutes 0.4% of the total sample. Four data points were missing on the mood status variable (0.8% of total sample), and 2 on stress status (0.4% of total sample). One missing data point (0.2% of total sample) was identified for MCQ internal sub-scale, and one for MCQ total score (0.2% of total sample). This missing data point appeared to be the same individual. Overall, the number of missing data points relative to sample size was deemed to be small (Tabachnik & Fidell, 2013).

A missing values analysis was conducted to assess the hypothesis that the missingness of these data points was MCAR. Little's MCAR was not significant for any of these variables ($\chi2 = 12.58$, *df* = 15, *p* = 0.635) which indicates no evidence to reject the assumption that that the missingness of data is random. Listwise deletion was applied to missing data on educational attainment as doing so was deemed unlikely to introduce bias to analyses, and missing data on this variable precluded inclusion of these two cases in analyses. For the remaining cases with missing data, pairwise deletion was applied to retain information from other variables of interest.

Outliers. To assist with detection of potential univariate outliers in the dataset, box plots were inspected for each variable of interest. Potential outliers are observations with values that falls outside the value of interquartile range multiplied by 3. One outlier was identified for CFQ total score, however it was not removed from the dataset as it represented a small proportion (0.2%) of the sample, and the value was believed to represent a meaningful observation. Four outliers were identified for the MCQ reliance sub-scale, and data from each of these respondents for all MCQ sub-scales was manually inspected for random responding or potential clerical errors. No such errors were identified and therefore it was assumed that their responses represent meaningful observations. Values for skewness and kurtosis were inspected and no evidence was found for non-normal distribution.

Descriptive statistics. The final Memory Performance Survey dataset contained responses from 513 individuals aged between 18 and 85 years. The characteristics of this sample are presented in Table 9.

Table 9

Demographic Information – The Memory Performance Survey

Age	Range	18-85
	Mean (SD)	47.7 (*13*)
Gender	Female	296 (57.7%)
	Male	216 (42.1%)
	Missing	1 (0.2%%)
Nationality	New Zealand	409 (79.7%)
	Great Britain	44 (8.6%)
	Ireland	10 (1.9%)
	Germany	8 (1.6%)
	United States of America	8 (1.6%)
	Scotland	7 (1.4%)
	Australia	5 (1%)
	South Africa	5 (1%)
	Other	17 (4.8%)
Education status	Primary school	2 (0.4%)
	Secondary school	139 (27.1%)
	Undergraduate	150 (29.2%)
	Postgraduate	222 (43.3%)

Analyses. The present section summarizes the results from bivariate analyses. Independent samples t-tests and one-way ANOVAs were used to analyse hypotheses related to educational attainment as a proxy measure of CR and variables related to SCCs, affective distress, and use of compensatory strategies. Unlike the Memory Difficulties Survey database, the present database did not contain sufficient variables to test Hypothesis 2 (regarding distress of experienced SCCs) or Hypothesis 4 (related to PS).

Hypothesis 1. Individuals with higher level of CR will report significantly more SCCs than those with lower level of CR.

An independent samples t-test was conducted to compare CFQ scores between individuals appraised as high CR and low CR. The test showed no statistically significant differences in scores between these two groups ($t(224.62) = -0.83$, $p = 0.407$). Means of the four education status groups on the CFQ were also compared using one-way ANOVA, however no significant differences were found ($F(3, 509) = 1.85$, $p = 0.137$).

Hypothesis 3. In individuals who report SCCs, those appraised as high CR will report experiencing more affective distress than those with low CR.

In this database, all individuals reported experiencing SCCs to varying degrees. Independent samples t-tests were conducted using the complete sample to compare the mood and stress status ratings of respondents with high CR and low CR. No significant differences in scores were found between the two groups for mood status ($t(257.94) = -1.90$, $p = 0.059$). However, a significant difference was found for stress status in that individuals with high CR ($M = 2.70$, $SD = 0.72$) reported higher levels of experienced stress ($t(248.69) = 2.20$, $p = 0.029$, $g = 0.22$) than those with low CR ($M = 2.54$, $SD = 0.73$). A comparison of group means based on education status found no significant differences for mood status ($F(3, 505) = 2.22$, $p = 0.085$) or stress status ($F(3, 507) = 1.81$, $p = 0.145$).

Hypothesis 5. Among individuals who report SCCs, those with higher level of CR will endorse using a larger number of compensatory strategies than those with low CR.

An independent samples t-test was conducted comparing the total and sub-scale scores on the MCQ between individuals with high CR and low CR. The test showed one significant difference between high CR ($M = 23.99$, $SD = 4.62$) and low CR ($M = 22.68$, $SD = 5.19$) groups for the MCQ External sub-scale in that individuals with high CR reported more frequent use of external memory compensation strategies ($t(511) = 2.77$, $p = 0.006$, $g = 0.27$) than individuals with low CR, and this effect was small to medium. No other significant differences between the two groups were found.

Means on the MCQ for each of the four education status groups were also compared using one-way ANOVA. Levene's tests for MCQ total and MCQ Internal, Effort, Reliance, and Time sub-scales were non-significant. However, no significant differences between education status groups were found for these variables. Levene's test for MCQ External was significant, indicating that there is evidence to reject the null hypothesis of homogeneity, and therefore Welch's procedures were employed. No significant differences were found for education status groups on the MCQ External sub-scale (*Welch's F*(3, 5.15) = 2.30, *p* = 0.192).

Summary of all tests reported for this database is presented in Table 26 and Table 27 in Appendix C.

Summary

The aim of Part A of the present research was to explore links between factors identified in literature as having an influence on reporting SCCs, and to provide guidance for the development of survey in Part B. Several research hypotheses were addressed as presented in Table 10. In summary, the results reinforced the need for collection of data through a purpose-built questionnaire for Part B. They indicated the need for an inclusion of a measure of psychological stress, and supported the use of measures of PS, and compensation strategies. Lastly, it was noted that while measuring SCCs through an unprompted questionnaire may be favourable in middle to older adults, it remains unclear whether this is also the case for younger adults who experience fewer or milder SCCs. Therefore, it was decided that the survey would incorporate a structured questionnaire of SCCs.

Table 10

Results summary – Part A

Questions		Hypotheses		Database	Measures	Outcome
1	Effect of CR on reporting of SCCs	1	High CR *more* SCCs than low CR.	The Memory Difficulties Survey	Educational Attainment and Memory Difficulties Questionnaire score	Not supported
					Educational Attainment and no. of spontaneously reported difficulties	Supported
				The Memory Performance Survey	Educational Attainment and Cognitive Failures Questionnaire score	Not supported
		2	High CR *higher* severity of SCCs than low CR	The Memory Difficulties Survey	Educational Attainment and Memory Difficulties Questionnaire score	Not supported
		3	High CR *more* affective distress than low CR	The Memory Difficulties Survey	Educational Attainment and Distress ratings spontaneous/prompted SCCs BDI; BAI; subjective mood/stress ratings	Support for stress All other not supported
				The Memory Performance Survey	Educational Attainment and Subjective mood/stress ratings	Support for stress Mood not supported
2	Effect of CR on PS	4	CR not related to PS scores	The Memory Difficulties Survey	WAIS-IV Coding and Symbol Search subtests	Supported
3	Impact of CR on use of compensatory strategies for SCCs	5	High CR *more* compensatory strategies than low CR.	The Memory Performance Survey	Educational Attainment and Memory Compensation Questionnaire score	Support for external compensatory strategies

CHAPTER 7

PART B RESULTS
STUDY 1 NORMAL AGING

Data Screening

Missing data. A total of 483 responses in the Study 1 sample were screened for missing data. Out of these, 45 responses were removed from the dataset due to noncompletion of more than half of survey questions pertaining to indicator variables in the SEM model. Rows of data were screened manually to detect unengaged responses, however none were identified.

Next, survey items that make up the observed variable scores in SEM model were screened for missing values; this was completed prior to computing questionnaire scores. The proportion of missing responses varied between individual items of the DASS, CFQ, AARC, compensation strategies questionnaire, and leisure activities, however no single item was missing more than 4.1% of total responses (see Table 11). The highest proportion of missing data was for items of the compensatory strategies questionnaire which varied from 2.3% to 4.1%. It is likely that non-response on these items represents an unintentional omission, likely influenced by participant fatigue. In some cases, this may indicate that the question was not relevant and therefore it was omitted by participant. Depending on the device used to complete the survey, nonresponse may also have been influenced by the size of the screen and font, or table display. Further, the survey did not provide prompts for incomplete responses and thus participants may have been unaware of any errors or omissions in selecting a response. Further missing responses were identified for education (0.7%), occupational attainment (2.3%), and caregiver occupational attainment (11.6%).

Table 11

Study 1 - Frequency of Missing Responses per Item

	Range (%)
DASS	0 – 6 (0% - 1.4%)
CFQ	0 – 6 (0% - 1.4%)
AARC	0 -2 (0 – 0.5%)
Compensatory Strategies	10 – 18 (2.3% - 4.1%)
Leisure Activities	2 – 13 (0.5% - 3%)

A missing values analysis was conducted to assess the hypothesis that the missingness of these data points (i.e., items of the DASS, CFQ, AARC, compensation strategies, leisure activities, education, occupational attainment, and caregiver occupational attainment) could be MCAR. Little's MCAR was not significant for any of the above variables ($\chi 2 = 8486.21$, $df = 8457$, $p = 0.41$) which provides no evidence to reject null hypothesis that the missingness of data is MCAR. An analysis of patterns of missing data also showed a random arrangement of missing data points, further indicating that these data points are likely to be MCAR.

The SRT mean and CRT mean were missing 58.5% each. The large amount of missing data is assumed to be related to the survey design in that it required participants to use a computer to complete the tasks that measured SRT and CRT. The missingness of these data points was, therefore, related to the device used to complete the survey questions (e.g., computer vs smart device) and not to the value of the variable itself. All cases were manually inspected, and it was found that values on SRT and CRT were always present or absent together (i.e., if value for SRT was missing for a given respondent then the value for CRT was also found to be missing). This also suggests that all participants who engaged in the tasks successfully completed all required elements. Whether a participant completed the survey on a computer or mobile device appeared to be random.

To further assess that the missingness of data on SRT and CRT could be MAR, a series of significance tests were carried out (Tabachnik & Fidell, 2013). Dummy coding was utilised for each variable where 0 = data missing, and 1 = data not missing, and a series of t-tests and chi-square analyses were conducted. One significant result was found for age in that participants with missing data on the SRT and CRT were older ($M = 63.16$) than those with non-missing data ($M = 58.86$), however the effect size was small ($t = 2.62$, $p = 0.008$, $g = 0.27$). No other significant differences were found for other continuous variables.

Chi-square tests of independence were conducted to explore links between missing values on SRT mean, CRT mean, and categorical variables of education, occupational attainment, and caregiver occupational attainment. The only significant relationships were found for educational attainment and SRT/CRT ($\chi 2 = 10.66$, $df = 4$, $p = 0.031$, $phi = 0.16$). Individuals with educational attainment of intermediate school attendance and below and high school attendance were more likely to be missing SRT/CRT data than those with a certificate or diploma, bachelor's degree, or a post-graduate qualification.

Univariate and multivariate assumptions. Several assumptions about the distribution of the data have to be satisfied to facilitate the use of SEM. This includes the absence of significant univariate and multivariate outliers (i.e., outliers which can cause breaches of these assumptions); normal distribution of the population sample in the absence of significant skewness and kurtosis; independence of cases (i.e., assumption that the error terms are uncorrelated); and linearity and homoscedasticity.

Univariate outliers. Outliers are extreme data points which may lead to bias in estimates of parameters and their standard errors (Field, 2019). Cases are identified as potential outliers when the value of observation fall outside the value of interquartile range multiplied by 3. In order to screen for univariate outliers in the dataset, box plots were inspected for each variable of interest. A total of 8 responses on the Depression sub-scale, 11 responses on the Anxiety sub-scale, and 1 response on the Stress sub-scale were identified as potential outliers. Rows containing these data points were re-inspected to ensure they do not constitute clerical errors. All outliers were retained as they were believed to represent meaningful observations (i.e., individuals experiencing high levels of distress).

Two outliers were also identified for the SRT mean. The first respondent appeared to have a significantly slower mean response time for SRT compared to their own score on the more complex CRT condition. Furthermore, the number of recorded errors for the SRT condition suggested that this respondent did not follow task instructions and pressed an incorrect key to a total of 65 times. The second outlier also appeared to have an unusually slow response time for the SRT condition given their recorded mean time for the CRT condition. One further consideration was that for the CRT, four different response options were available and successful completion of task required not only visual identification of target stimuli, but also motor response to that stimuli. Therefore, the completion time for CRT is expected to be significantly higher compared to SRT which was not the case for this outlier. An analysis of other D-L task data (i.e., minimum RTs and maximum RTs) appeared to support this assumption. It was noted that no errors were recorded for this respondent which indicates that it could be related to internal factors such as inattention, or external factors such as device latency or poor internet connection, however the latter is less likely given their CRT mean score. As both of these outliers were believed to represent user error which could not be corrected, listwise deletion was applied to them.

Values for skewness and kurtosis, and PP plots were then inspected for variables included in the SEM model to assess the fit between the distributions and assumptions of normality for parametric tests. Values exceeding -2 or 2 on skewness, and -7 or 7 on kurtosis were adapted as indicating a non-normal distribution (West, Finch, & Curran, 1995). Moderate to high, positively skewed distribution was identified for all sub-scales of the DASS. This is not surprising given that DASS was developed as a measure to detect clinically significant levels of distress and the sample in the present study is reflective of the general population. It appears that the sampling also included individuals who were experiencing clinical depression and anxiety which would explain the positive skew. It was determined that applying variable transformation to Depression, Anxiety, and Stress sub-scales was appropriate in order to reduce the impact of outliers on distribution of data while preserving other data points. Log10 transformations were applied to these variables and they were shown to have improved normality.

Multivariate outliers. Multivariate outliers are identified when cases in the dataset produce an unusual combination of scores on two or more variables (Tabachnik & Fidell, 2013). Mahalanobis distance (D^2) was used to detect multivariate outliers. The computed D^2 statistics were evaluated using chi-square distributions with probability value set at 0.001 alpha level. Seven outliers were identified. Analyses were run with and without outliers and as the results were not significantly different, these outliers were retained in the dataset (Aguinis, Gottfredson, & Joo, 2013).

Linearity and homoscedasticity. The assumption of linearity is that the relationships between pairs of variables are adequately linear, and homoscedasticity refers to a situation where the variance in scores of one variable is consistent with variance across different levels of another variable (Field, 2019; Tabachnik & Fidell, 2013). Tests for linearity were performed and no evidence of non-linearity was found. An analysis of scatterplots of residuals against predicted values of dependent variables supported assumption of homoscedasticity.

Missing data management. Median values were substituted for missing values for items on the DASS, CFQ, AARC, compensatory strategies, and leisure activities (Tabachnik & Fidell, 2013) and the sub-scores and total scores were then computed. The Full Information Maximum Likelihood (FIML) method was utilised to manage missing data on educational attainment, occupational attainment, caregiver occupational attainment, SRT, and CRT. In

FIML, all data (missing and non-missing) is organised into subsets with the same pattern of missing observations, statistical information for each subset are calculated, and model parameters are then estimated from combined subset information (Kline, 2016). These methods were deemed appropriate as they allowed for other data from cases to be retained, whilst being less likely than other methods to introduce bias to analyses given that there was no evidence to reject the assumption that missingness of data was MCAR/MAR (Byrne, 2016; Tabachnik & Fidell, 2013).

Descriptive Statistics

After conducting data screening procedures, the Study 1 Normal Aging dataset contained a total of 436 responses from individuals aged 19 to 90 years old. A summary of demographic data is presented in Table 12.

Table 12

Demographic Information – Study 1 Normal Aging

Age	Range (years) Mean (*SD*)	19-90 61.3 (*15.9*)
Gender	Female	348 (80.6%)
	Male	84 (19.3%)
	Missing	4 (0.9%)
Ethnicity	NZ European	361 (82.8%)
	Māori	9 (2.1%)
	South African	5 (1.1%)
	Indian	5 (1.1%)
	Chinese	3 (0.7%)
	Other European	24 (5.5%)
	Other	29 (6.7%)
Education status	Intermediate school attendance and below	5 (1.1%)
	High school attendance	83 (19%)
	Certificate or Diploma	152 (34.9%)
	Bachelor’s Degree	104 (23.9%)
	Post-graduate qualification (includes Master’s and Doctoral degrees)	92 (21%)

Results

Hypothesis 6. There is a linear relationship between AARC scores and use of compensatory strategies. Specifically, use of compensatory strategies will be higher at higher levels of AARC.

A simple linear regression was conducted to determine whether the level of AARC can predict the use of compensatory strategies. AARC was found to be a significant predictor of use of compensatory strategies (B=0.30, r=0.25, $p = 0.001$) indicating that for every 1-point increase in AARC, the score on use of compensatory strategies increases by 0.30 point. In this model, AARC explained 6.1% of the total variance in use of compensatory strategies (R^2=0.061).

Hypothesis 8. In the general population, cognitive difficulties will be more frequently attributed to affective symptoms, attention, or memory functioning than normal aging.

A total of 349 participants responded to the question asking to make a causal attribution to any perceived cognitive difficulty. The content of responses was reviewed as outlined in Chapter 5 and arranged into the following categories: aging (1), affective symptoms (2), attention/concentration (3), medical condition (4), effects of medication (5), fatigue (6), memory functioning (7), suspected dementia (8), and don't know (9). The results are presented in Table 13.

Table 13

Causal Attributions – Study 1 Normal Aging

Category	Frequency (%)
Aging	107 (30.7%)
Affective symptoms	77 (22.1%)
Attention/concentration	74 (21.2%)
Memory	30 (8.6%)
Fatigue	21 (6%)
Don't know	17 (4.9%)
Medical condition	15 (4.3%)
Medication	5 (1.4%)
Suspected dementia	3 (0.9%)

Hypothesis 9. The severity of reported affective distress will be greater at lower levels of AARC.

A simple linear regression was conducted to assess whether the level of AARC can predict affective distress. AARC was found to be a significant predictor of affective distress (B=0.73, $r = 0.30$, $p = 0.001$), and the results indicated that for every 1-point increase in AARC, affective distress score increased by 0.73 point. In this model, AARC explained 8.7% of the total variance in affective distress scores (R^2=0.087).

Hypotheses 7 and 11. These two hypotheses were tested in the following sections using SEM are:

H7. AARC scores will have an inverse relationship with SCCs in that lower AARC scores will be related to higher reporting of SCCs.

H11. The level of AARC, affective distress, CR, PS, and use of compensatory strategies will have a direct effect on reporting SCCs in the general population of New Zealand.

Measurement modelling. The first step of SEM analyses is assessment of the measurement model. Measurement modelling refers to the process of describing latent constructs and operationalising them in a series of indicator variables based on an underlying theoretical framework (Blunch, 2013). The constructed factor structure of the measure is then assessed for adequacy of the model to fit to the sample data. Confirmatory Factor Analysis (CFA) was employed to confirm the factor structure of the present hypothesized model. To evaluate the fit of the model and enhance the likelihood of detecting a model mis-fit, a number of different fit statistics were consulted (Hu & Bentler, 1999). The following guidelines were adapted for assessment of model fit.

1. Chi-square test (χ^2) assesses the hypothesis about discrepancy between sample population covariance matrix and the hypothesized covariance matrix. As the goal is to have no such discrepancy, the χ^2 statistic is desired with a significance value $p >$ 0.05. However, Hair, Black, Babin, Anderson, and Tatham (2014) noted that significant p-values are often expected when the sample size is large, even with good model fit. This is because the chi-square tests a null hypothesis that the model fits perfectly in the population, and therefore in large samples even a small deviation from perfect fit will return a significant chi-square result. A good fit of a model is often

assumed when the ratio of χ^2 statistic to corresponding degrees of freedom is below 3 (Tabachnik & Fidell, 2013).

2. The goodness-of-fit index (GFI) spans from 0-1, with values over 0.90 being indicative of a better model fit. However, caution is required as the GFI was demonstrated to be affected by sample size, and therefore is unsuitable as a stand-alone measure of model fit (Sharma, Mukherjee, Kumar, & Dillon, 2005).
3. The adjusted goodness-of-fit index (AGFI) adjusts the GFI for the number of parameters estimated in the model relative to the number of points in the data. AGFI > 0.80 is considered to indicate a good model fit (Hair et al., 2014).
4. The comparative fit index (CFI) refers to the variance that has been accounted for in the covariance matrix, with CFI values over 0.90 and *p*-value > 0.05 indicating a good fit of the model (Hu & Bentler, 1999).
5. The root square mean of approximation (RMSEA; Browne & Cudeck, 1993) assesses the lack of fit in the model compared to a perfect model, with larger values indicating a poorer fit. Values below 0.10, and ideally below 0.05 with *p*-value below 0.05 were recommended as representing a good model fit. Compared to other fit indices such as the χ^2 test, the RMSEA is less sensitive to variations in sample size.
6. The standardized root mean square residual (SRMR) is the standardized difference between the observed correlation and the predicted correlation, with values below 0.08 and preferably below 0.05 indicating a good model fit (Hu & Bentler, 1999).
7. Tucker-Lewis index (TLI) is a non-normed fit index which was suggested by Hu and Bentler (1999) as supplemental to SRMR where higher values indicate a better fit between hypothesized model and observed data. Scores > 0.90 indicate acceptable fit, and scores > 0.95 indicate excellent fit.

Measurement modelling examined a multi-dimensional, five-factor model of influence on reporting SCCs in normal aging as presented in Figure 7. The goodness-of-fit indices for the present model were calculated and are presented in Table 14.

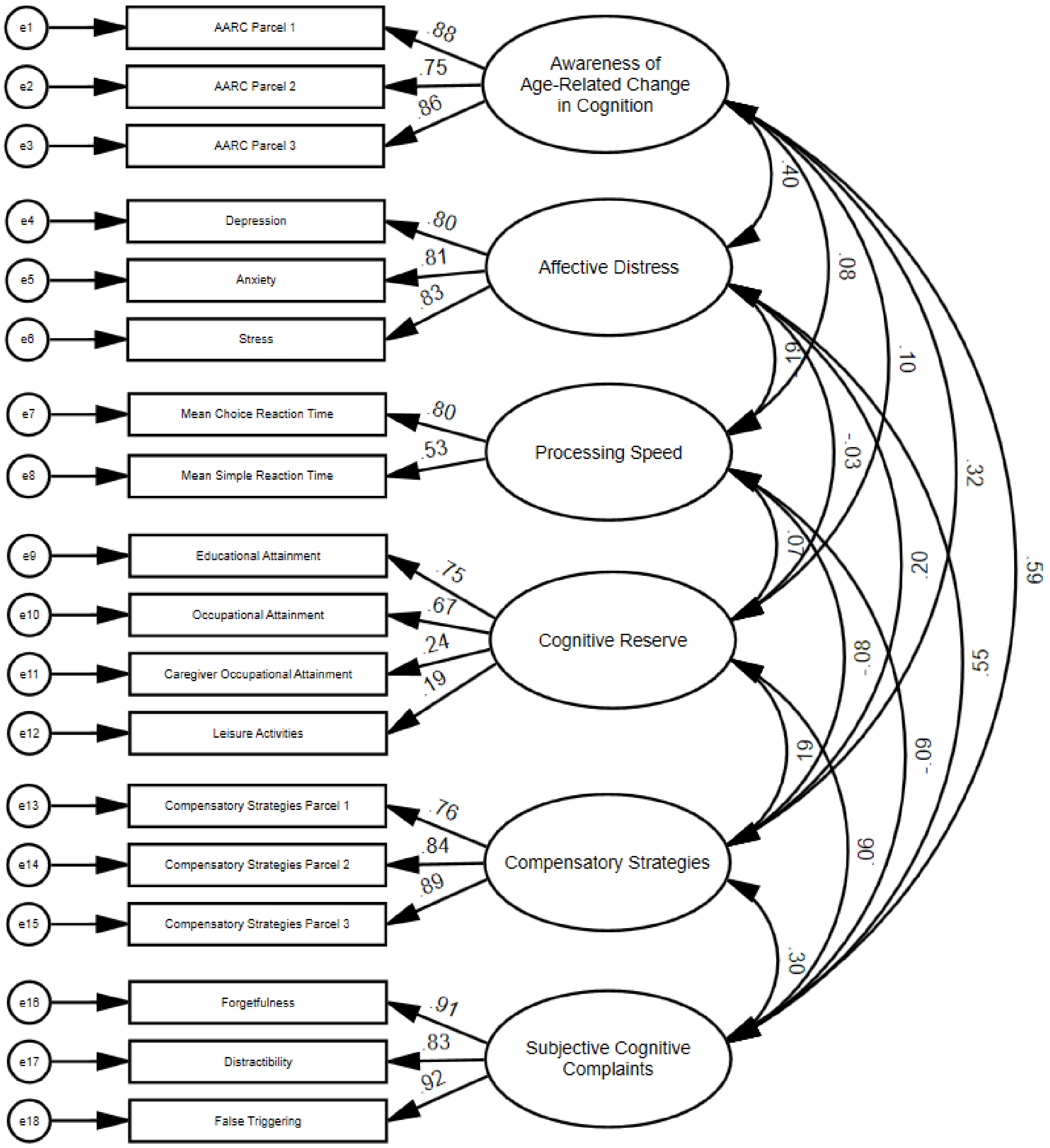


Figure 7. Measurement model (standardised parameter estimates) – study 1 normal aging.

Table 14

Goodness-of-Fit Indices for Measurement Model – Study 1 Normal Aging

				Model fit indices*							
χ^2	*Df*	χ^2/df	*p*	GFI	AGFI	CFI	PCFI	RMSEA	PCLOSE	SRMR	TLI
287.69	120	2.40	0.00	0.93	0.90	0.95	0.75	0.06	0.09	0.05	0.94

* Refer to pages 95-96 for an overview of the model fit indices

Model fit statistics were inspected to detect any potential discrepancies in model fit (Hair et al., 2014). All statistics were within thresholds for adequate model fit. Of note is that the *p*-value for χ^2 statistic was still significant, but as previously discussed this is not uncommon when the sample size is large (Byrne, 2016). Inspection of individual factor loadings indicated potential issues with variables Caregiver Occupational Attainment and Leisure Activities, and therefore these were removed from the model due to low factor loadings (0.19 and 0.24, respectively). In this case, low factor loadings could indicate that these variables are not valid indicators of CR. The adjusted model is presented in Figure 8.

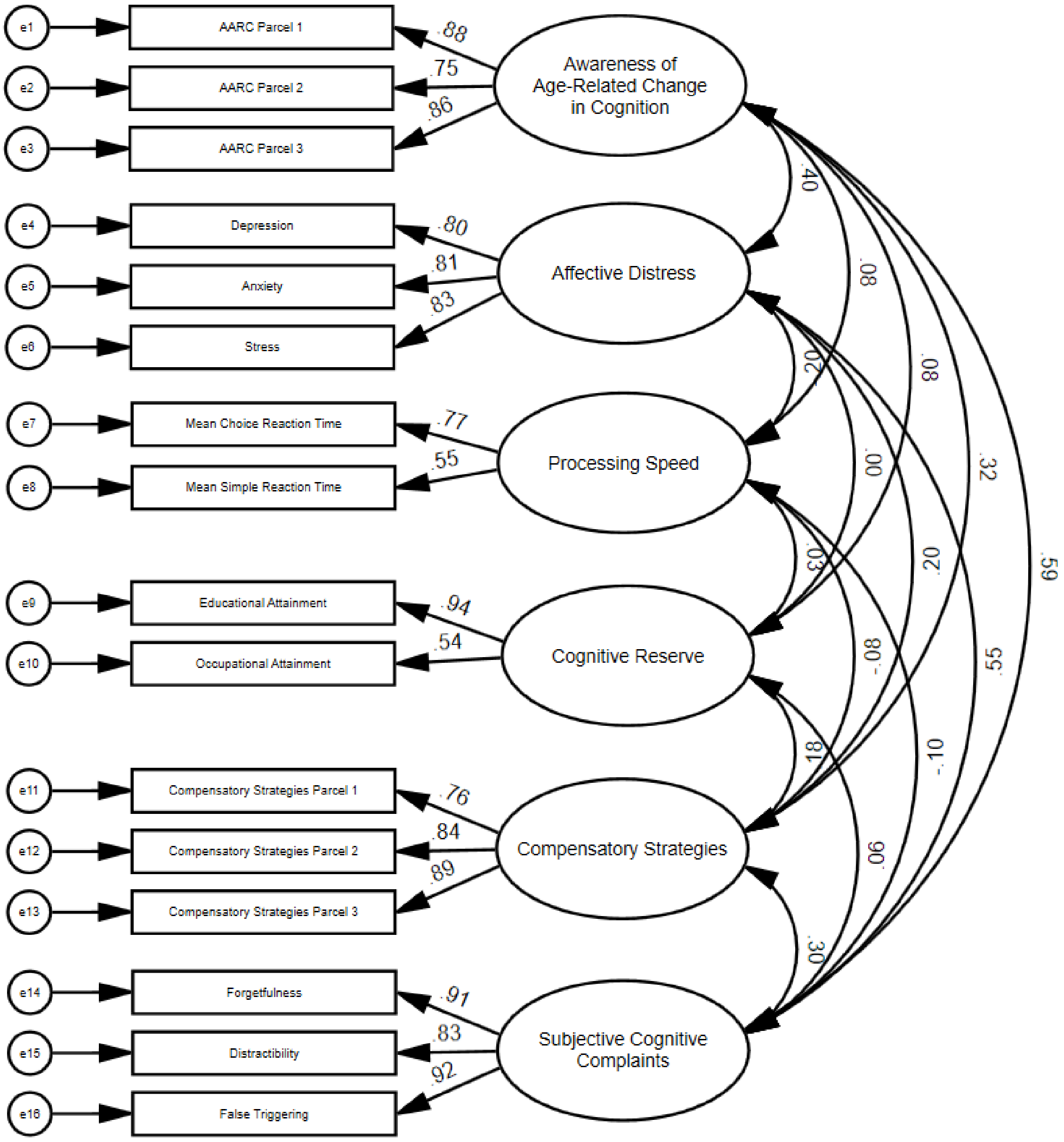


Figure 8. Adjusted measurement model (standardised parameter estimates) – study 1 normal aging.

Model fit statistics for the adjusted model are presented in Table 15. Model adjustment resulted in a slight refinement of model fit statistics except for χ^2/df which increased from 2.40 to 2.52. Factor loadings were re-inspected and all were above the recommended 0.5 (Cheung and Wang, 2017). Model fit statistics appear to meet or exceed their respective cut-off thresholds. Overall, the fit of this model was demonstrated to be good.

Table 15

Goodness-of-Fit Indices for Adjusted Measurement Model – Study 1 Normal Aging

				Model fit indices*							
χ^2	*df*	χ^2/df	*p*	GFI	AGFI	CFI	PCFI	RMSEA	PCLOSE	SRMR	TLI
224.13	89	2.52	0.00	0.94	0.91	0.96	0.71	0.06	0.06	0.04	0.95

* Refer to pages 95-96 for an overview of the model fit indices

Structural modelling. The hypothesized structural model was imposed on the adjusted measurement model, and the resulting model fit indices did not change between the measurement and structural model. The fit indices are presented in Table 16.

Table 16

Goodness-of-Fit Indices for Structural Model of Influences on Reporting SCCs – Study 1 Normal Aging

				Model fit indices*							
χ^2	*df*	χ^2/df	*p*	GFI	AGFI	CFI	PCFI	RMSEA	PCLOSE	SRMR	TLI
224.13	89	2.52	0.00	0.94	0.91	0.96	0.71	0.06	0.06	0.04	0.95

* Refer to pages 95-96 for an overview of the model fit indices

It was estimated that this model explained 47.6% of variance in reporting of SCCs in the normal aging population. Of five paths among latent factors, two were found to be statistically significant at the 0.05 alpha level. These reflected a positive effect of Awareness of Age-Related Change in Cognition on SCCs; and a positive effect of Affective Distress on SCCs. Pathway coefficients for PS and SCCs, CR and SCCs, and Compensatory Strategies and SCCs were found to be non-significant. Standardised path coefficients were used to assess the strength of relationship between each of the factors and the dependent variable of SCCs. The structural model is presented in Figure 9.

Summary

The aim of Study 1 was to assess the hypothesized model of influence on reporting SCCs in normal aging. The fit of this model was found to be good at the measurement level, however the structural model returned significant results for only two out of five factors, including AARC and affective distress. Four remaining research hypotheses were also tested, and the results indicated that both AARC and causal attributions are an important area of investigation in the context of SCCs in this population. The hypotheses and outcomes of Study 1 are presented in Table 17.

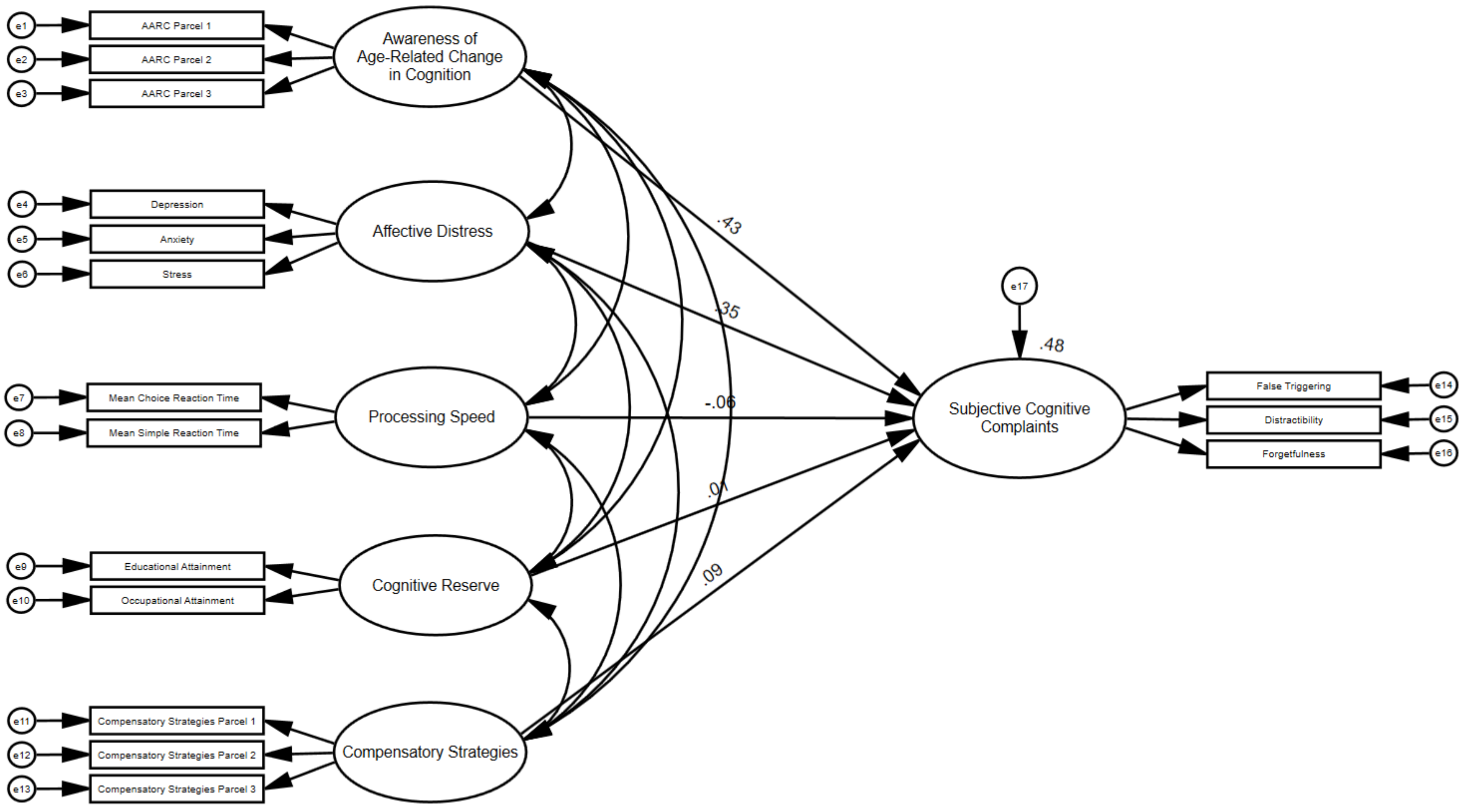


Figure 9. Structural model – study 1 normal aging.

Table 17

Results summary – Study 1 in Part B

Questions		Hypotheses		Measures	Outcome
3	Impact of CR on use of compensatory strategies for SCCs?	6	Lower AARC *fewer* compensatory strategies than high AARC	Awareness of Age-Related Change Questionnaire score and Compensatory Strategies Questionnaire score	Supported
4	General awareness of cognition across the lifespan, and attributions made about the cause of experienced SCCs	7	Lower AARC *more* SCCs	Awareness of Age-Related Change Questionnaire score and Cognitive Failures Questionnaire score	Not supported – higher AARC associated with more SCCs
		8	Cognitive difficulties *more* frequently attributed to affective symptoms, attention, or memory functioning than normal aging.	Attributions (Question 44)	Not supported
		9	Severity of reported affective distress *higher* at lower levels of AARC.	Awareness of Age-Related Change Questionnaire score and Depression Anxiety Stress Scales score	Supported
5	Influence of AARC, affective distress, CR, PS, and compensatory strategies on SCCs	11	Level of AARC, affective distress, CR, PS, and use of compensatory strategies have a direct effect on reporting SCCs in *NZ general population*	Awareness of Age-Related Change Questionnaire score Depression Anxiety Stress Scales scores Compensatory Strategies Questionnaire score Educational attainment, occupational attainment, caregiver occupational attainment, leisure activities Simple Reaction Time and Choice Reaction Time scores Cognitive Failures Questionnaire score	Support for AARC and affective distress Not supported for CR, PS, and compensatory strategies

CHAPTER 8

PART B RESULTS
STUDY 2 MILD TRAUMATIC BRAIN INJURY

Data Screening

Sample. As previously outlined in Chapter 5, the Study 2 sample included data from individuals who reported to have endorsed one or more of the following: a TBI of mild severity, a concussion, or experience of being knocked out in the past. Responses from individuals who indicated to have sustained a moderate or severe TBI were not included in this sample due to the potential for introducing bias to present analyses as such injuries are associated with presence of more severe symptoms.

Missing data. A total of 247 responses in the Study 2 sample were screened for missing data. Out of these, 21 responses were missing more than half of survey questions pertaining to indicator variables in the SEM model. They were, therefore, removed from Study 2 dataset. Screening of rows of data identified two unengaged responses characterised by intermittent and repetitive responding, and conflicting responses on measures that included reverse coded items. The decision was made to also remove these responses from the dataset.

Missing values were identified for individual items of the DASS, CFQ, compensation strategies questionnaire, and leisure activities, and no single item was missing more than 3.1% of responses (see Table 18). Further missing values were identified for education (1.3%), occupational attainment (1.3%), and caregiver occupational attainment (10.3%).

Table 18

Study 2 - Frequency of Missing Responses per Item

	Range (%)
DASS	0 – 4 (0% - 1.8%)
CFQ	0 – 2 (0% - 0.9%)
Compensatory Strategies	4 – 7 (1.8% - 3.1%)
Leisure Activities	2 – 7 (0.9% - 3.1%)

A missing values analysis was conducted to assess the hypothesis that the missingness of these data points was MCAR. Little's MCAR was not significant for these variables ($\chi 2$ = 5460.75, *df* = 5480, *p* = 0.571) which indicates that there is no evidence to reject assumption of MCAR. An analysis of patterns of missing data further indicated that data is likely to be MCAR.

The SRT mean and CRT mean were missing 57.1% of responses. As discussed in Chapter 7, missingness of responses on these two variables was assumed to stem from limitations of study design where only individuals who used a computer were able to complete the RT tasks. As such, the conclusion from Study 1 – Normal Aging that there was no evidence to reject the MAR assumption was adapted.

To further test this hypothesis, a series of significance tests were carried out using dummy coded variables where 0 = data missing, and 1 = data not missing. It was found that participants with missing data on the SRT and CRT reported more symptoms of affective distress. They reported experiencing more anxiety (*M* = 9.09) than those with non-missing data (*M* = 4.59), and this effect size was medium (*t* = 4.40, *p* = 0.000, *d* = 0.59). They also reported experiencing more depressive symptoms (*M* = 10.35) than those with non-missing data (*M* = 6.69), and this effect size was small (*t* = 2.80, *p* = 0.000, *d* = 0.38). Lastly, they reported more symptoms of stress (*M* = 12.81) than those with non-missing data (*M* = 9.53), and this effect size was small (*t* = 2.63, *p* = 0.009, *d* = 0.36). No other significant results were found for continuous variables.

Next, chi-square tests of independence were conducted to explore links between missing values on SRT mean and CRT mean, and categorical variables of education, occupational attainment, and caregiver occupational attainment. No significant differences were found.

Univariate and multivariate assumptions. To facilitate SEM analyses, the following assumptions about the data have to be satisfied: absence of significant univariate and multivariate outliers (i.e., outliers which can cause breaches of these assumptions); normal distribution of the population sample in the absence of significant skewness and kurtosis; independence of cases (i.e., assumption that the error terms are uncorrelated); and linearity and homoscedasticity.

Univariate outliers. A potential outlier was defined as an observation which falls outside the value of interquartile range multiplied by 3. Box plots and normal QQ plots were produced for each variable of interest, and this method identified 4 outliers on Depression sub-scale, 1 outlier on Anxiety sub-scale, and 1 outlier for the SRT. Rows of data containing these outliers were manually screened and no clerical errors or monotonous responding was identified. It is possible that these outliers represent meaningful observations, e.g., individuals who were experiencing high levels of distress at the time. For the respondent identified as an outlier on the SRT mean, an exploration of other related variables including minimum and maximum SRT, SRT *SD*, SRT errors, and comparison to more complex CRT indicated that the SRT score obtained by this respondent is unusual. Their score on CRT was only slightly higher than SRT, and considering that CRT is a more complex condition as it places additional demand on EF, this pattern of scores is less likely to be observed in individuals who engaged in RT tasks with full attention or adequate internet connection.

Values for skewness and kurtosis, and PP plots were then inspected for each variable included in the SEM model to assess the fit between the distributions and assumptions of normality for parametric tests. For the purpose of maintaining consistency across the present thesis, values exceeding -2 or 2 on skewness, and -7 or 7 on kurtosis were adapted as indicating a non-normal distribution (West et al., 1995). These analyses indicated high skew and kurtosis of the distribution of SRT. Analyses were re-run with listwise deletion of previously identified outlier which resulted in a significant improvement in the distribution of data. Therefore, the decision was made to apply listwise deletion of this outlier from further analyses.

Multivariate outliers. Mahalanobis D^2 was used to detect potential multivariate outliers, and the computed D^2 statistics were evaluated using chi-square distributions with probability value set at 0.001 alpha level. Five multivariate outliers were detected using this method. Analyses were run with and without these outliers and as the results were not significantly different, these outliers were retained in the dataset (Aguinis, Gottfredson, & Joo, 2013).

Linearity and homoscedasticity. Tests for linearity were performed in SPSS, and the relationships between three variables (Anxiety; Stress; and AARC Parcel 1) and dependent variables of Forgetfulness, Distractibility, and Stress were highlighted as potentially non-linear. Ordinary Least Squares (OLS) regressions were performed for each pair of variables and these were found to be sufficiently linear. An analysis of scatterplots of residuals against predicted values of dependent variables supported the assumption of homoscedasticity.

Missing data management. Median values were substituted for missing data for individual items on the DASS, CFQ, compensatory strategies, and leisure activities (Tabachnik & Fidell, 2013), and the sub-scores and total scores were then computed. The FIML method was utilised to manage missing data on educational attainment, occupational attainment, caregiver occupational attainment, SRT, and CRT. See Chapter 7 for a detailed description of the FIML method for management of missing data.

Descriptive Statistics

After conducting data screening procedures, the Study 2 mTBI dataset contained a total of 223 responses from individuals aged 18 to 83 years old. A summary of demographic data is presented in Table 19.

Table 19

Demographic Information – Study 2 mTBI

Age	Range (years)	18-83
	Mean (*SD*)	57.60 (*15.9*)
Gender	Female	167 (74.9%)
	Male	54 (24.2%)
	Missing	2 (0.9%)
Ethnicity	NZ European	188 (84.3%)
	Māori	4 (1.8%)
	South African	2 (0.9%)
	Indian	2 (0.9%)
	Other European	24 (5.5%)
	Other	15 (6.7%)
Education status	Intermediate school attendance and below	3 (1.3%)
	High school attendance	28 (12.6%)
	Certificate or Diploma	90 (40.4%)
	Bachelor’s Degree	46 (20.6%)
	Post-graduate qualification (includes Master’s and Doctoral degrees)	56 (25.1%)

Results

Hypothesis 10. In the mTBI population, cognitive difficulties will be most frequently attributed to the injury, and less often to the process of normal aging.

A total of 200 participants responded to the question asking to make a causal attribution to their perceived cognitive difficulties. To test this hypothesis, responses were analysed (see Chapter 5) and grouped into the following attribution categories: aging (1), affective symptoms (2), attention/concentration (3), medical condition (4), effects of medication (5), fatigue (6), memory functioning (7), suspected dementia (8), don't know (9), mTBI (10). The results are presented in Table 20.

Table 20

Causal Attributions – Study 2 mTBI

Category	Frequency (%)
Aging	63 (31.5%)
Attention/concentration	41 (20.5%)
mTBI	28 (14%)
Affective symptoms	24 (12%)
Medical condition	15 (7.5%)
Fatigue	12 (6%)
Don't know	7 (3.5%)
Memory	4 (2%)
Suspected dementia	4 (2%)
Medication	2 (1%)

Hypothesis 12. The level of AARC, affective distress, CR, PS, and use of compensatory strategies will have a direct effect on reporting SCCs in individuals who experienced a mTBI.

Measurement modelling. First, measurement modelling assessed the adjusted model presented in Chapter 7. This model is a multi-dimensional, five-factor model of influence on reporting SCCs in mTBI population (see Figure 10). The goodness-of-fit indices for this model are presented in Table 21.

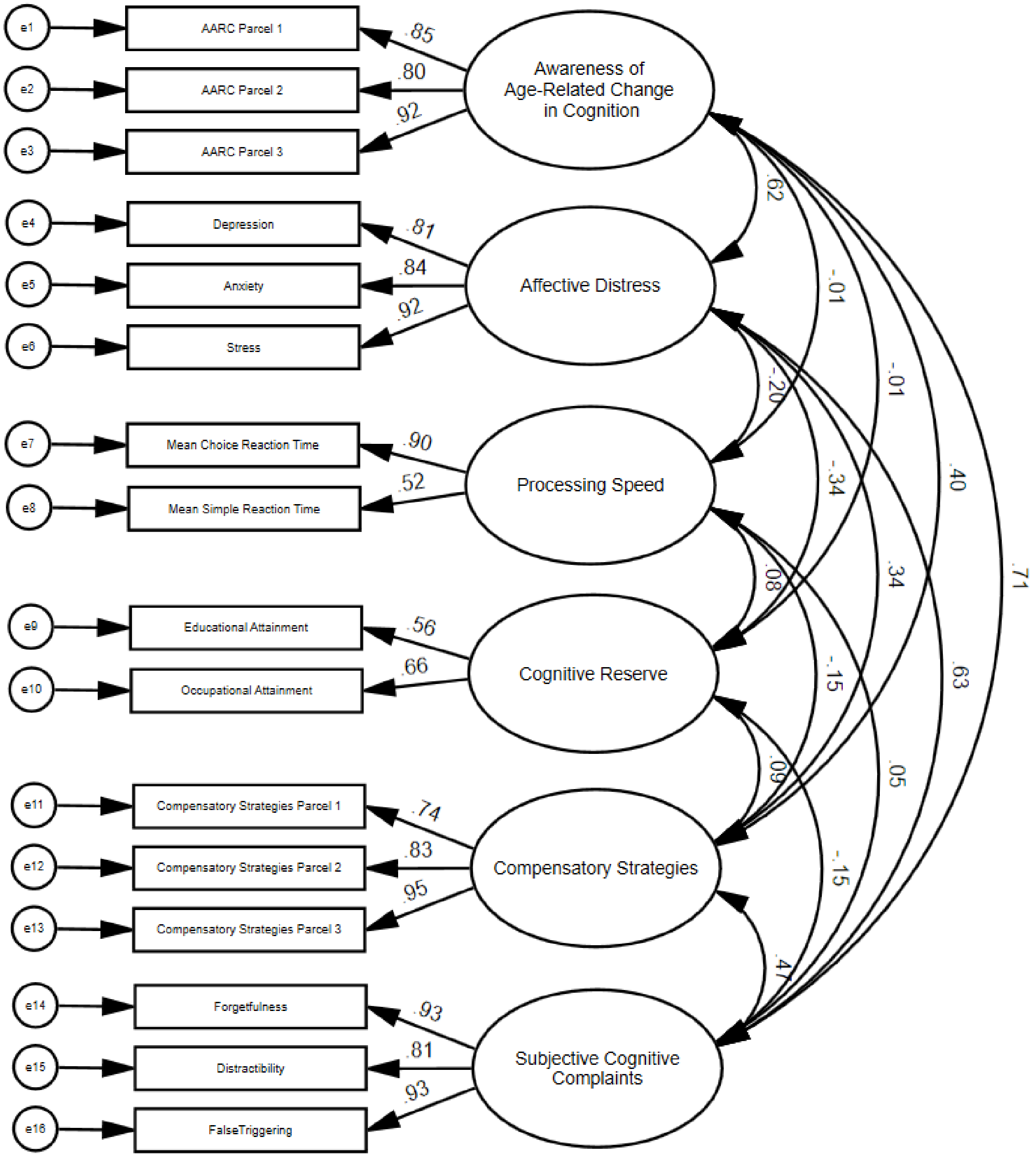


Figure 10. Measurement model (standardised estimates) – study 2 mTBI.

Table 21

Goodness-of-Fit Indices for Adjusted Measurement Model – Study 2 mTBI

Model fit indices*											
χ^2	*df*	χ^2/df	*p*	GFI	AGFI	CFI	PCFI	RMSEA	PCLOSE	SRMR	TLI
223.33	89	2.51	0.00	0.9	0.85	0.94	0.70	0.08	0.00	0.05	0.92

* Refer to pages 95-96 for an overview of the model fit indices

Model fit statistics were assessed and no significant discrepancies in model fit were identified as all statistics were within thresholds for adequate model fit. The exception to this was the *p*-value for χ^2 statistic which was significant, however as previously discussed in Chapter 8 this is not uncommon in large samples (Byrne, 2016). Factor loadings were also inspected, and all were above the recommended threshold value of 0.5 (Cheung and Wang, 2017). To conclude, model fit statistics appeared to meet or exceed their respective cut-off thresholds, indicating that a good model fit.

Structural modelling. The hypothesized structural model was imposed on the tested measurement model to ensure that model fit remains adequate. The calculated model fit indices did not change between the measurement and structural model. The obtained fit indices are presented in Table 22.

Table 22

Goodness-of-Fit Indices for Structural Model of Influences on Reporting SCCs – Study 2 mTBI

					Model fit indices*						
χ^2	*df*	χ^2/df	*p*	GFI	AGFI	CFI	PCFI	RMSEA	PCLOSE	SRMR	TLI
223.33	89	2.51	0.00	0.9	0.85	0.94	0.70	0.08	0.00	0.05	0.92

* Refer to pages 95-96 for an overview of the model fit indices

The structural model is presented in Figure 11. It was estimated that the model comprised of AARC in Cognition, Affective Distress, PS, CR, and Compensatory Strategies explained 62.5% of variance in reporting of SCCs in mTBI population.

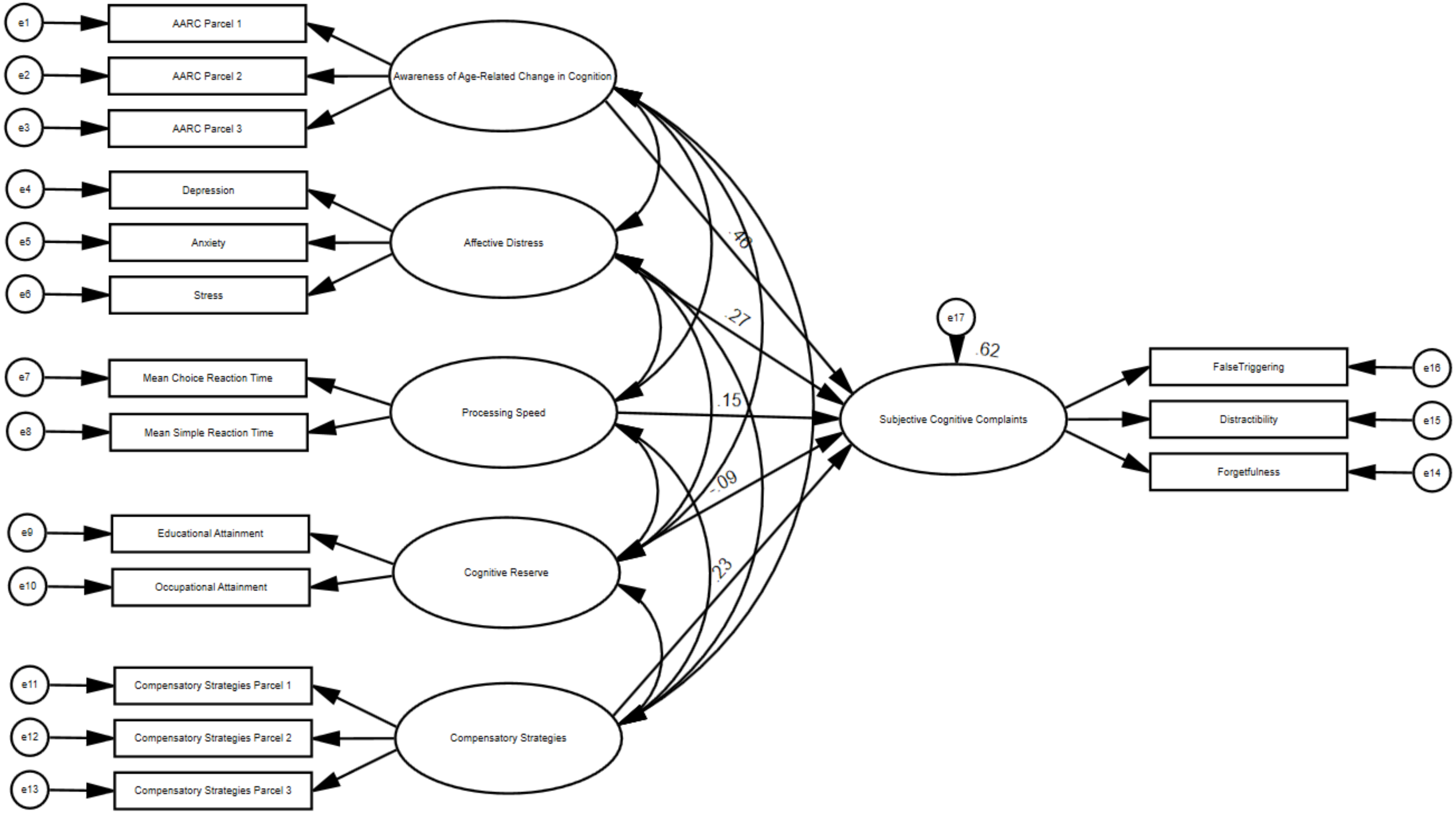


Figure 11. Structural model – study 2 mTBI.

Standardised path coefficients were used to assess the strength of relationship between each of the causal factors and the dependent variable of SCCs. Of five paths among latent factors, four were found to be significant at the 0.05 alpha level. These reflected a positive effect of AARC in Cognition on SCCs; positive effect of Affective Distress on SCCs; a positive effect of PS on SCCs; and a positive effect of Compensatory Strategies on SCCs. Pathway coefficients for CR and SCC was found to be non-significant.

Summary

The aim of Study 2 was to assess the model of influence on reporting SCCs after mTBI. At measurement level, this model was demonstrated to have a good fit to the data. Assessment of the structural model found significant associations between SCCs and four of the hypothesized factors, including AARC, affective distress, PS, and compensatory strategies. One factor (CR) did not reach statistical significance. Overall, the model explained a high proportion of variance in reporting of SCCs after mTBI (62.5%) which indicates that this is a promising area for future research. This study also addressed the remaining hypothesis pertaining to attributions of SCCs after mTBI. Hypotheses and outcomes of Study 2 are presented in Table 23.

Table 23

Results summary – Study 2 in Part B

Questions		Hypotheses		Measures	Outcome
4	General awareness of cognition across the lifespan, and attributions made about the cause of experienced SCCs?	10	In the mTBI population, cognitive difficulties most frequently attributed to the injury, and less often to the process of normal aging.	Attributions (Question 44)	Not supported
5	Influence of AARC, affective distress, CR, PS, and compensatory strategies aon SCCs	12	Level of AARC, affective distress, CR, PS, and use of compensatory strategies have a direct effect on reporting SCCs in individuals *after mTBI.*	Awareness of Age-Related Change Questionnaire score Depression Anxiety Stress Scales scores Educational attainment, occupational attainment, caregiver occupational attainment, leisure activities Simple Reaction Time and Choice Reaction Time scores Compensatory Strategies Questionnaire score Cognitive Failures Questionnaire score	Support for AARC, affective distress, PS, and use of compensatory strategies Not supported for CR

CHAPTER 9

DISCUSSION

The current research involved two parts – Part A and Part B - which examined relationships between different factors and reporting of SCCs in normal aging and after mTBI. The present chapter discusses findings from both parts of research as described in Chapters 6-8. This includes a summary and discussion of research findings, discussion of research limitations, recommendations for clinicians who work with individuals who report SCCs, and suggestions for future research.

Summary of Findings

Part A of the present research aimed to bridge the identified gaps in literature on links between factors such as CR, affective distress, use of compensatory strategies, and PS and reporting of SCCs in normal aging. Group comparisons found that individuals with higher CR as assessed by proxy measure of educational attainment reported more unprompted SCCs but not more distress associated with reported difficulties than those with lower CR. It was further found that in individuals with higher CR, reporting of more SCCs was associated with higher levels of perceived stress but not anxiety, depression, or general distress. This is surprising considering previous research which demonstrated links between symptoms of depression and anxiety, and reporting SCCs (e.g., Edmonds et al., 2014; Markova et al., 2017; Nicholas et al., 2017; Yates et al., 2017). Individuals with higher CR also reported more frequent use of external compensatory strategies, but the two groups did not differ in use of other compensatory strategies. No significant group differences were found for prompted SCCs across two different assessment measures. Furthermore, the study found no significant effect of CR on PS. Lastly, no significant differences were found for any of the assessed hypotheses between each individual educational attainment group.

It was hypothesized that individuals with higher CR (assessed by proxy of education attainment) would report more SCCs. The results provided partial support for this – significant differences were found for unprompted SCCs but not for prompted SCCs. One plausible explanation for this result could be that individuals with higher CR are more likely to notice even mild difficulties in daily life, and consequently may have engaged in research to enhance their understanding and learn compensatory strategies to mitigate these difficulties. Previous research discussed reporting of unprompted SCCs in individuals with higher education as a potential marker for later development of a neurodegenerative condition (e.g., van Oijen et al., 2007), and therefore it may also reflect a higher degree of vigilance and worry about developing more serious difficulties. Higher unprompted reporting may also be related to intentional engagement of compensatory strategies, and this behaviour has been found to be common in individuals experiencing functional limitations or losses (Lachman, 2004). In turn, effective compensating for identified difficulties may result in lower perceived distress which could explain why individuals with higher CR do not report experiencing more distress despite reporting significantly more difficulties.

Several explanations of the remaining results can be offered. A lack of significant associations between depression, anxiety, and CR could be explained by the potential for CR to attenuate the relationship between cognitive performance and perceived psychological wellbeing (Ihle et al., 2020). Such an explanation would, however, only be valid on the assumption that reporting of SCCs in this group is associated with a degree of awareness of progressive, subtle age-related changes in cognitive functioning (this was found to be the case in Part B; Stewart, 2012). It also does not explain why the results were different for self-reported stress. Another explanation may be that reporting of SCCs is associated primarily with stress symptoms, and in individuals with other pre-existing vulnerabilities, stress could contribute to the future development of anxiety and depression (Krishnan & Nestler, 2008; Sandi, 2007; Slavich & Irwin, 2014; Tafet & Nemeroff, 2016; Yang et al., 2015). This may be particularly relevant to individuals who struggle to compensate for any concerning cognitive difficulties (Lachman, 2004). Engagement of appropriate compensatory strategies could lead to an overall reduction in self-reported SCCs, and therefore symptoms reported on unprompted measures would capture only the most distressing or troublesome SCCs. But such individuals may still endorse experiencing other SCCs when provided with a prompt as in the case of a questionnaire. Lastly, there is some evidence that employment of compensatory strategies may moderate the relationship between memory functioning and psychological distress which could further explain the present results (Burt, Zembar, & Niederehe, 1995).

Analyses of Coding and Symbol Search subtest scores on the Memory Difficulties Survey found no significant relationship between information PS and CR. While these findings do not definitively disprove that the protective effect of CR does not apply to PS in the context of reporting SCCs, they indicate that this is a plausible hypothesis. As outlined in Chapter 1, PS is believed to underlie the performance of other cognitive abilities, for example WM and memory. Therefore, any overt age-related changes in PS may contribute to negative perception of cognitive performance and could become expressed as SCCs. Further research is required to clarify these findings.

Lastly, it was found that individuals appraised as higher CR reported using more compensatory strategies based on external aids. However, no significant results were found between individual education attainment levels. It was expected that all dimensions of compensatory strategy use would be significantly higher in higher CR given that CR was previously found to be positively correlated with both external and internal compensatory strategy use (Frankenmolen et al., 2018). It is possible that these results were affected by the population that the sample was drawn from, i.e., individuals who self-reported predominantly memory difficulties. Compared to the general population, such individuals may already be more likely to employ compensatory strategies due to their subjective perceptions of cognitive difficulties and experiencing heightened stress (Garrett et al., 2010).

A number of further research hypotheses were addressed in Part B of the present research. As hypothesized, awareness of age-related cognitive change was found to be significantly associated with the use of compensatory strategies in normal aging in that higher score on AARC corresponded to higher engagement of compensatory strategies. AARC was also found to be significantly related to affective distress in this population in that an increase in AARC score corresponded to an increase in self-reported affective distress. It appears that knowing more about cognitive aging may not in itself be protective against experiencing symptoms of depression, anxiety, or stress. Given that higher AARC was also related to higher use of compensatory strategies, it may prompt individuals to seek ways to remedy their difficulties, however it remains unclear whether such strategies are effective at ameliorating their complaints and related distress. To further explore the relationship between AARC and reporting of affective distress, and whether employment of compensatory strategies significantly mediates this relationship, a study utilising a longitudinal design is required to track changes over time as compensatory strategies are progressively implemented by participants.

The overarching goal of Part B was validation of a model of influence on reporting SCCs in two distinct populations. The adjusted model consisting of AARC, affective distress, PS, CR, and compensatory strategies accounted for 47.6% of variance in reporting of SCCs in normal aging. Of the five factors, AARC and affective distress were found to significantly relate to the reporting of SCCs, as has been reported by Tang et al., (2018). However, the remaining three factors did not reach statistical significance which was surprising given that existing research supported relevance of all the factors in SCCs, including PS (Burmester et al., 2017), CR (Perquin et al., 2015), and compensatory strategies (Robinson, Rickenbach, & Lachman, 2016). Although the reason for this outcome remains unknown, possible explanations are that in real life there is no relationship between these factors and SCCs, or that the present research did not have adequate statistical power, i.e., the ability to correctly reject the null hypothesis of no significant effects. Although the minimum sample size to satisfy the requirements for SEM was exceeded more than twofold, it is possible that it was still not large enough to detect what would have likely been a small to medium effect size. It is also possible that a characteristic of the sample which was not captured by the questionnaires influenced this result. Further research is required to clarify these results.

As hypothesized, affective distress was positively related to reporting of SCCs and it was observed that for every 1 *SD* increase in affective distress, SCCs increased by 0.34 *SD*. This result is consistent with research that demonstrated significant associations between different dimensions of affective distress including depression, anxiety, and stress, and reporting of SCCs (e.g., Mascherek, Werkle, Goritz, Kuhn, & Moritz, 2020; Topiwala et al., 2021). These results reinforce the importance of assessing for symptoms of affective distress in individuals who report SCCs.

Although AARC in cognition was found to be significantly related to SCCs, the obtained result contradicts the hypothesis of an inverse relationship between AARC in cognition and SCCs. Contrary to expectations, it was found that for every 1 *SD* increase in AARC in cognition, SCCs *also increased* by 0.43 *SD.* One potential explanation for this result is that individuals who participated in research survey were inclined to do so out of personal interest. Specifically, they may have already been noticing changes or difficulties in cognitive performance which prompted them to research this topic. This, in turn, may have enhanced their knowledge of cognitive aging which led to refinement of their beliefs and more accurate perceptions without necessarily resolving their initial difficulty. In this case, such individuals would still report their perceived SCCs, but their responses to the AARC questionnaire would have changed to reflect knowledge acquired through own research. The method of assessment of SCCs should also be considered here for two main reasons. First, the measure used to assess SCCs consisted of questions on minor cognitive errors which are common and non-specific, and therefore endorsement of items on this questionnaire is likely to fluctuate depending on individual factors. Second, using prompted questionnaires may lead to over-reporting of SCCs, possibly due to individuals attempting to accurately represent their individual experience of SCCs.

In the mTBI population, this model was found to account for 62.5% of variance in reporting of SCCs. Of the five factors included in the model, four factors including AARC, affective distress, PS, and compensatory strategies were found to significantly relate to reporting of SCCs. Although the pathway coefficient between CR and SCCs was not significant, this could again be related to insufficient statistical power, particularly given that the sample in Study 2 was significantly smaller compared to Study 1. An even smaller sample size has likely hampered the ability to reliably detect a significant, small to moderate size effect. Another possibility is that CR is not related to reporting of SCCs, however given the results from Part A of the study, this appears to be a less likely explanation. It is also possible that instead of being directly linked to SCCs, CR could be a factor that moderates the relationship between other factors and SCCs. Further research is required to clarify the associations between CR and reporting of SCCs.

AARC was again found to be positively related to SCC in this population. Specifically, it was found that for every 1 *SD* change in AARC, SCCs increased by 0.46 *SD*. This is comparable to results obtained in normal aging population and may suggest that AARC remains consistent across different populations. A possible explanation of the obtained result is that higher awareness of age-related change is unlikely to reduce reporting of SCCs, and that if the goal is to reduce reporting of SCCs, a more proactive approach is required. Theoretically, higher AARC could help facilitate identification, implementation, and evaluation of suitable approaches, but in itself is not guaranteed to minimise reporting of SCCs. However, this theory requires further empirical exploration.

Affective distress was also found to be positively related to SCCs in the mTBI population in that every 1 *SD* change in affective distress corresponded to 0.27 *SD* increase in SCCs. This is congruent with previous research that demonstrated significant associations between heightened psychological distress and reporting of SCCs after mTBI (e.g., Stillman, Madigan, Torres, Swan, & Alexander, 2019). However, it is important to highlight that this appears to be less than previously observed in normal aging. As the present study was cross-sectional and the sample consisted of individuals at different stages of recovery after mTBI, including those who had already recovered, this may suggest that reporting of affective distress and its relationship with reporting of SCCs could be independent from the injury. However, both of these hypotheses require further clarification through research.

It was found that higher PS scores were positively associated with reporting of SCCs. However, it is important to note that in the present research, *higher* PS scores corresponded to *slower* PS. whereas traditionally higher PS scores indicate faster PS, and therefore better PS functioning. This is because the latent variable of PS consisted of two observed RT task scores where *longer* time to process information resulted in a *higher* score. Therefore, the results indicate that slower processing of information is associated with reporting of more SCCs. For every 1 *SD* increase in PS score, SCCs were found to increase by 0.15 *SD.* As outlined in Chapter 1, SCCs appear to be unrelated to objective cognitive functioning, and therefore this result may be surprising. One explanation of this result could be that in the mTBI population, the temporary injury-related decline in PS and cessation of usual activities is perceived by affected individuals as particularly distressing and disruptive. Furthermore, the affective consequences of this continue despite the subsequent recovery to approximately similar level of PS functioning. It is also possible that compared to their other cognitive abilities, such individuals had a relatively slower PS to begin with. More research exploring the relationship between PS and SCCs in mTBI is needed to clarify this.

Lastly, engagement of compensatory strategies was positively related to reporting of SCCs. It was found that for every 1 *SD* increase in compensatory strategies, SCCs increased by 0.23 *SD*. This result is somewhat surprising considering that compensatory strategies are usually employed by individuals to mitigate the effects of any perceived cognitive difficulties. Several assumptions could be drawn from this result. First, compensatory strategies employed by individuals may be ineffective at mitigating subjective difficulties, either because the strategies used are inappropriate to identified difficulty, or because they are used incorrectly. It could also be that it is the emergence of SCCs that prompts the use of compensatory strategies in an attempt to reduce any perceived difficulties. It is further possible that use of strategies was over-reported by individuals, and so they may have endorsed use of a particular strategy based on knowledge that such strategy exists, rather than the actual frequency of use. And lastly, assuming that these compensatory strategies are appropriate to the identified difficulties, this result could reinforce the hypothesis that in mTBI, SCCs are unrelated to objective cognitive functioning. Rather, reporting of SCCs could be due to other factors, for example affective distress, and therefore compensatory strategies based on cognitive remediation would be ineffective at reducing these complaints. Further research is required to clarify this result, and it is recommended that this includes exploration of any potential barriers to use of compensatory strategies.

Part B also included an open-ended question which asked participants to make a causal attribution of their identified cognitive difficulty. It was hypothesized that in normal aging population, these difficulties will be most frequently attributed to affective symptoms, attention, and memory functioning. This hypothesis not supported. However, it was found that amongst all coded categories, aging accumulated the highest proportion of responses (30.7%) which means that the remaining 69.3% responses named a perceived cause other than aging. The next three most frequently reported causes included affective distress (22.1%), attention/concentration (21.2%), and memory functioning (8.6%). Given that all three of these attribution categories were considered in the initial hypothesis (i.e., *In the general population, cognitive difficulties will be more frequently attributed to affective symptoms, attention, or memory functioning than normal aging.*), it could be argued that together they make up 51.9% of responses which is considerably more than 30.7% reported for aging. However, it is acknowledged that this wording could be open to interpretation and ideally it would have been made more specific at the research planning stage.

It was hypothesized that in mTBI population, the causal attributions will most frequently pertain to the traumatic injury, and less often to the process of normal aging. This hypothesis was not supported as the coded attribution category with the highest proportion of responses was aging (31.5%). In comparison, only 14% of individuals indicated mTBI as the perceived cause of their cognitive difficulty. Of note is that the present sample is representative of individuals who reported to have had a mTBI, and therefore this figure may in fact reflect the proportion of individuals in the sample who perceive any present difficulties as chronic. This is consistent with previous research which indicated prevalence of chronic complaints to be between 8% and 25% across different age groups (i.e., Balakrishnan et al., 2019; Levin & Diaz-Arrastia, 2015).

To summarise, Part B of the study provided unique insights into the phenomenon of SCCs reported in normal aging and after mTBI. The results in both populations provided support for the five-factor model where AARC, affective distress, PS, CR, and compensatory strategies influence reporting of SCCs. They also emphasized the potential associations between AARC and affective distress, and use of compensatory strategies, highlighting the importance of inclusion of AARC in future research in this field.

Limitations

Several limitations of the present research were identified. As previously noted, the two databases in Part A recruited only individuals who perceived themselves as having memory difficulties. While results obtained from this part of research provide some insight into relationships between analysed constructs, there is no certainty that they can be extrapolated to the general population as the studied samples did not include individuals who do not consider themselves to have cognitive difficulties. A further limitation pertains to the use of the Memory Difficulties Survey database as it did not include responses from individuals younger than 40 years.

A significant limitation of conducting secondary analyses using pre-existing datasets in that they often do not contain measures or variables of interest, i.e., research using this type of data is limited to the variables in the database. In Part A, both databases contained only one proxy measure of CR (educational attainment). As outlined in Chapter 2, it is preferable to use a combination of several proxy measures of CR as using a single measure may be insufficient to provide an accurate estimate of one’s CR. It was also noted that the groups comprising the educational attainment were uneven, particularly in The Memory Difficulties Survey database where one of the groups consisted of only two responses. Furthermore, the measurement of psychological distress in the Memory Performance Survey dataset was through single-item questions which is unlikely to be as accurate and valid as using a longer, structured measure of affective distress.

One further limitation is related to the fact that both databases in Part A were not created specifically to test hypotheses in the present research. It is, therefore, possible that failure to support hypotheses is related to insufficient statistical power that would enable correct rejection of null hypothesis of no effect, rather than actual lack of significant relationship between variables. This uncertainty also applies to analyses which found no evidence to reject null hypothesis of no significant relationship between CR and PS. A significant relationship between these constructs may, in fact, exist, but it was not able to be detected in this part of the study.

Further limitations pertain to Part B of the present research. Recent advances in technology and a rapid expansion of the smart device market has significantly influenced how people interact with academic research. Participation in research appears to have increased as individuals are able to access the relevant studies more easily and at a time that suits them. It has also facilitated access to research by individuals who live in more remote parts of the country. In the present research, the majority of individuals who completed the survey using a touchscreen device appeared to have done so during their commute to and from work, and during lunch breaks. The uptake of survey by individuals located outside of the place of residence of chief researcher was also significant, increasing the diversity of sample.

However, the ever-evolving variety in technology and devices offered to consumers pose unique challenges to designing and hosting research surveys. One of such challenges resulted in the most significant limitation of the present research related to a large proportion of missing data on the two interactive RT tasks. Specifically, the issue of measuring touchscreen device latency was highly problematic in the context of RT tasks programmed specifically for the present research. In this situation, latency refers to the time delay between input of data (i.e., touching the response on touchscreen) and how long it then takes for this data to reach its' destination (i.e., being recorded and responded to by the software). This latency varies between types of devices and their manufacturers, and as this information is not available in the public domain, it can only be obtained through careful measurement in a specialist lab setting. The variability in latencies can be highly significant, and existing research estimated that touch latency in personal use devices can reach between 50 ms and 200 ms (Ikematsu, Tsubouchi, & Yamanaka, 2020). In time-sensitive tasks, the compounding effect of latency (which occurs each time a response to stimuli is required) can significantly alter the results and likely render them invalid. It was identified that the only solution to the issue of device latency would be to measure latency for each smart device available on the New Zealand market and embed an adjustment for these values in the design of the RT tasks. However, the number of devices available and in development at the time of recruitment of research participants rendered this task not possible. It was also recognized that using touchscreen devices to complete these tasks would further introduce the possibility of losing time due to missed touches, and response errors due to spurious responding which can occur when the initial response is not recorded and the screen is not refreshed at the pace expected by user.

Due to the desired number of participants, no feasible alternative solution was identified. The decision was thus made to make the RT tasks available only to individuals completing the survey using a computer. This meant that RT values for individuals who used a touchscreen device (e.g., a mobile phone or tablet) to complete their survey had to be statistically imputed and thus introduce uncertainty to the validity of analyses using this data. However, the researcher attempted to mitigate this risk by including information about this condition in the information sheet and encouraging potential participants to complete the survey on a computer. This was intended to increase the number of participants who were able to complete the interactive tasks and therefore enhance robustness of study sample.

A further limitation of using computerised RT tasks as proxy measure of PS is that while they are useful in quantifying PS, their ability to predict PS performance in real life is unclear. In older adults, computerised tests may have reduced utility in estimating everyday cognition (Rumpf, Menze, Muller, & Schmicker, 2019) and may be insufficiently sensitive to differentiate between memory problems and difficulties in information retrieval due to slower PS. This could further explain the apparent lack of significant association between PS and SCCs in Study 1 Normal Aging in that an underlying significant association was not found due to limitations of selected assessment measures of PS. It is also acknowledged that the research did not include any measures of effort. Future research in this area may, therefore, consider utilising ecologically valid measures of PS (e.g., everyday tasks that involve optimal PS performance such as basic mathematical operations, copying figures, or sorting objects) in addition to computerised or more traditional pen-and-paper PS tasks, and validity testing.

Another limitation is related to the use of online means to recruit research participants. Whilst it appeared to be an effective tool in obtaining a large number of responses, it is likely to have had limited access to individuals living in areas of New Zealand where the access to internet is inconsistent. It may further have been problematic to access by individuals who could not afford to pay for an internet connection, and by individuals who did not own a device capable of running the survey and task with minimal interruptions. The survey design included an option to pause and resume the survey within two weeks of registering of initial interest which meant that in an instance of broken internet connection, such individuals were able to resume the survey at a later date. However, it is unclear if this survey function was utilised by participants.

A further potential limitation of the survey was the lack of a user-friendly option to highlight missed responses and feedback this information to participants. The prompt available in the survey closely resembled the forced response option in that it did not allow individuals to dismiss the screen prompt and proceed with the survey easily. It was identified by the researchers that such an option may be confusing for participants and potentially result in greater user error or non-completion of the remainder of this survey. There was also no certainty whether such questions were omitted by chance or deliberately, and it was deemed that inserting a prompt could be viewed to be in conflict with the ethical commitment of allowing participants to not respond to certain questions. However, if a more gentle and user-friendly way of identification of missed responses was available, it may have reduced the amount of missing data points.

It was intended that the sample recruited through online survey would reflect that of the general population of New Zealand. However, demographic information revealed that recruitment fell short of this expectation, with individuals of New Zealand European descent constituting the majority of study sample. While individuals who identify as Māori, Pacific, or Asian did participate in the survey, the proportion of these ethnicities in study sample does not accurately reflect that of New Zealand general population. Therefore, the results of present research should be interpreted with caution as they may be less relevant to these ethnic groups. It is recommended that future research in this area considers how participation of these ethnic group could be encouraged, and this may include revision of the online survey format, in person recruitment, and face-to-face engagement with communities.

It is also acknowledged that the survey in Part B did not exclude individuals who may have been reporting SCCs and who had been diagnosed with a specific physical or mental health illness, for example dementias (Lehrner et al., 2015), bipolar disorder (Toyoshima et al., 2019), HIV/AIDS (Sheppard, Woods, Massman, & Gilbert, 2019), and psychotic illnesses (Koyanagi et al., 2020; Sellwood et al., 2013). These conditions have been demonstrated to potentially result in significant functional difficulties and have been associated with objective cognitive decline. However, as this was outside of the scope of the present thesis and such individuals represent a part of the general population of New Zealand, they were not excluded from participation.

While attempts were made to engage different groups of individuals in the survey, the majority of respondents appear to have achieved a higher level of education. Consequently, such individuals may have been over-represented in the survey, and this is likely to be problematic for at least two reasons. First, it is possible that such individuals sought to engage in the survey out of personal interest, i.e., they may have already done prior research pertaining to cognitive concerns specific to their personal situation. If that were the case, responses provided may have been altered as a result of enhanced knowledge or understanding of this topic. As the survey did not ask about prior knowledge, it is difficult to know how much this was a factor. The second reason pertains to CR, specifically to the hypothesis that individuals with higher educational attainment are believed to have a higher level of CR. Literature suggests that higher level of CR is related to higher functioning across different domains, including cognitive and emotional (e.g., Amoretti et al., 2020; Huang et al., 2019; Opdebeeck et al., 2016) and it could, therefore, act as a confounding factor. Such individuals may experience less functional difficulties related to an underlying cognitive problem, possibly as a result of their ability to implement effective compensatory approaches to mitigate their difficulties. A thorough face-to-face assessment would be necessary to precisely ascertain whether this was the case.

A further limitation related to CR is that the proxy measures identified through literature review appeared to not converge well. Previous research noted that as proxy measures such as education, occupational attainment, leisure activities, and caregiver occupational attainment are inherently different constructs, issues of convergence may arise (e.g., Scarmeas & Stern, 2003). However, the use of individual proxy measures appeared to still be the most widespread in research in this field. In the research planning stage, use of a CR questionnaire was also considered, however there appeared to be insufficient support for use of such measures. This was due to limited studies exploring psychometric properties of these instruments, inadequate reporting of measurement properties, and lack of evidence for use in normal aging population (Kartschmit, Mikolajczyk, Schubert, & Lacruz, 2019). As the majority of studies exploring CR utilised individual proxy measures with good results, the decision was made to adapt this approach. A further potential advantage of using individual proxy measures was that this allowed for use of an employment classification system that is widely used in New Zealand by agencies such as ACC, and therefore enhance the accuracy of classification in the local context. However, initial measurement modelling highlighted low factor loadings for caregiver occupational attainment and leisure activities, raising the possibility that in this instance they may not be valid indicators of CR. Consequently, these two proxy measures had to be removed from the model.

There are two further limitations relevant to the mTBI population. First, it is recognized that for the benefit of survey brevity, more thorough screening questions based on diagnostic criteria for mTBI were omitted. Although the accuracy of classification of individuals into their respective groups (e.g., normal aging and after mTBI) may have been enhanced this way, it is still difficult to ascertain if individuals who were not formally diagnosed with mTBI by a medical professional would be able to be identified that way. It is also uncertain whether some individuals may have been classified as having had a mTBI when in fact their experience was related to another mechanism of injury. Another limitation is not explaining technical terms in the survey, for example the meaning of mnemonics, and omission of more detailed explanation of terms such as ‘concussion’ and ‘mTBI’.

Lastly, a more general limitation of the present study is that the research hypotheses involved causal effects, but the data used in analyses was cross-sectional and controls for confounding variables were not applied. It was also not possible to manipulate the causes of interest in the real world as would otherwise be expected of a randomized experiment, the widely accepted gold standard for inferring causal effects (Field, 2019). Consequently, the validity of the estimates of presented effects needs to be interpreted with caution. Further inquiry into the proposed models using diverse research designs is recommended in order to increase confidence in the obtained results.

Recommendations

Although in the model, higher AARC was associated with reporting of more SCCs, psychoeducation on changes that occur in the course of normal aging may still, in some cases, be a helpful intervention. It appears that while increasing one’s AARC may enhance the ability to identify even very mild cognitive difficulties (and therefore increase their prompted reporting of SCCs), it is unlikely to lead to significant distress in those who do not experience major cognitive difficulties. This is because previous research demonstrated that prompted SCCs are frequently reported as less distressing than unprompted SCCs (Burmester et al., 2017). Psychoeducation could be delivered in the form of informational booklets or a face-to-face intervention in either individual or group format, depending on the setting and the ability of clients to access these resources (Lukens & McFarlane, 2004). However, it is advised that providers of such an intervention screen for symptoms of affective distress and connect individuals with appropriate supports where required. The potential benefit of enhanced awareness is that it may lead to improvements in the ability to identify and implement appropriate compensatory strategies which could, in turn, lead to improvements in other significant areas of functioning. On the other hand, Part B of the present research found that higher AARC was related to higher reporting of affective distress, and therefore psychoeducation may not be a suitable intervention for individuals who are already experiencing heightened burden of psychological symptoms. In such instances, individual psychological assessment and treatment may be more appropriate in the first instance before other approaches are considered.

The results of content analysis raised the possibility that individuals can be both aware of changes that occur in cognition in the course of aging and still perceive another cause as the explanation for their difficulties. While these attributions may be correct for some, as in the case of reduced concentration in individuals experiencing major depression (American Psychiatric Association, 2013), others may hold inaccurate perceptions of their difficulties. This could be preventing them from seeking appropriate supports and successfully mitigating the effects of identified difficulties. In such cases, psychoeducation may help to correct erroneous attributions. However, as the present research did not aim to appraise the accuracy of each individual attribution, further research is needed to test the validity of this assumption.

The present research demonstrated a significant association between affective distress and reporting of SCCs. Therefore, for individuals with milder symptoms of depression and/or anxiety, relatively intact motivation, and an established support system, interventions could include self-help resources such as online therapy, phone apps, and books, or brief therapeutic input. In contrast, individuals who experience heightened levels of distress, who have fewer social supports available, and who experience suicidal thoughts would require a more individualised treatment approach that is likely to include psychological assessment and treatment, pharmacological treatment, and support from local mental health services (Malhi et al., 2015). Addressing this should take priority over implementation of other interventions.

Additionally, professionals working with individuals who report SCCs are encouraged to explore the level of stress experienced across different areas of their life. Relevant areas may include for instance interpersonal, occupational, or educational, and this would ideally be followed by training in appropriate stress management strategies, for example mindfulness or relaxation (Chiesa & Serretti, 2009; Stillwell, Vermeesch, & Scott, 2017; Wright, 2018).

The above recommendations pertaining to AARC and affective distress also extend to include individuals who report SCCs after mTBI. Ideally, these would be further customised to enhance their relevance in the context of mTBI. Due to the observed associations between slower PS and SCCs in this group, psychoeducation could be further enhanced by inclusion of information on PS and how aging affects its functioning. In individuals who report a high number of SCCs, a cognitive assessment with particular focus on PS may also be considered to assist with making relevant recommendations, for example strategies for accommodating a relatively slower PS. However, in line with research showing no associations between SCCs reported in mTBI and objective cognitive functioning, it would be expected that obtained scores would be congruent with estimated baseline functioning. Lastly, more research is required to investigate PS functioning in individuals who report ongoing complaints post-mTBI, and to clarify its' role in reporting SCCs.

Further research is also required to clarify the positive association between use of compensatory strategies and SCCs in mTBI popuation. As previously discussed, it is unclear if the SCCs that these strategies aim to mitigate are reflective of objective difficulties. If they are not, such strategies would be unlikely to bring about any significant change. However, it is also possible that the strategies used are not appropriate to the noted difficulty, and therefore an assessment of present compensatory strategies followed by compensatory strategy training may be considered as an intervention aimed at reducing reporting of SCCs.

Unique Contribution

To the knowledge of the researcher, this is the first research which utilised SEM in assessing the influence of factors on reporting SCCs in normal aging and after mTBI. Furthermore, the proposed model of influence on reporting SCCs that includes AARC, affective distress, PS, CR, and compensatory strategies has not been previously defined in research. Another unique contribution is the AARC questionnaire which was developed and validated specifically for the purpose of the present research as no previous studies exploring AARC were identified in the course of literature review. This research also addressed a number of questions pertaining to AARC and CR which have not been looked at previously.

It was intended for this research to contribute to the field of clinical psychology through clarification of factors that influence the reporting of SCCs in normal aging and after mTBI, and the recommendations for clinical practice and future research as outlined in the previous section. Advancing the knowledge of aetiology and management of SCCs is important as it is common for individuals to seek clarification and support for their identified difficulties, and they are often highly concerned about their symptoms. This research also intended to advance the knowledge and clinical management of SCCs reported after mTBI, with the hope that this will result in improved outcomes for the people of New Zealand.

Conclusion

The present research was first to link factors including AARC, affective distress, PS, CR, and use of compensatory strategies to reporting of SCCs in normal aging and after mTBI. Further research in this area may benefit from increasing sample sizes and considering alternative options to measure CR and PS. The results showed that this is a promising avenue for exploration in future research pertaining to SCCs in these two populations.

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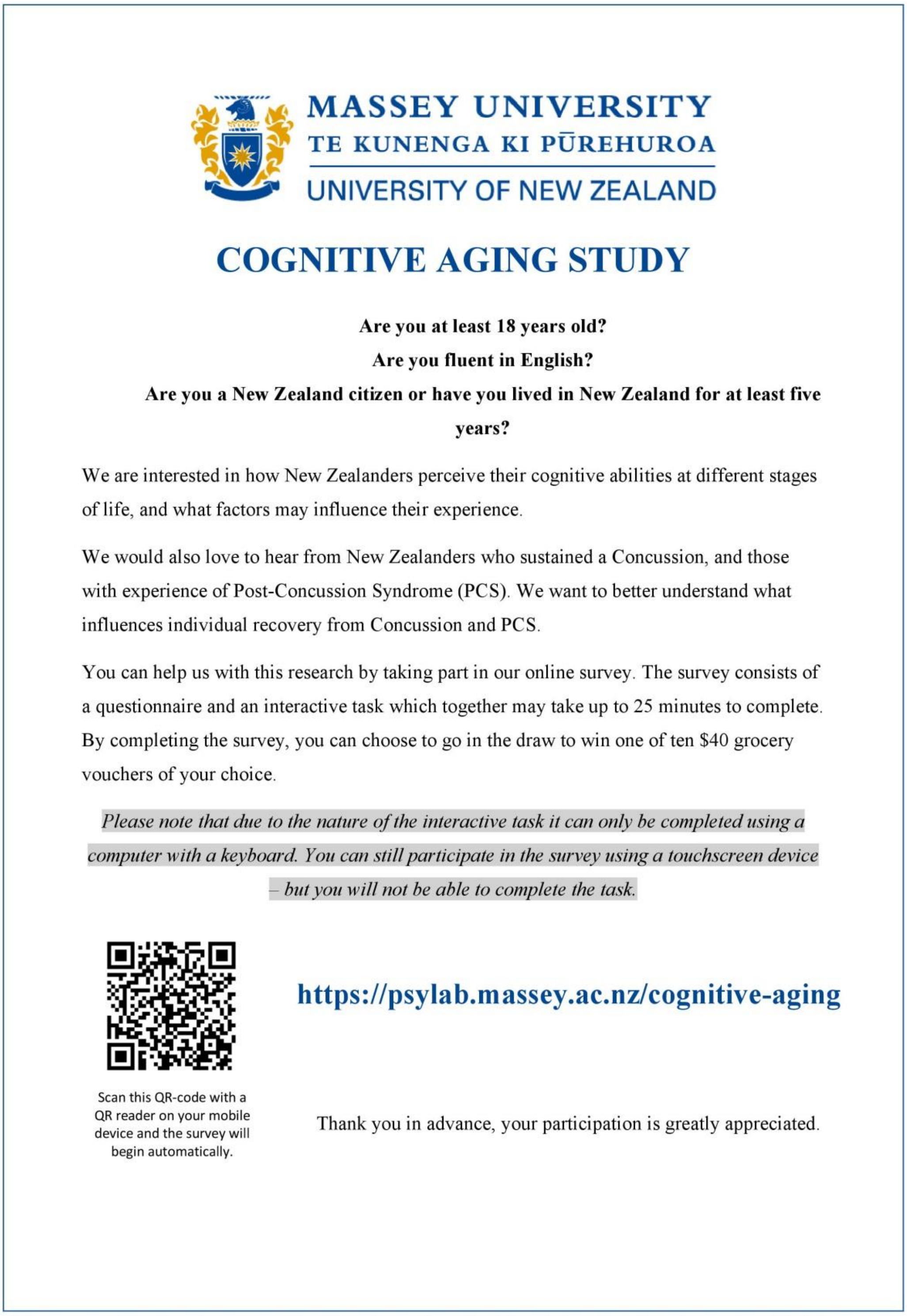
APPENDICES

Appendix A: Survey Poster



MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

COGNITIVE AGING STUDY

Are you at least 18 years old?

Are you fluent in English?

Are you a New Zealand citizen or have you lived in New Zealand for at least five years?

We are interested in how New Zealanders perceive their cognitive abilities at different stages of life, and what factors may influence their experience.

We would also love to hear from New Zealanders who sustained a Concussion, and those with experience of Post-Concussion Syndrome (PCS). We want to better understand what influences individual recovery from Concussion and PCS.

You can help us with this research by taking part in our online survey. The survey consists of a questionnaire and an interactive task which together may take up to 25 minutes to complete. By completing the survey, you can choose to go in the draw to win one of ten $40 grocery vouchers of your choice.

Please note that due to the nature of the interactive task it can only be completed using a computer with a keyboard. You can still participate in the survey using a touchscreen device – but you will not be able to complete the task.

https://psylab.massey.ac.nz/cognitive-aging

Scan this QR-code with a QR reader on your mobile device and the survey will begin automatically.

Thank you in advance, your participation is greatly appreciated.

Appendix B: Survey

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

COGNITIVE AGING SURVEY

INFORMATION SHEET

Thank you for your interest in this survey. This research is conducted by Dominika Watts for the fulfilment of the requirements for the degree of Doctor of Clinical Psychology at Massey University.

If you are a New Zealand citizen or have lived in New Zealand for more than five years and are at least 18 years old, you are invited to participate in the current research. This survey will ask you to reflect on your cognitive abilities as they are currently, and in the past. It will request that you indicate whether you have ever experienced a neurological event, list any symptoms you may still be experiencing, and provide brief demographic information. It also involves completion of a two-part, 5-minute task measuring the speed of your responses. The survey and interactive task will take approximately 25 minutes to complete.

Due to the nature of the interactive task, it can only be completed using a computer/laptop. If you use a touchscreen device to complete this survey, you will find that the task does not load – this is normal. This will not affect your survey responses and they will be recorded. The interactive task is compatible with the following browsers: Google Chrome, Mozilla Firefox, Microsoft Edge, Safari, and newer versions of Internet Explorer. To complete the task, please ensure that JavaScript is enabled. To see if JavaScript is enabled in your browser, or to access instructions how to enable it, please visit https://www.enable-javascript.com/.

The survey will also ask about any brain injury that you may have had, and your mood. Should you experience any discomfort while answering the questions, we encourage you to seek support through free services, your primary health practitioner, and your trusted family members and friends. The support services are listed in the survey.

This survey is anonymous – you will not be asked for your name or address. The data collected is confidential and unidentifiable. Access is limited to the main researcher and the supervisors as listed below. Data will be stored on a password-protected computer for a period of ten years after which it will be destroyed.

Completion and return of the questionnaire implies consent. You have the right to decline to answer any particular questions.

As a way to thank you for your participation, ten randomly selected participants will receive a $40 supermarket voucher. You can register your interest in the draw or request a summary of research findings by following a link towards the end of the survey and providing your e-mail address. It will be collected separately from your survey responses to ensure that your data is unidentifiable.

CONTACT DETAILS

Please do not hesitate to contact us should you have any concerns regarding this research or require any further information.

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This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application SOA 18/70. If you have any concerns about the conduct of this research, please contact Dr Lesley Batten, Chair, Massey University Human Ethics Committee: Southern A, telephone +00 64 6 356 9099 x 85094, email humanethicsoutha@massey.ac.nz

Q1 What is your age?

____

Q2 Are you a New Zealand citizen/resident?

○ Citizen

○ Resident

○ Other - please specify ____

Q3 How long have you lived in New Zealand?

○ Less than 5 years

○ More than 5 years

Q4 Which ethnicity do you most identify with?

- ○ NZ European
- ○ Māori
- ○ Samoan
- ○ Tongan
- ○ Niuean
- ○ Chinese
- ○ Indian
- ○ Other European
- ○ South African
- ○ Other - please specify ____

Q5 Which region do you live in?

- ○ Northland
- ○ Auckland
- ○ Waikato
- ○ Bay of Plenty
- ○ Gisborne
- ○ Hawke's Bay
- ○ Taranaki
- ○ Manawatu-Wanganui
- ○ Wellington
- ○ Tasman
- ○ Nelson
- ○ Marlborough
- ○ West Coast
- ○ Canterbury
- ○ Otago
- ○ Southland

Q6 Which gender do you most identify with?

- ○ Male
- ○ Female

Q7 What is your highest qualification?

○ Intermediate school attendance and below

○ High school attendance

○ Certificate or Diploma

○ Bachelor's degree

○ Post-graduate qualification (includes Master's and Doctoral degrees)

Q8 Please specify your most recent occupation (including position, i.e., senior member, manager).
Example: Hospitality - Cafe Manager

____

Q9 How many years have you worked in your current occupation?

○ Less than 1 year

○ 1 to 4 years

○ 5 years and above

Q10 Please specify your previous longest held occupation (including position, i.e., senior member, manager).
Example: Hospitality - Barista

____

Q11 How many years have you worked in your previous longest held occupation?

○ Less than 1 year

○ 1 to 4 years

○ 5 years and above

Q12 Growing up, what were your caregivers' longest held occupations?______________________

Q13 Have you ever experienced a neurological event (i.e., traumatic brain injury, stroke, epilepsy)? Please select all that are relevant.

- ☐ Traumatic Brain Injury
- ☐ Concussion
- ☐ Stroke
- ☐ Epilepsy or seizures
- ☐ Brain Tumour
- ☐ Other neurological condition (i.e., Parkinson's Disease, Huntington's Disease, Multiple Sclerosis)
- ☐ Other - please specify ____
- ☐ Not applicable

Q14 How severe was the traumatic brain injury?

- ○ Mild
- ○ Moderate
- ○ Severe

Q15 How long ago did you experience the traumatic brain injury?

- ○ Less than 3 months ago
- ○ More than 3 months ago
- ○ More than 6 months ago

○ More than 12 months ago

Q16 Do you continue to experience symptoms related to your traumatic brain injury? Please select all that apply.

☐ Headaches

☐ Low mood

☐ Anxiety

☐ Memory difficulties

☐ Difficulties with concentration

☐ Fatigue

☐ Dizziness

☐ Irritability

☐ Sleep difficulties

☐ Vision difficulties (including photophobia)

☐ Tinnitus

☐ Other - please specify ____

☐ Not applicable

Q17 Did you lose consciousness around the time of the concussion?

○ No

○ Yes - please enter how long did you lose consciousness for ____________________

Q18 Did you experience loss of memory or disorientation at the time of the concussion?

○ No

○ Yes - please enter how long did this experience last for ________________________

Q19 How long ago did you experience concussion?

○ Less than 3 months ago

○ More than 3 months ago

○ More than 6 months ago

○ More than 12 months ago

Q20 Do you continue to experience symptoms related to the concussion? Please select all that apply.

☐ Headaches

☐ Low mood

☐ Anxiety

☐ Memory difficulties

☐ Difficulties with concentration

☐ Fatigue

☐ Dizziness

☐ Irritability

☐ Sleep difficulties

☐ Vision difficulties (including photophobia)

☐ Tinnitus

☐ Other - please specify ____

☐ Not applicable

Q21 Have you ever been knocked out?

○ No

○ Yes

Q22 How long were you knocked out for?

○ Less than 30 minutes

○ More than 30 minutes but less than 6 hours

○ More than 6 hours

Q23 Did you experience loss of memory or disorientation at the time of the injury?

○ No

○ Yes - please enter how long did this experience last for ________________________

Q24 How long ago were you knocked out?

○ Less than 3 months ago

○ More than 3 months ago

○ More than 6 months ago

○ More than 12 months ago

Q25 Do you experience any symptoms related to that event? Please select all that apply.

☐ Headaches

☐ Low mood

☐ Anxiety

☐ Memory difficulties

☐ Difficulties with concentration

☐ Fatigue

☐ Dizziness

☐ Irritability

☐ Sleep difficulties

☐ Vision difficulties (including photophobia)

☐ Tinnitus

☐ Other - please specify ____

☐ Not applicable

If you would like to obtain more information regarding your experiences or access support services, you can use any of the following free resources.
Neurological Foundation of New Zealand - https://neurological.org.nz/resources/other-neurological-organisations
Brain Injury New Zealand - https://www.brain-injury.nz/resources-links/

Stroke Foundation New Zealand - https://www.stroke.org.nz/free-resources
Epilepsy New Zealand - http://epilepsy.org.nz/resources

If you have any concerns regarding your health and would like to talk to a trained professional, you can contact Healthline New Zealand. It is a free service available 24/7.

Healthline - 0800 611 116

Q26 How would you rate your current level of physical health in relation to your peers?

○ Excellent

○ Good

○ Fair

○ Poor

○ Very Poor

Q27 Please rate the quality of social support available to you.

○ Excellent

○ Good

○ Fair

○ Poor

○ Very Poor

Q28 How often do you engage in the following leisure activities?

	Never	A few times a month or less	Once a week	Two to three times a week	More than four times a week
Sports and exercise	○	○	○	○	○
Reading and learning	○	○	○	○	○
Puzzles and crosswords	○	○	○	○	○
Social media	○	○	○	○	○
Visual media (i.e., TV, movies)	○	○	○	○	○
Entertainment - theaters, shows, concerts	○	○	○	○	○
Entertainment - other (game centers, theme parks)	○	○	○	○	○
Socialising	○	○	○	○	○
Gaming	○	○	○	○	○
Other - please specify	○	○	○	○	○

Please rate your responses to the following questions. Select one rating that feels the most applicable and try not to spend too much time on any one question. There is no right or wrong answer.

Q29 My cognitive abilities are not much different now than they were 10 years ago

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q30 I regularly think about how much these abilities have changed over the past 10 years.

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q31 I regularly compare my current cognitive ability to what it used to be when I was younger

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q32 I can identify a point in time when my cognitive abilities were at their peak

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q33 My memory is not much different now than it was 10 years ago

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q34 The speed at which I complete tasks (i.e., at work or leisure) is not much different now than it was 10 years ago

○ Very True

○ True

○ Neither True nor Untrue

○ Not True

○ Not True at all

Q35 My ability to make quick decisions is not much different now than it was 10 years ago

○ Very True

○ True

○ Neither True nor Untrue

○ Not True

○ Not True at all

Q36 My ability to concentrate on tasks and ignore distractions is not much different now than it was 10 years ago

○ Very True

○ True

○ Neither True nor Untrue

○ Not True

○ Not True at all

Q37 I find multitasking more challenging than 10 years ago

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q38 I have sought or plan on seeking ways to remedy my cognitive difficulties (examples: discussion with GP, use of self-help materials)

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q39 My difficulties make me concerned that I may be developing a more serious condition

- ○ Very True
- ○ True
- ○ Neither True nor Untrue
- ○ Not True
- ○ Not True at all

Q40 Do you experience any specific cognitive difficulties?

○ Yes

○ No

Q41 Please specify the difficulty you are experiencing and what do you think is the cause of this difficulty

☐ Difficulty ____

☐ Cause ____

Q42 The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. How often did these happen to you in the last six months?

	Very often	Quite often	Occasionally	Very rarely	Never
Do you read something and find you haven't been thinking about it and must read it again?	○	○	○	○	○
Do you find you forget why you went from one part of the house to the other?	○	○	○	○	○
Do you fail to notice signposts on the road?	○	○	○	○	○
Do you find you confuse right and left when giving directions?	○	○	○	○	○
Do you bump into people?	○	○	○	○	○
Do you find you forget whether you've turned off a light or a fire or locked the door?	○	○	○	○	○
Do you fail to listen to people's names when you are meeting them?	○	○	○	○	○
Do you say something and realise afterwards that it might be taken as insulting?	○	○	○	○	○
Do you fail to hear people speaking to you when you are doing something else?	○	○	○	○	○
Do you lose your temper and regret it?	○	○	○	○	○

Do you leave important letters unanswered for days?	○	○	○	○	○
Do you find you forget which way to turn on a road you know very well but rarely use?	○	○	○	○	○
Do you fail to see what you want in a supermarket (although it's there)?	○	○	○	○	○
Do you find yourself suddenly wondering whether you've used a word correctly?	○	○	○	○	○
Do you have trouble making up your mind?	○	○	○	○	○
Do you find you forget appointments?	○	○	○	○	○
Do you forget where you put something like a newspaper or a book?	○	○	○	○	○
Do you find you accidentally throw away the thing you want and keep what you meant to throw away - as in the example of throwing away the matchbox and putting the used match in your pocket?	○	○	○	○	○
Do you daydream when you ought to be listening to something?	○	○	○	○	○

Do you find you forget people's names?	○	○	○	○	○
Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	○	○	○	○	○
Do you find you can't quite remember something although it's 'on the tip of your tongue'?	○	○	○	○	○
Do you find you forget what you went to the shops to buy?	○	○	○	○	○
Do you drop things?	○	○	○	○	○
Do you find you can't think of anything to say?	○	○	○	○	○

Q43 Looking back at the responses to the previous question, how much of a problem are those mistakes for you in everyday life?

○ Very problematic

○ Quite problematic

○ Neither problematic nor unproblematic

○ Not problematic

○ Not problematic at all

○ I do not experience any mistakes

Q44 Please specify what do you think may be the cause(s) of these mistakes

____

Q45 Please read each statement and select a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time

2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

	0	1	2	3
I found myself getting upset by quite trivial things	○	○	○	○
I was aware of dryness of my mouth	○	○	○	○
I couldn't seem to experience any positive feeling at all	○	○	○	○
I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion)	○	○	○	○
I just couldn't seem to get going	○	○	○	○
I tend to over-react to situations	○	○	○	○
I had a feeling of shakiness (e.g., legs were going to give way)	○	○	○	○
I found it difficult to relax	○	○	○	○
I found myself in situations that made me so anxious I was most relieved when they ended	○	○	○	○
I had nothing to look forward to	○	○	○	○
I found myself getting upset rather easily	○	○	○	○

	0	1	2	3
I felt that I was using a lot of nervous energy	○	○	○	○
I felt sad and depressed	○	○	○	○
I found myself getting impatient when I was delayed in any way (e.g., lifts, traffic lights, being kept waiting)	○	○	○	○
I had feeling of faintness	○	○	○	○
I felt that I had lost interest in just about everything	○	○	○	○
I felt I wasn't worth much as a person	○	○	○	○
I felt that I was rather touchy	○	○	○	○
I perspired noticeably (e.g., hands sweaty) in the absence of high temperatures or physical exertion	○	○	○	○
I felt scared without any good reason	○	○	○	○
I felt that life wasn't worthwhile	○	○	○	○
I found it hard to wind down	○	○	○	○

	0	1	2	3
I had difficulty in swallowing	○	○	○	○
I couldn't seem to get any enjoyment out of the things I did	○	○	○	○
I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)	○	○	○	○
I felt down-hearted and blue	○	○	○	○
I found that I was very irritable	○	○	○	○
I felt I was close to panic	○	○	○	○
I found it hard to calm down after something upset me	○	○	○	○
I feared that I would be "thrown" by some trivial but unfamiliar task	○	○	○	○
I was unable to become enthusiastic about anything	○	○	○	○
I found it difficult to tolerate interruptions to what I was doing	○	○	○	○

	0	1	2	3
I was in a state of nervous tension	○	○	○	○
I felt I was pretty worthless	○	○	○	○
I was intolerant of anything that kept me from getting on with what I was doing	○	○	○	○
I felt terrified	○	○	○	○
I could see nothing in the future to be hopeful about	○	○	○	○
I felt that life was meaning less	○	○	○	○
I found myself getting agitated	○	○	○	○
I was worried about situations in which I might panic and make a fool of myself	○	○	○	○
I experienced trembling (e.g., in the hands)	○	○	○	○
I found it difficult to work up the initiative to do things	○	○	○	○

If you would like to talk to a trained professional about how you are feeling, or ask any questions, you can use one of the following resources.

NATIONAL HELPLINES

Depression helpline - 0800 111 757 or free text 4202

Lifeline - 0800 543 354 (0800LIFELINE) or free text 4357 (HELP)

Healthline - 0800 611 116

Samaritans - 0800 726 666

Suicide Crisis Helpline - 0508 828 865 (0508TAUTOKO)

Anxiety Helpline - 0800 269 4389 (0800ANXIETY)

WEBSITES

Depression and Anxiety - https://www.depression.org.nz/

Depression self-help resource - https://www.sparx.org.nz/

Apps, e-therapy, and self-help resources - https://www.mentalhealth.org.nz/get-help/a-z/apps-e-therapy-and-guided-self-help/

Q46 How often do you use the following strategies to enhance your cognitive performance?

	Never	Sometimes	About half the time	Most of the time	Always
Lists and planners	○	○	○	○	○
Calendars and diaries	○	○	○	○	○
Reminders (i.e., post-it notes, phone alarms)	○	○	○	○	○
Ask others for prompts and reminders	○	○	○	○	○
Bookmarks	○	○	○	○	○
Mnemonics, stories, peg words and similar	○	○	○	○	○
Categorizing and organizing	○	○	○	○	○
Mind maps	○	○	○	○	○
Breaking large tasks into smaller parts	○	○	○	○	○
Repeated practice and rote learning	○	○	○	○	○
Cognitive exercises (i.e., training games and tasks)	○	○	○	○	○
Taking more time to do tasks	○	○	○	○	○
Avoiding distractions when performing a task	○	○	○	○	○
Doing only one thing at a time	○	○	○	○	○

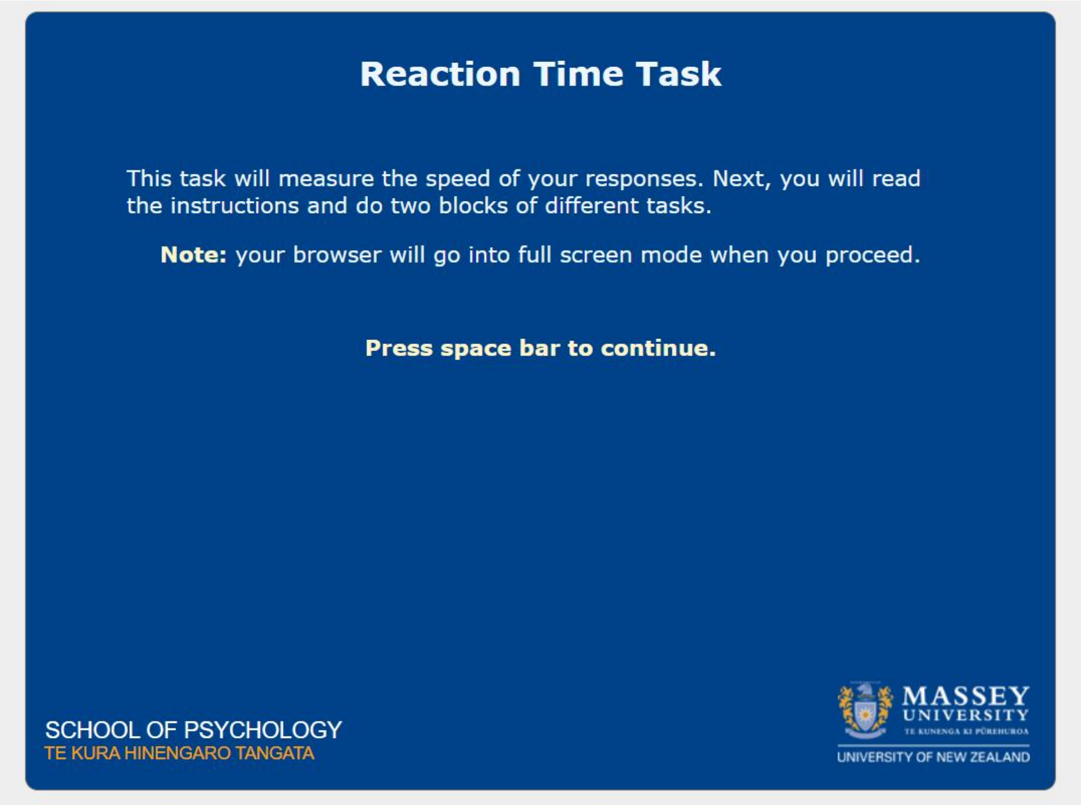
Other - please specify	○	○	○	○	○

Q47 The current task will measure the speed of your responses. It can only be completed using a computer or a laptop. Touchscreen devices are not supported at this stage. We apologize for any inconvenience this may have caused.

If you are using a touchscreen device, this is the end of the survey. Please click here to enter the prize draw or request a summary or research findings. If you are using a computer, you will be automatically redirected to the prize draw page after the interactive task is completed.

Please ensure you have enabled JavaScript and pop-up windows. To see if JavaScript is enabled in your browser, or to access instructions how to enable it, please visit https://www.enable-javascript.com/.

Please press the right arrow to continue. You will be automatically redirected.



Reaction Time Task

This task will measure the speed of your responses. Next, you will read the instructions and do two blocks of different tasks.

Note: your browser will go into full screen mode when you proceed.

Press space bar to continue.

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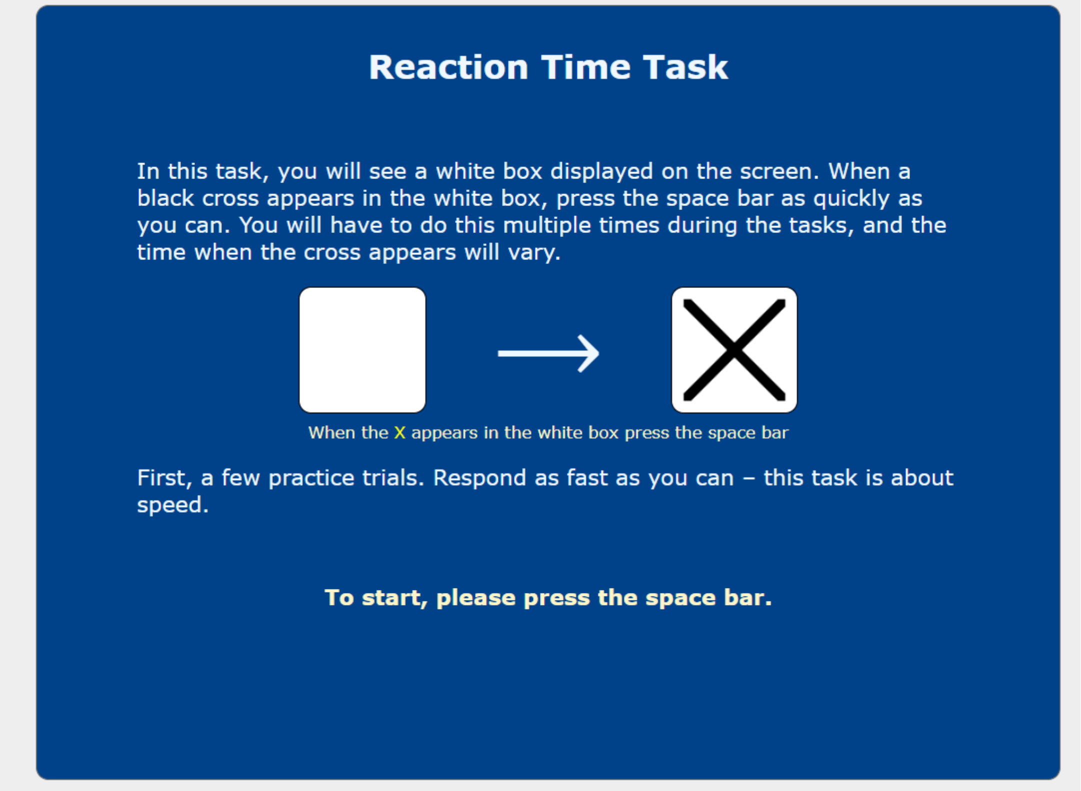


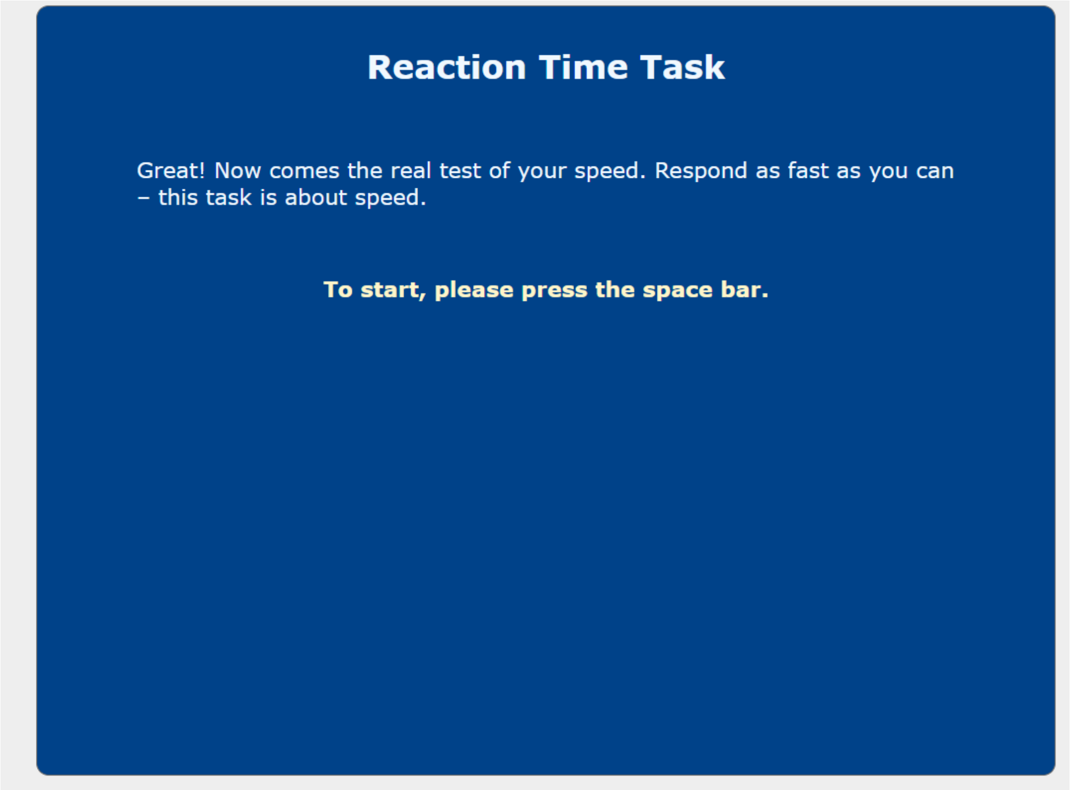
Reaction Time Task

In this task, you will see a white box displayed on the screen. When a black cross appears in the white box, press the space bar as quickly as you can. You will have to do this multiple times during the tasks, and the time when the cross appears will vary.

When the X appears in the white box press the space bar

First, a few practice trials. Respond as fast as you can – this task is about speed.

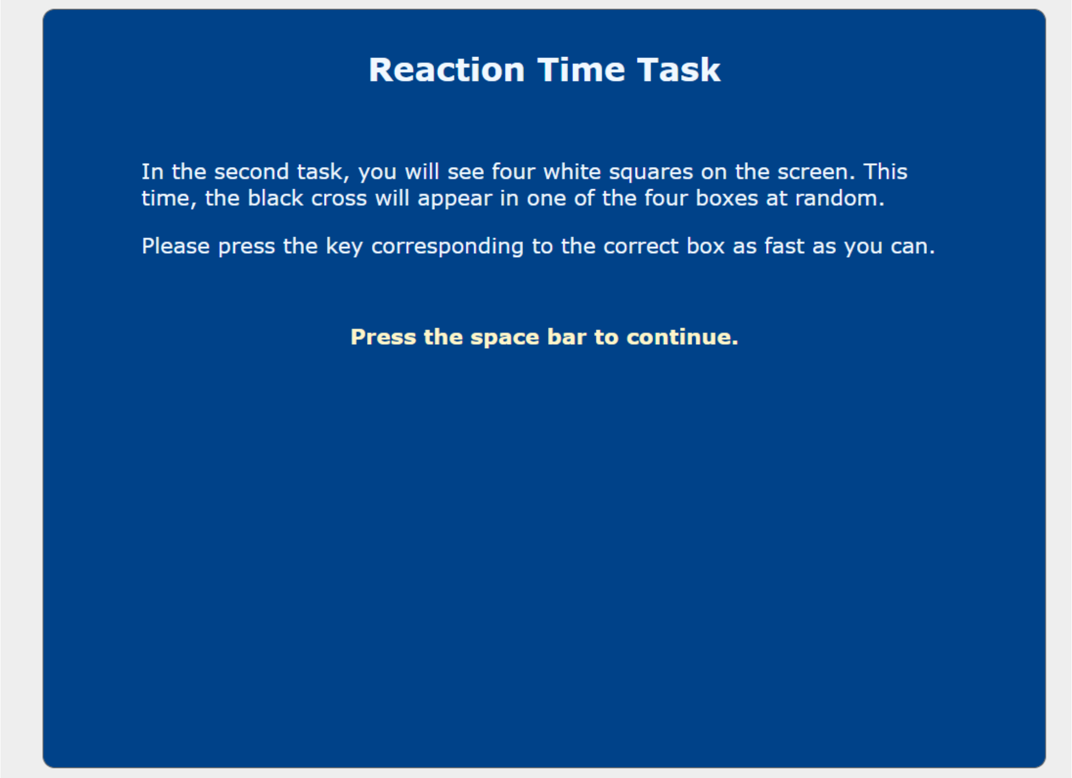
To start, please press the space bar.



Reaction Time Task

Great! Now comes the real test of your speed. Respond as fast as you can – this task is about speed.

To start, please press the space bar.

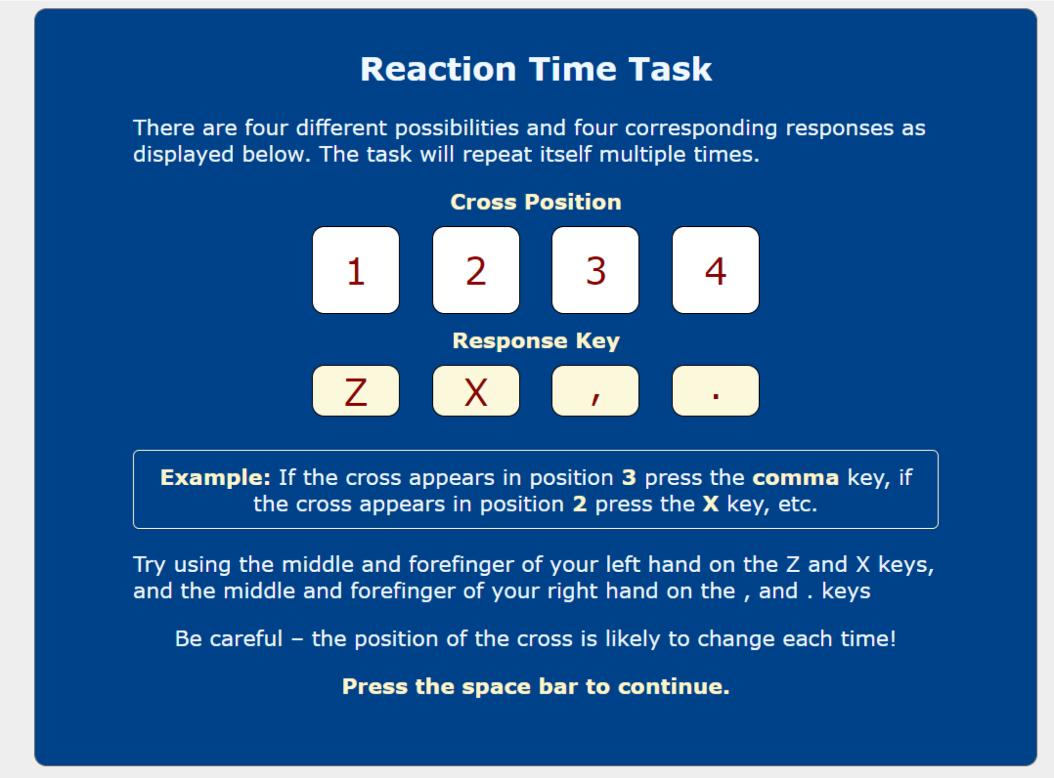


Reaction Time Task

In the second task, you will see four white squares on the screen. This time, the black cross will appear in one of the four boxes at random.

Please press the key corresponding to the correct box as fast as you can.

Press the space bar to continue.



Reaction Time Task

There are four different possibilities and four corresponding responses as displayed below. The task will repeat itself multiple times.

Cross Position

1 2 3 4

Response Key

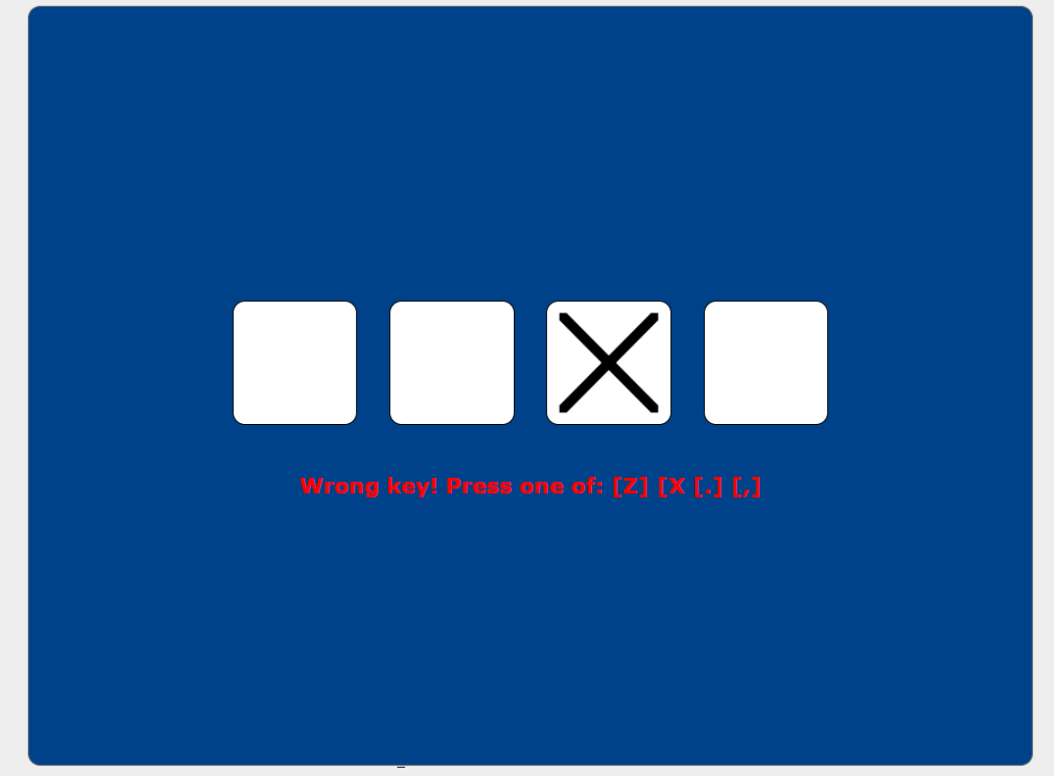
Z X , .

Example: If the cross appears in position **3** press the **comma** key, if the cross appears in position **2** press the **X** key, etc.

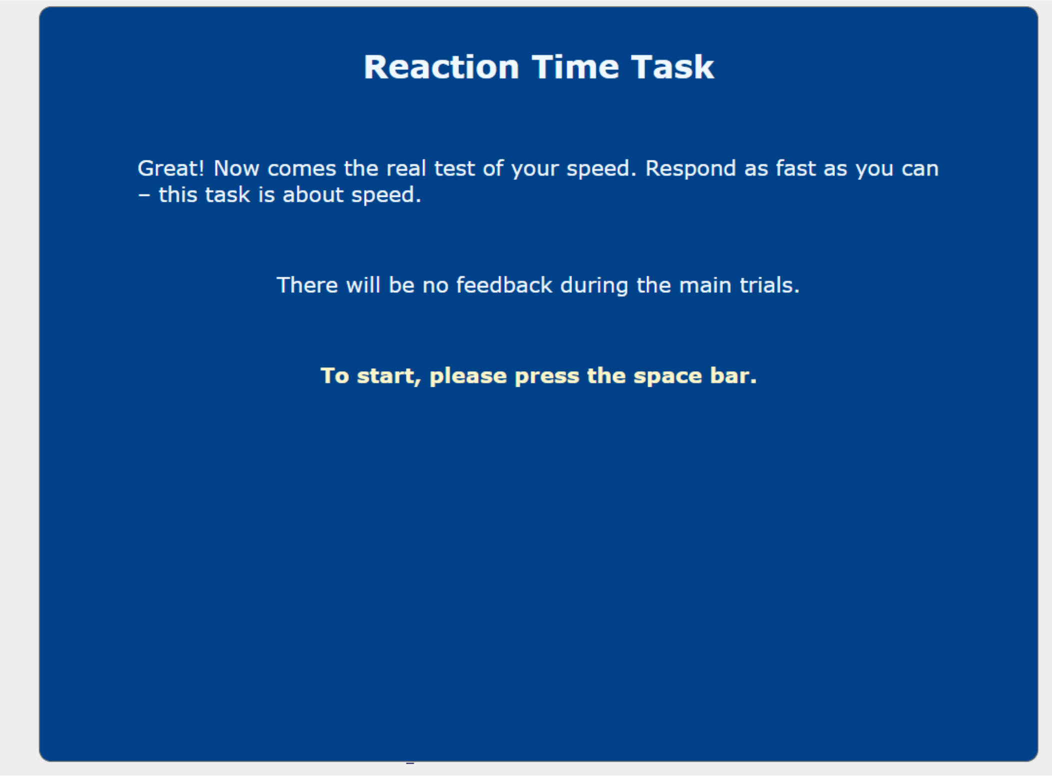
Try using the middle and forefinger of your left hand on the Z and X keys, and the middle and forefinger of your right hand on the , and . keys

Be careful – the position of the cross is likely to change each time!

Press the space bar to continue.



Wrong key! Press one of: [Z] [X [.] [,]

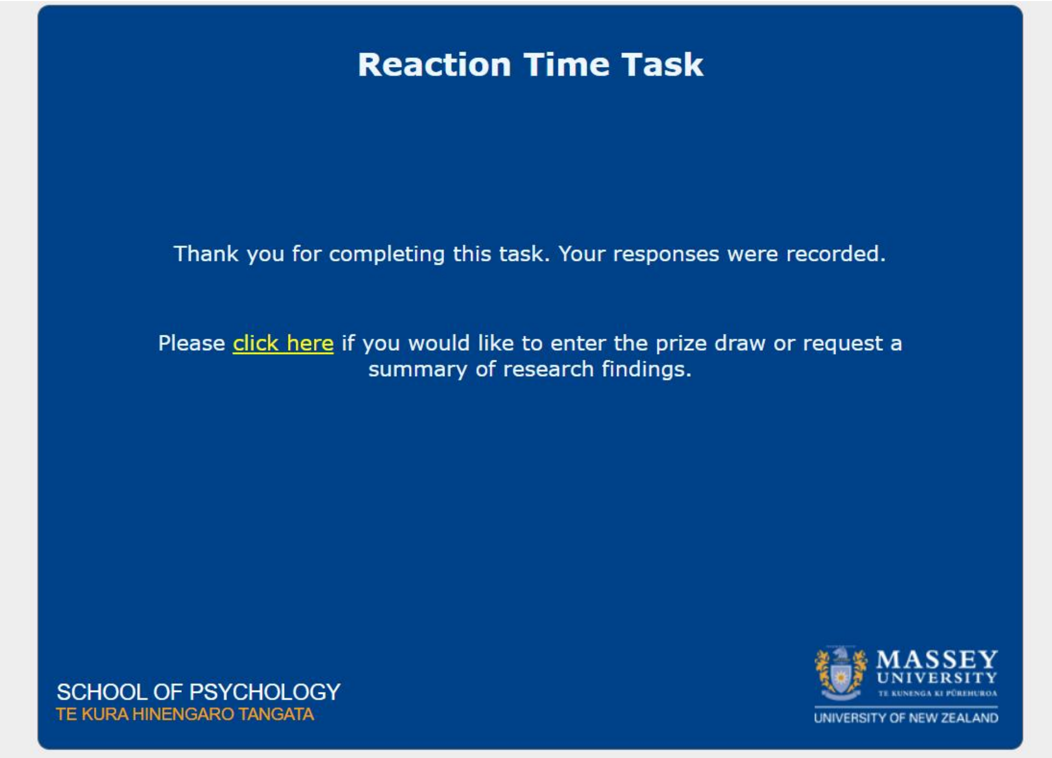


Reaction Time Task

Great! Now comes the real test of your speed. Respond as fast as you can – this task is about speed.

There will be no feedback during the main trials.

To start, please press the space bar.



Reaction Time Task

Thank you for completing this task. Your responses were recorded.

Please click here if you would like to enter the prize draw or request a summary of research findings.

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Appendix C Part A Inferential Statistics

Table 24

The Memory Difficulties Survey – Comparison of High and Low Cognitive Reserve Groups

		Cognitive Reserve*				*t(df)*	*p*	*g*
		High CR		Low CR				
		n	M (*SD*)	n	M (*SD*)			
Spontaneous SCCs		288	2.86 (1.45)	107	2.44 (1.35)	2.70 (202.17)	0.008	0.30
Prompted SCCs		288	14.65 (5.47)	107	13.68 (5.79)	1.49 (180.47)	0.137	
Distress	Spontaneous SCCs	288	3.42 (1.19)	107	3.47 (1.34)	-0.32 (172.58)	0.746	
	Prompted SCCs	288	3.14 (0.74)	107	3.24 (0.84)	-1.18 (393)	0.239	
Mood		286	2.01 (0.71)	106	2.03 (0.65)	-0.19 (202.70)	0.851	
Stress		288	2.31 (0.72)	106	2.09 (0.64)	2.74 (392)	0.006	0.31
BDI-II		70	-0.19 (0.73)	22	-0.33 (0.74)	0.75 (34.90)	0.586	
State Anxiety		70	-0.33 (0.86)	23	-0.12 (0.91)	-0.98 (35.70)	0.779	
Trait Anxiety		71	-0.36 (0.89)	23	-0.40 (0.83)	0.20 (40.11)	0.841	
Coding**		71	0.82 (0.86)	23	0.58 (1.00)	1.05 (33.34)	0.154	
Symbol Search**		71	0.74 (0.95)	23	0.51 (1.05)	0.95 (34.20)	0.188	

***** Educational attainment was used as proxy measure of CR

** Z-scores were used in analyses

Table 25

The Memory Difficulties Survey – Comparison of Groups Based on Educational Attainment

	Groups	*SS*	*df*	*MS*	*F*	*p*
Spontaneously reported SCCs	Between	25.64	5	5.13	2.54	0.028
	Within	787.04	389	2.02		
	Total	812.68	394			
Mean distress ratings – spontaneous SCCs	Between	4.32	5	0.86	0.57	0.726
	Within	594.20	389	1.53		
	Total	598.52	394			
Prompted SCCs (endorsed on a questionnaire)	Between	151.06	5	30.21	0.98	0.433
	Within	12050.45	389	30.98		
	Total	12201.51	394			
Mean distress ratings – prompted SCCs	Between	6.77	5	1.35	2.32	0.043
	Within	226.77	389	0.58		
	Total	233.54	394			
Mood	Between	0.29	5	0.06	0.12	0.988
	Within	188.58	386	0.49		

	Total	188.88	391			
Stress	Between	4.60	5	0.92	1.86	0.100
	Within	192.02	388	0.50		
	Total	196.62	393			
BDI-II	Between	2.65	5	0.53	0.99	0.428
	Within	45.90	86	0.53		
	Total	48.55	91			
State Anxiety	Between	5.41	5	1.08	1.45	0.214
	Within	64.83	87	0.75		
	Total	70.25	92			
Trait Anxiety	Between	5.96	5	1.19	1.63	0.160
	Within	63.52	87	0.73		
	Total	69.48	92			
Coding*	Between	3.80	5	0.76	0.94	0.458
	Within	71.01	88	0.81		
	Total	74.81	93			
Symbol Search*	Between	3.98	5	0.80	0.83	0.532
	Within Groups	84.33	88	0.96		
	Total	88.30	93			

* Z-scores were used in analyses

Table 26

The Memory Performance Survey – Comparison of High and Low Cognitive Reserve Groups

Measure	Cognitive Reserve*				*t(df)*	*p*	*g*
	High CR		Low CR				
	n	M (*SD*)	n	M (*SD*)			
CFQ	372	48.20(8.64)	141	49.00 (9.94)	-0.83 (224.62)	0.407	
Mood status	368	2.11 (0.75)	141	2.25 (0.74)	-1.90 (257.94)	0.059	
Stress status	370	2.70 (0.72)	141	2.54 (0.73)	2.20 (248.69)	0.029	0.22
MCQ Total	371	78.06 (13.55)	141	76.34 (14.41)	1.23 (239.74)	0.222	
MCQ Internal	371	21.40 (4.95)	141	20.93 (5.45)	0.90 (232.70)	0.369	
MCQ External	372	23.99 (4.62)	141	22.68 (5.19)	2.77 (511)	0.006	0.27
MCQ Effort	372	14.58 (3.55)	141	14.39 (3.41)	0.55 (262.23)	0.584	
MCQ Time	372	10.01 (2.67)	141	9.86 (2.92)	0.52 (234.03)	0.601	
MCQ Reliance	372	8.06 (2.64)	141	8.48 (2.80)	-1.58 (240.59)	0.117	

***** Educational attainment was used as proxy measure of CR

Table 27

The Memory Performance Survey - Comparison of Groups Based on Educational Attainment

	Groups	Sum of Squares	df	Mean Square	F	Sig.
CFQ	Between	448.64	3	149.55	1.85	0.137
	Within	41126.92	509	80.80		
	Total	41575.56	512			
Mood Status	Between	3.72	3	1.24	2.22	0.085
	Within	282.23	505	0.56		
	Total	285.95	508			
Stress Status	Between	2.83	3	0.94	1.81	0.145
	Within	264.86	507	0.52		
	Total	267.69	510			
MCQ Total	Between	440.05	3	146.68	0.77	0.512
	Within	96862.63	508	190.67		
	Total	97302.68	511			
MCQ Internal	Between	103.68	3	34.56	1.34	0.262
	Within	13140.20	508	25.87		
	Total	13243.88	511			
MCQ External	Between	208.59	3	69.53	2.30	0.192
	Within	11644.30	509	22.88		
	Total	11852.89	512			
MCQ Effort	Between	7.32	3	2.44	0.20	0.898
	Within	6302.05	509	12.38		
	Total	6309.37	512			
MCQ Reliance	Between	51.24	3	17.08	2.38	0.069
	Within	3654.97	509	7.18		
	Total	3706.21	512			
MCQ Time	Between	6.82	3	2.27	0.30	0.824
	Within	3829.44	509	7.52		
	Total	3836.25	512			

Appendix D Graphs of Linear Regressions

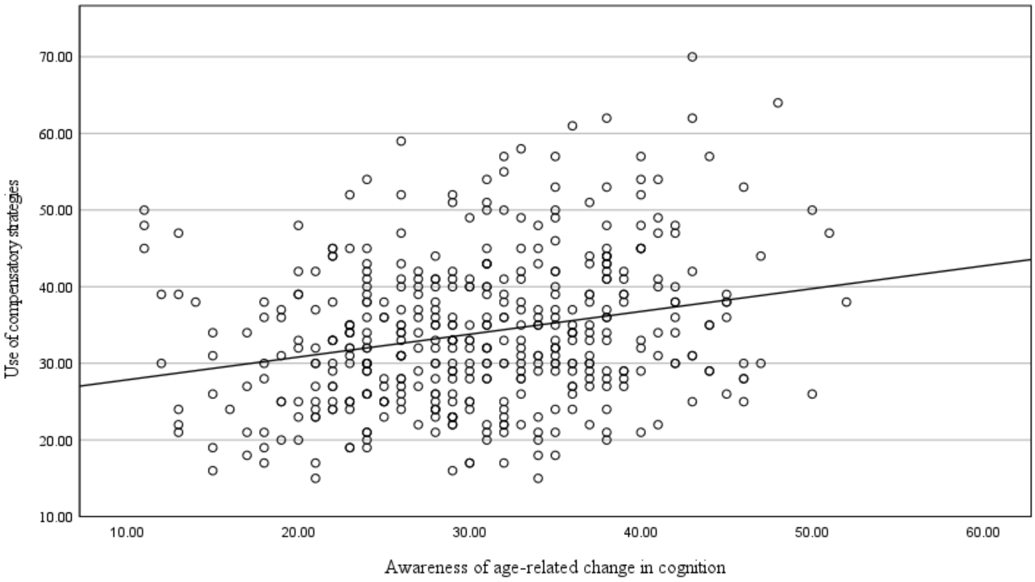


Figure 12. Linear regression for change in use of compensatory strategies for levels of AARC in part B study 1.

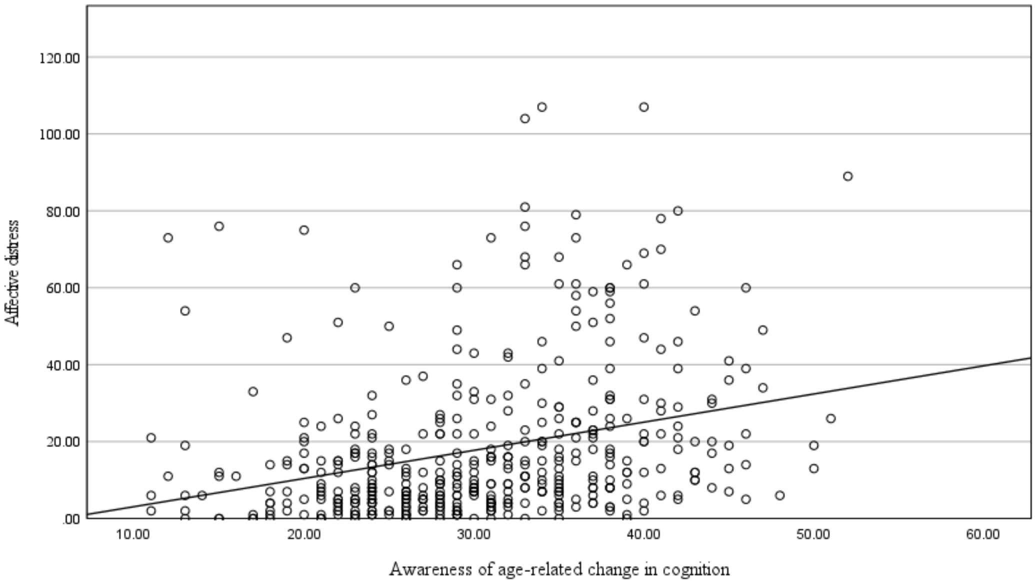
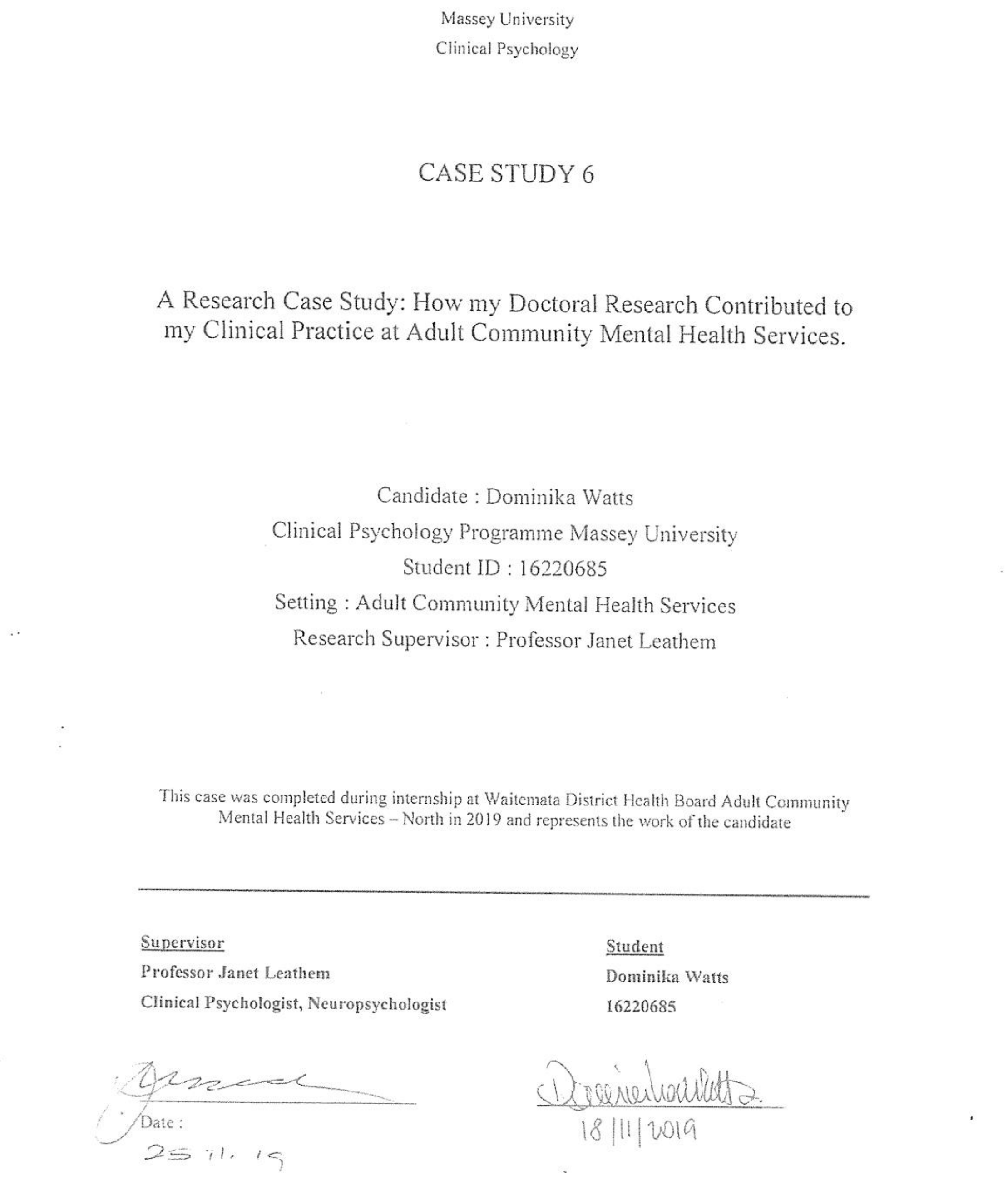


Figure 13. Linear regression for change in affective distress for levels of AARC in part B study 1.

Appendix E Research Case Study



Massey University
Clinical Psychology

CASE STUDY 6

A Research Case Study: How my Doctoral Research Contributed to my Clinical Practice at Adult Community Mental Health Services.

Candidate : Dominika Watts
Clinical Psychology Programme Massey University
Student ID : 16220685
Setting : Adult Community Mental Health Services
Research Supervisor : Professor Janet Leathem

This case was completed during internship at Waitemata District Health Board Adult Community Mental Health Services – North in 2019 and represents the work of the candidate

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Supervisor	**Student**
Professor Janet Leathem	**Dominika Watts**
Clinical Psychologist, Neuropsychologist	**16220685**
Date : 25.11.19	18/11/2019

ABSTRACT

The present case study will describe the influence that my doctoral research has had on my clinical practice during internship at Adult Community Mental Health Services. First, it will describe how the topic for my research was developed, the key concepts, research aims, and methodology. It will also summarize findings from the first part of research. Second, it will discuss how the research process and topic influenced my clinical practice. The main areas covered include research skills, neuropsychology and cognitive assessments, and knowledge and understanding of cognitive aging and mild traumatic brain injury.

RESEARCH OVERVIEW

Topic Development

The idea for the present research began with my interest in mild Traumatic Brain Injury (mTBI) and persistent cognitive symptoms reported in post-acute phase of mTBI known as post-concussion syndrome (PCS). In PCS, commonly reported symptoms include complaints of difficulties in attention, concentration, and memory (Levin & Diaz-Arrastia, 2015). Literature suggests that these symptoms are frequently not observed on formal measures of assessment and it has been hypothesized that they may instead be related to physical and psychological sequelae of mTBI and attributional biases regarding the perceived cause of those symptoms (Broshek et al., 2015; Levin et al., 1987; Prince & Bruhns, 2017; Spencer, Drag, Walker, & Bieliauskas, 2010). These findings appear similar to those from recent research on reporting of subjective cognitive complaints (SCCs) in normal aging where such complaints were also found to be unsupported by objective means of assessment (Burmester, Leathem, & Merrick, 2017). The literature on factors implicated as related to this observation in both normal aging and PCS was therefore further reviewed.

The findings from the literature review were that both in normal aging and PCS, the objectively measured cognitive abilities of individuals who report SCCs are not significantly different compared to their age-matched peers who reported no complaints (Levin et al., 1987; Mitchell, Beaumont, Ferguson, Yadegarfar, & Stubbs, 2014). It was found that in both cases, SCCs were frequently co-reported with symptoms of affective distress such as depressed mood, anxiety, and stress (Edmonds, Delano-Wood, Galasko, Salmon, & Bondi, 2014; Gotlib & Joormann, 2010; Levin & Diaz-Arrastia, 2015). They were also significantly associated with objective slowing in processing speed (PS) which is considered to be the most reliable marker of age-related change and which underpins functioning of other cognitive abilities, including memory and concentration (Burmester et al., 2017; Carroll et al., 2014; Iverson, Gaetz, Lovell, & Collins, 2004; Kail & Salthouse, 1994; Salthouse, 1996; Salthouse, 2000; Whiting, Baranova, & Hamm, 2006). It was also found that Cognitive Reserve (CR), a construct hypothesized as an acquired protective threshold for clinical expression of brain pathology may mediate the effects of aging and brain pathology on cognitive abilities (Stern, 2002; Stern, 2009; Stern, 2012; Tucker-Drob, Johnson, & Jones, 2009). In particular, higher CR was found to be significantly associated with reporting of SCCs in the absence of supporting evidence from objective assessment measures (Comijs, Deeg, Dik, Twisk, & Jonkey, 2002; Van Oijen, Jan de Jong, Hofman, Koudstaal, & Breteler, 2007). The reason for this finding remains unclear.

One further idea that came from initial reading was that perhaps some *perceived* cognitive decline arises because people misattribute the changes that occur in the normal course of aging, as due in mTBI or another neurological disorder. While it is recognized that awareness of age-related changes in cognition may have a significant role in reporting subjective difficulties, further research is required as the majority of to-date research focuses on memory difficulties rather than the possible interplay with other cognitive domains (e.g., Begum et al., 2014; Edmonds et al., 2014). Inaccurate perceptions of what occurs to cognition as a result of aging are likely to lead to false attributions e.g., older people may incorrectly assume that they are developing dementia and thus contribute to ongoing SCCs.

It appears plausible that similarly to SCCs in normal aging, persistent cognitive symptoms in PCS may be a manifestation of limited awareness that a decline in cognitive functioning has occurred (Burmester et al., 2017; Broshek et al., 2015). Individuals who sustained a mTBI may be unaware what changes occurred to their cognitive abilities in the process of normal aging and that they can at best recover to the level of ability immediately preceding the injury. They may attribute changes in cognitive function entirely to the injury and overestimate the expected level of cognitive performance post-recovery. Incorrect attribution of the cause of their difficulties may prevent them from accepting that the change has occurred and preclude engagement in appropriate compensatory strategies to mitigate the effects of these difficulties.

To summarize, reporting of SCCs in normal aging and in PCS share a high degree of similarity in terms of hypothesized factors which may influence their development. These factors include affective distress, CR, PS, awareness of age-related change in cognition and attributional bias, and use of compensatory strategies.

Research Aims

The rationale for the present study emerged from identified gaps in research pertaining to factors influencing subjective perceptions of cognitive functioning in normal aging and in mTBI. Specifically, the increasing average lifespan of the populations of developed countries and increasing rates of lifetime incidence of concussion prompt the need to gain a better understanding of the relationship between age-related change in cognition, and concussion, on subjective perceptions of laypersons' everyday functioning. In the study, "everyday functioning" refers to cognitive and emotional functioning which may further impact other domains for instance educational, occupational, social, or family functioning.

The research consists of two parts with corresponding study aims:

Part A: analyses of existing databases. The aim of this part of the study was to inform the Structural Equation Model (SEM) of influences of different factors on reporting SCCs in cognitive aging and after mTBI. Specifically, secondary analyses of existing neuropsychological databases were conducted in order to provide further empirical support to factors which were implicated as significant in existing literature. Those included CR, PS, affective symptoms, and use of compensatory strategies.

Part B: structural equation model of influences on reporting subjective cognitive complaints. The aim of this part of the study is to assess the fit of the model of influences on reporting SCCs in two conditions, namely in cognitive aging, and after mTBI.

Methodology: Part A

Sources of data. Two databases from existing research projects conducted at Massey University were identified as containing variables relevant to the current research. The first database was constructed from responses to the Memory Difficulties Survey (Burmester, 2017); and the second database was derived from the Memory Performance Survey (Scheibner, 2012).

Ethics. Ethical approval for the present research was granted by the Massey University Human Ethics Committee: Southern A (SOA 18/70). The data contained no identifying information and was accessed from and stored on a password protected computer stored in a secure location.

Results. The secondary data analysis of the first database found that individuals with higher CR reported more SCCs than those with lower CR, however the two groups did not differ in reporting affective symptoms. No differences in PS were found between higher and lower CR, indicating that CR may not have a protective effect on PS.

An analysis of the second database confirmed the above findings of no significant differences in reporting affective symptoms between groups with higher and lower CR.

Significant differences were found for reported levels of stress and use of compensatory strategies. It appears that individuals with higher CR engaged on average more compensatory strategies for identified SCCs.

Methodology: Part B

Procedure. The factors of interest were assessed through an internet-based survey. It included questions regarding participants' cognitive functioning; their subjective perceptions of present cognitive functioning; attributions made to any identified cognitive complaints; use of compensatory strategies; background information to assess CR; and an assessment of affective symptoms. The survey also queried any past experience of mTBI and both cognitive and physiological symptoms related to PCS.

Participants.

Recruitment. Participants for the survey were recruited online from the general population of New Zealand.

Exclusion criteria. New Zealand citizens and long-term residents who have lived in New Zealand for at least five years were invited to participate. The survey was limited to participants over the age of 18 years old.

Measures. The survey included the Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995) to assess affective symptoms; the Cognitive Failures Questionnaire (Broadbent, Cooper, Fitzgerald, & Parkes, 1982) to assess cognitive complaints; and the Deary-Liewald Reaction Time Task (Deary, Liewald, & Nissan, 2011) to obtain a proxy measure of PS.

Ethics. Ethical approval for this study was granted by the Massey University Human Ethics Committee: Southern A (SOA 18/70). The front page of the survey outlined the details of participation and participant rights, such as the right to decline to respond questions, and informed that participation implied consent. The obtained survey responses were anonymous (i.e., no questions pertaining to potentially identifying data were asked) and kept in a secure location.

INTERNSHIP REFLECTIONS

Adult Community Mental Health Services

I began my psychology internship at Adult Community Mental Health Services (CMHS), Waitemata District Health Board (WDHB) on the 4th of March 2019. The duration of this internship is 1 year and it is based with the North Shore's Multidisciplinary Team (MDT), however during my internship I was also able to visit and briefly work at other WDHB sites such as the regional forensic unit and the local inpatient unit. CMHS provides services to individuals typically aged between 18 and 65, however some of our clients are around 80 years of age. Access to services is overseen by the referrals management team and typically limited to individuals whose severity of symptoms necessitate urgent response. In the following section I will reflect on the impact that my experiences as a researcher had on my clinical work at Adult CMHS.

Research skills

Some of the most valuable learnings from conducting my doctoral research were related to being able to research, critically evaluate, and integrate and apply knowledge gained from the research process to my clinical practice. In the first two weeks of my internship I met individuals whose presenting difficulties were not something that I have studied in great detail during my training. Upon realising that there are no clearly recommended treatment protocols with extensive research evidencing their effectiveness for such difficulties, I briefly felt at a loss of how to proceed. I have then realised that this is no different to when I first began to explore my thesis topic. I followed the steps of gathering available and reputable research and then critically evaluating claims and methodology of these studies, after which I integrated the relevant findings and recommendations into treatment. I found this process challenging at first due to lack of consensus regarding the most effective treatment and my own lack of confidence as a clinician. The treatment outcomes of my first client proved to me that this was the right process to follow as the client has successfully overcome their difficulty, and the recovery process closely resembled one described in a research paper. This experience helped me better understand and appreciate the skills I have developed in the process of conducting my doctoral research in obtaining, selecting, and applying knowledge, and evaluating the outcomes.

Neuropsychology and Cognitive Assessments

Engaging in my doctoral research has sparked my interest in neuropsychology and its applications in clinical settings. Developing and refining my research topic required me to gain a better understanding of the functions of different cognitive abilities, the ways in which these can be measured, how they are related, the effects that different mental and physical health conditions may have on them, and practical implications of both pathological and non-pathological changes in cognition. I also had to gain a good degree of understanding and familiarity with the existing measures of cognitive abilities, for example the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) and Delis-Kaplan Executive Function System (D-KEFS). These experiences turned out to be invaluable during my internship at adult CMHS, particularly with clients whose engagement in therapeutic interventions was complicated by underlying difficulties in cognition. I believe it made me more sensitive to notice such difficulties and therefore offer an assessment which included an exploration of their functioning across different cognitive domains. It also allowed me to offer and implement a therapeutic approach which capitalized on the person's strengths and reduced the impact of any difficulties. The knowledge of these measures has also proven to be immensely helpfulin assessments of neurodevelopmental conditions in adulthood such as Autism Spectrum Disorder and Attention Deficit/Hyperactivity Disorder.

Learning more in-depth about cognition, aging, and TBI has also proved highly valuable at the level of report writing and integrating assessment information into a working formulation. It enhanced my understanding of factors that may influence cognitive functioning and that difficulties that people experience in cognition could manifest in worry about developing a neurodegenerative illness. My research has also provided me with knowledge of how different client and environmental variables can affect cognitive testing and prompted me to remain aware that the measures used in practice may not always be suitable for a given client, and the results may be inaccurate given their circumstances.

Lastly, I firmly believe that conducting research in the area of neuropsychology made me a better clinician in that it aided my understanding of people's functioning in general and after mTBI, it helped me become, more accurate in differentiating between the effects of different mental health conditions and underlying cognitive ability on different presentations, and more able to observe and respect the limits of my own clinical ability.

Cognitive Aging

Prior to my research I have never heard of the concept of subjective cognitive complaints. From time to time I have heard people of all ages describe their “memory being bad” or “having an attention deficit”, however I had never given these any serious consideration. Up until then I held a misinformed belief that “only older adults complain about memory” and that it is reasonable for them to do so because older adulthood is when cognition declines. I was not aware how incorrect that was. When I began research in this area, I realised that while the experience of noticing a change in cognitive functioning in adults may be transient for most people, this is not uniformly the case for everyone. Rather than induced by situational circumstances, such passing comments may, in fact, relate to a phenomenon that we all as humans experience but often do not reflect on, namely cognitive aging. An experience that begins as soon as early adulthood, but one which we are largely unaware of.

After working in CMHS for a few months I have realised that these complaints are in fact quite common. Furthermore, I have observed that individuals who begin to suddenly notice a difference in cognitive functioning which then continued beyond their recovery found this experience highly distressing. They struggled to find an explanation for what had happened and thus overestimated the danger of such changes in that they catastrophically misinterpreted these difficulties as a sign that they are “going crazy” or that they are “developing dementia at a young age”. Such interpretations were unhelpful to them and instead further complicated the problem through, for instance, increased worry about making serious mistakes. Some individuals even insisted that these had an organic cause; however, no such cause was found. It was not until they were given the space to reflect on their experience, supported in findings alternative, less threatening explanations, worked towards acceptance of the change, and focused on finding ways to minimize the impact of their difficulties that they ceased to be a problem to them. I believe that without the experience of my doctoral research I would not have been able to effectively work with them to achieve such results as I would have likely remained unaware of this phenomenon and the possible reasons for it.

MTBI

My research has also greatly contributed to developing my awareness of the impact that concussions, particularly repeated concussions, can have on cognition, both short and long-term. It has also highlighted that despite social campaigns on concussion, public awareness on this matter remains relatively low. I was surprised to find that history of head injury is seldom gathered at entry to mental health services and that it often remains unrecognized unless the person spontaneously self-reports the injury or has consulted a General Practitioner for this reason. Often times they are not aware that the injury they recently sustained is significant enough to explain an array of symptoms that have emerged seemingly unexpectedly including for instance a drop in mood, increase in anxious feelings, confusion, difficulty with decision-making, and a general sense of "feeling slowed down". My research in this area prepared me well not only to recognize that this may be a difficulty for the person, but also helped shape my approach in selecting appropriate assessment measures, adjusting the environmental conditions of the assessment, and appreciating factors that may affect their engagement in testing such as fatigue, headaches, and visual difficulties. Furthermore, during my research I have gained knowledge of support services available to individuals and this enhanced my ability to make appropriate and helpful recommendations post-assessment.

To summarize, I believe that the experience of conducting my doctoral research has become a basis for the development of my clinical skills during my internship. It provided me with knowledge and skills in the area of neuropsychology which have been invaluable in appropriately assessing and intervention planning for my clients. It has also helped me become more efficient in writing reports, enhanced my formulation skills, and has given me direction that I wish to follow beyond my internship.

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