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**The Impact of Social Relationships on Cognitive Performance in  
the Older Adult: Emotional Loneliness is Detrimental to Cognitive  
Performance.**

**A thesis presented in partial fulfilment of the requirements for the degree of Doctor of  
Clinical Psychology at Massey University, Palmerston North**

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*“The most terrible poverty is loneliness and the feeling of being unloved”*

Mother Teresa

## **Abstract**

The present study examined the influence of loneliness and objective social isolation on cognitive performance at baseline (time 1) and after two years (time 2) among older adults aged 65 - 84 years old. The exploration of the moderating role of objective social isolation on the relationship between loneliness and cognitive performance was investigated. The role education may have in moderating the relationship between loneliness, objective social isolation and cognitive performance was also investigated. This study extends previous work on loneliness and social isolation, and cognition in two ways. While previous research has found a link between loneliness, objective social isolation, and cognition, many studies have considered loneliness and objective social isolation independent of each other when investigating their relationship with cognition. This study investigated the relative and synergistic relationship between loneliness, objective social isolation and cognition. Secondly, Weiss (1973) conceptualised loneliness as emotional loneliness or social loneliness. Social loneliness as a risk factor for cognitive performance in the older adult has been overlooked. This study considered both emotional loneliness and social loneliness, as two different forms of loneliness that may influence cognition in the older adult. The current study examined the impact of three different types of social isolation (emotional loneliness, social loneliness and objective social isolation) on global cognition and cognitive domains (memory, fluency, language and visuospatial ability).

Pre-existing data from the New Zealand Longitudinal Study of Ageing (NZLSA; 2010 and 2012) was used for analysis. The relationships between emotional loneliness, social loneliness and objective social isolation were examined using standard quantitative statistical procedures with linear hierarchical multiple regression being the primary technique. Results showed that loneliness (emotional and social) and objective social isolation may be differentially important for cognitive performance in the older adult. Emotional loneliness had an association with global cognition, verbal fluency, language and visuospatial ability, though not memory at baseline. At the two year follow-up emotional

loneliness had an association with global cognition, memory, language, and visuospatial ability, though not verbal fluency. Social loneliness did not have an association with cognition at baseline, and was found to be a suppressor variable at the two year follow-up. Objective social isolation had an association at baseline with visuospatial ability only, which did not carry through to the two year analysis.

Novel findings were that older adults who were emotional lonely and not socially isolated had poorer cognitive performance at baseline for global cognition, language and visuospatial tasks, than those who were emotionally lonely and socially isolated. Also older adults who had low levels of education and were socially isolated performed better in visuospatial tasks at baseline than older adults with low levels of education who were not socially isolated. Explanations of why emotional loneliness influence cognition is discussed, with a focus on the ‘lonely in the crowd’ subsample of older adults. Limitations of the study and implications for future research, such as need for longitudinal research that includes control variables such as personality factors, stress and sleep is also discussed.

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Finally, this topic was also important for me to research, as seeing first hand through previous work, the impact of loneliness and social isolation on our older population. I genuinely believe that we can do better for our older population and we should do better.

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# **Chapter One: Social Relationships, Successful Ageing, and Current Trends**

**Chapter Overview:** Section 1.1 introduces the topic of this thesis and outlines the thesis structure. Social relationships, social isolation, and loneliness are outlined including the impact on overall wellbeing for the older adult (1.2). The current study is placed in context to explain its relevance to current trends such as successful ageing, demographic trends, costs of cognitive decline and the emerging issues of social isolation and loneliness (1.3).

## **1.1 Introduction**

For over four decades, research has signalled that social isolation can have a detrimental effect on mental and physical health. However, until recently there has been little focus on the relationship between social isolation and cognition in older adults, though research on this subject is now gathering momentum. Studies have reported that some forms of social isolation may be a risk factor for poorer cognitive performance and increased rates of cognitive decline (Boss, Kang, & Branson, 2015; Brown et al., 2012; Kelly et al., 2017; Kuiper et al., 2016). This claim is yet to be conclusively supported (Baumgart et al., 2015; Hertzog, Kramer, Wilson, & Lindenberger, 2009; Plassman, Williams, Burke, Holsinger, & Benjamin, 2010). An opportunity exists to expand on previous research, and further increase understanding of the relationship between social isolation and cognitive performance.

This thesis explores whether different forms of social isolation, namely, objective social isolation, emotional loneliness and social loneliness, is related to the cognitive performance of older Aotearoa/New Zealand adults and if different forms of social isolation predict cognitive performance over a two year period. This study will also look at the synergetic effects of objective social isolation and loneliness (emotional and social) on cognitive performance at baseline and follow up. Finally, the research

question of whether education acts as a protective factor against poorer cognitive performance in those that are socially isolated or lonely will be investigated.

This introductory chapter will argue why it is important to understand the relationship between social isolation, loneliness and cognition in the older adult, by discussing successful ageing, demographic changes and current trends in social isolation. Chapter Two reviews the literature on relation to the older adult's social world and cognition. Chapter Three describes the important social relationship concepts, specifically objective social isolation and loneliness and explores how they are related. Risk factors for poor social relationships are also outlined and the importance of controlling for extraneous variables when investigating how social relationships affect cognition is highlighted. Chapter Four discusses the pathways through which poor social relationships may influence cognitive performance in the aged. A model of social relationships and pathways to poorer health, with a focus on cognition, is then introduced. The aim of this chapter is to argue the importance of assessing different forms of social isolation and the relationship with cognition simultaneously and synergistically. Chapter Five begins by asking the question of whether cognitive decline is inevitable. Evidence is presented that explains that the aged population is a heterogeneous group. A model of ageing and cognition that outlines factors that may influence cognitive performance as we age is described. The model also includes factors such as social relationships, and the role they may have in cognitive ageing. To end the introduction of social isolation and cognition Chapter Six formally introduces the study's hypotheses. Chapter Seven describes the research design, and data collection. Additionally there is a description of the larger New Zealand Longitudinal Study of Ageing (Towers et al., 2012) and the New Zealand Health, Work, and Retirement Study (Alpass et al., 2007), which the current study's data and sample were derived from. The chapter also includes a description of the representativeness of the current sample compared to the New Zealand National Population, and measures used. Chapter Eight describes methodology and results. Chapter Nine discusses the results and explores

possible explanations for the findings, as well as highlighting the strengths and limitations of the study, and future questions that need to be addressed.

## **1.2 Introducing Social Relationships and Influence on Overall Wellbeing**

### **1.2.1 Social relationships: Social isolation, loneliness and overall wellbeing.**

Social ties or connections with family and community, access to social support, and active participation in stimulating intellectual and physical activities in the community (i.e., social integration) have all been associated with good health, well-being, and successful cognitive ageing in the older adult (Aquino, Russell, Cutrona, & Altmaier, 1996; Berkman, Glass, Brissette, & Seeman, 2000; Hertzog et al., 2009; Pinquart & Sorensen, 2000; Victor, Scambler, Bond, & Bowling, 2000).

However, many older adults are socially isolated or lonely as they age. *Social isolation* is regarded as the converse of social integration or social connection. Socially isolated individuals have limited social ties which may decrease their opportunity to receive quality social support and participate in productive social activities (Berkman, 1983; Grenade & Boldy, 2008; Nicholson Jr, 2009). *Loneliness*, on the other hand, is a subjective experience characterised by a lack of satisfaction in relationships, whether through frequency and closeness of contacts, a perception of unfulfilled intimate and social needs, feelings of social isolation, and/or absence of companionship (Adams, Openshaw, Bennion, Mills, & Noble, 1988; Austin, 1983; Tilvis et al., 2012). Social isolation and loneliness are both terms that have been defined in a variety of ways and though regarded as distinct concepts, are clearly related (further discussion of definitional issues of social isolation and loneliness occurs in Chapter Three).

### **1.2.2 Social isolation, loneliness and physical and mental wellbeing.**

Evidence shows that social isolation and loneliness are associated with poorer health outcomes and wellbeing in general (Cohen, 2004; Cornwell & Waite, 2009b; Tomaka, Thompson, & Palacios, 2006). Social isolation and its influence on reduced

psychological wellbeing, was first discussed in the work of sociologist Emile Durkheim that focused on the relationship between society and mental health (Berkman et al., 2000; Kawachi & Berkman, 2001). The link between interpersonal relations and psychological wellbeing has long been acknowledged by psychologists, with many viewing Freud as one of the first to emphasise the importance of the association (Nuttall, 2004). Initial studies in social isolation focused on its association with mental health (Antonucci, 2001). An empirical turning point came about in the late 1970s, when a ground-breaking study by Berkman and Syme (1979) documented a relationship between mortality and size of social networks. Older people who were reported as socially isolated due to a lack of social ties were less likely to be alive nine years later than their counterparts who had more and extensive social networks.

Numerous studies have gone on to replicate the findings of Berkman and Syme, reporting that socially isolated people having a two to four-fold increase in all-cause mortality compared to those with increased social ties (Brummett et al., 2001; Clarke et al., 2012; Fratiglioni, Wang, Ericsson, Maytan, & Winblad, 2000; House, Robbins, & Metzner, 1982; Smith, Anderson, Bradham, & Longino Jr, 1995). One of the most compelling studies demonstrating the importance of interpersonal relationships and the relationship to mortality is a recent meta-analysis of 148 longitudinal studies published between 1900 and 2007; it examined 308,849 adults with an average age of 63.9 years, and the average follow-up time of studies was 7 years (Holt-Lunstad, Smith, & Layton, 2010). The meta-analysis found that adults who had adequate social relations had a 50% greater likelihood of survival than adults with social relationships that were poor or inadequate. This survival rate remained consistent across age, gender, initial health status, follow-up period, and cause of death (Holt-Lunstad et al., 2010).

Alongside the work on social isolation and mortality, researchers have also investigated how social isolation and loneliness influence disease risk and physical health and mental wellbeing. The risk of social isolation to one's health has been suggested as having a similar level of risk as smoking, obesity, lack of exercise, and high blood pressure (Holt-

Lunstad, Smith, Baker, Harris, & Stephenson, 2015; House, Landis, & Umberson, 1988). Social isolation and loneliness have been linked to increased rates of depression and diabetes, increased systolic blood pressure, disability, metabolic syndrome, higher incidence of coronary heart disease, poorer prognosis in cancer and cardiovascular disease, stroke, and slower recovery from major health events (Brummett et al., 2001; Cacioppo & Hawkley, 2003; Cacioppo, Hawkley, & Thisted, 2010; Golden, et al., 2009a; Reynolds & Kaplan, 1990; Tomaka et al., 2006).

With the knowledge that social isolation and loneliness has an association with poorer physical health and mental wellbeing, researchers have been studying the link between social relationships and cognition. This is in part due to the evidence that many key health outcomes associated with social isolation and loneliness such as diabetes, high blood pressure, heart disease and depression have also been reported as risk factors for cognitive decline, (O'Donnell et al., 2012; Ownby, Crocco, Acevedo, John, & Loewenstein, 2006; Raffaitin et al., 2011; Seeman, Lusignolo, Albert, & Berkman, 2001; Yaffe, 2007). Findings from some of the investigations on social isolation and loneliness have indicated that older adults' cognitive functioning may be influenced by their social environment, including perceptions of that world (Bourassa, Memel, Woolverton, & Sbarra, 2017; Donovan et al., 2017; Holwerda et al., 2014). However, other studies did not report a consistent link between an older adult's social environment and cognitive performance as they age (Amieva et al., 2010; Gow, Corley, Starr, & Deary, 2013).

### **1.3 The Relevance of Successful Ageing, the Consequences of Cognitive Decline, Demographic Trends and Emerging Social Isolation Trends, to the Current Study**

This section describes successful ageing, the consequences of cognitive decline to the individual and society, demographic trends and social isolation challenges. Providing the context for why investigating the relationship between social relationships and cognition is relevant.



### **1.3.1 Successful ageing – The importance of social relationships and cognitive ability.**

*Successful ageing* is a term used interchangeably in the ageing literatures, with terms such as *healthy ageing*, *active ageing*, *productive ageing*, and *positive ageing*. There is an ongoing debate in the academic community as to what the components of successful ageing are. This debate includes disagreement as to operationalising successful ageing, methodology issues, the need to include lifecourse perspective, the use of terms such as “successful ageing” or “ageing-well” that are considered value-laden judgements that only advantaged groups may achieve, and lack of incorporating the older adult population’s perspectives on ageing, (Depp & Jeste, 2006; Dillaway & Byrnes, 2009; Phelan, Anderson, Lacroix, & Larson, 2004; Stowe & Cooney, 2014). The following discussion seeks to provide the reader with current main constituents of successful ageing, rather than critique definitions or methodology discrepancies.

The World Health Organisation uses the term *active ageing*, which is defined as “the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age” allowing people to “realize their potential for physical, social and mental well-being throughout the life course” (World Health Organisation, 2002, p. 12). Reviews of the theoretical literature on successful ageing indicate themes reflecting psychosocial or biomedical approaches, or a combination of both (Bowling & Dieppe, 2005; Bülow & Söderqvist, 2014). The psychosocial models of successful ageing, though varied, focus on factors such as life satisfaction, social engagement and connectedness, psychological resources, self-efficacy, individual agency, and adaptive coping strategies with changing circumstances (Baltes & Baltes, 1990; Bowling & Dieppe, 2005). By contrast, biomedical models have focused on optimisation of life expectancy, the absence of chronic disease, and independent physical functioning (Rowe & Kahn, 1997, 1998). Bowling and Dieppe, argue theoretical views have some commonality with lay views, which are more comprehensive and multifaceted. Studies that have investigated the perspectives of the older adults have noted broader themes associated with successful ageing such as productivity and contribution to life,

spirituality, accomplishments, financial security, neighbourhood, humour, and sense of purpose (Bowling & Dieppe, 2005; Phelan et al., 2004).

One of the most widely applied and influential models of successful ageing was proposed by Rowe and Kahn (1987; 1997, 1998, 2015) which aimed to take into account the heterogeneity of the older population (Dillaway & Byrnes, 2009; Stowe & Cooney, 2014). The model attempts to distinguish those who age as usual in comparison to those who age successfully (Rowe & Kahn, 1987; 1997, 1998). Rowe and Kahn argued that successful ageing requires three factors: low probability of disease and disease-related disability, high cognitive and physical functional capacity, and an active engagement with life (maintenance of interpersonal relations and productive activity). The successful ageing model proposed by Rowe and Kahn, though often critiqued (Martinson & Berridge, 2014), and could be argued as having some overlap to the lay views provided by the older adult when asked about successful ageing. For example, the areas regarded as most important in community surveys on successful ageing undertaken by older adults (65 years and over) are their health, social activities, and social relationships with friends and family, which aligns with Rowe and Kahn's factors of health, physical functioning and active engagement with life (Bowling, 1995; Farquhar, 1995; Victor et al., 2000). Rowe and Kahn state high cognitive functioning is important for successful ageing. Older adults report that poor cognitive functioning is consistently one of the greatest fears of ageing; more so than cancer, heart disease, and diabetes (YouGov, 2015). The fear of losing one's mental capacity presented even in responses from younger adults in a public opinion poll, and was feared more than physical impairment in older age (PARADE/Research!America, 2006).

What is apparent, regardless of conflicting definitions of successful ageing, is that cognitive ability and social relationships for the older adults are key determinants of successful ageing. Though the three factors (avoiding disease and disability, high cognitive and physical function, and engagement with life) of Rowe and Kahn's model of successful ageing have the ability to influence each other; cognitive ability is the one

factor that uniquely influences ability to engage with life, functional capacity, and health status (Buchman, Boyle, Leurgans, Barnes, & Bennett, 2011; Hellström, Persson, & Hallberg, 2004; Steen, Sonn, Hanson, & Steen, 2001). Thus, it is important to understand the factors that affect cognitive ageing, both positive and detrimental. A decline in cognitive ability may lead to the older adult withdrawing from social relationships and activities, which may, in turn, result in poorer physical, mental, and cognitive health. Increasing the knowledge of how social relationships may influence cognition is crucial, to ensure that any policies, processes, interventions that are focusing on cognitive health in the ageing incorporate the role of social relationships.

### **1.3.2 The consequences of cognitive decline in the older adult.**

There is an abundance of evidence in the literature of the burdens of cognitive decline. Cognitive decline may impact individuals emotionally, financially, and impact their functioning, as well as there being a cost to society. Declines in cognitive ability that occur with normal ageing, or more significant cognitive impairment such as dementia, may contribute to emotional distress for the individual (Anstey, von Sanden, Sargent-Cox, & Luszcz, 2007). An individual experiencing change in cognitive ability may withdraw socially and become depressed inadvertently reducing their opportunities for further cognitive stimulation. Research has also shown that for spouses of those with cognitive decline, the spouse themselves can often become withdrawn, depressed, and thereby reduce the opportunity for cognitive stimulation for both partners (Dufouil, Alperovitch, & EVA Study Group, 2000; Lee, Paddock, & Feeney, 2012; Schulz & Martire, 2004).

Poorer cognitive function and subsequent decline is a risk factor in the development of functional impairment and disability (Herzog & Wallace, 1997; Johnson, Lui, & Yaffe, 2007; Moritz, Kasl, & Berkman, 1995). This can result in the inability to function independently and adequately in daily life. This decline may manifest through an inability to manage finances (Widera, Steenpass, Marson, & Sudore, 2011), drive, and engage in self-care through preparing meals, bathing and dressing (Dodge et al., 2005).

Older adults with cognitive decline are also at greater risk of increased medication non-adherence, have poorer medical decision-making capacities and decrease in mental health status (Insel, Morrow, Brewer, & Figueredo, 2006; Okonkwo et al., 2007). Older adults with lower cognitive performance at baseline are more at risk for admission to institutional care and increased risk of mortality at a later point in time than those with higher cognitive ability (Barberger-Gateau & Fabrigoule, 1997; Johnson et al., 2007; McGuire, Ford, & Ajani, 2006). A study conducted over 12 years showed that older adults with a 1 point decline in average standardised scores for processing speed and executive functioning had a higher mortality rate (6.6 and 7.5 times) during the study period than peers who did not have the same decline in performance, even after controlling for dementia or preclinical dementia (Lavery, Dodge, Snitz, & Ganguli, 2009).

In New Zealand the information on economic costs<sup>1</sup> associated with cognitive decline has focused on severe cognitive impairment (dementia) and was estimated at \$1.7 billion for the year 2016, which is an 80% (\$955 million) increase since 2011 (Alzheimers New Zealand, 2012, 2017). Direct costs associated with cognitive decline include residential aged care, medication, and the increased use of general practitioners. There are also substantial indirect costs associated with informal care and loss of productivity for those who are cognitively impaired and for their caregivers. In 2011, the Ministry of Health estimated that approximately 1% of the population or 48,000 New Zealanders had dementia. This is expected to increase to 75,000 or 1.5% of the population by 2026 (Ministry of Health, 2011). However, these figures fail to consider the costs associated with mild cognitive decline to individuals and society. Currently there is no available data to quantify the percentage of older adults who have mild cognitive impairment in New Zealand.

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<sup>1</sup> Economic costs value the production lost and resources spent on dementia; burden of disease costs value the loss of healthy life from dementia.

The prevalence of mild cognitive impairment and age-associated cognitive decline, overseas, has been estimated in the range of 3.2% to 53.8% (Katz et al., 2012; Lopez et al., 2003; Schönknecht, Pantel, Kruse, & Schröder, 2005). Furthermore, for many adults the later years are a time when they can give back to the community by, volunteering within the community, providing childcare for family members or others, as well as enjoying productive hobbies. There are financial costs to society if older adults are unable to do this. More importantly, however, there is a loss for older adults in having a sense of belonging or purpose if they are unable to continue living successfully or independently due to poor cognitive functioning.

In summary, there is much emphasis being placed on increasing the knowledge on non-genetic factors such as mental health, physical health and social relationships that support successful cognitive ageing, as well as determining what are those modifiable risk factors for cognitive ageing that may increase the rate of decline (Baumgart et al., 2015; Deary et al., 2009; Fillit et al., 2002). Understanding the role social isolation and loneliness may play in cognitive ageing cannot be underestimated, when considering the importance of maintaining for as long as possible, adequate cognitive functioning, due to the broad array of losses that can occur as a result of cognitive difficulties.

The next section discusses social isolation and loneliness as an emerging issue, which may in part be due to the demographic and technological trends that present a greater opportunity for many people to be socially isolated or lonely.

### **1.3.3 Demographic changes and the relationship to public health.**

The global population is on the verge of entering one of the most demographically significant events of the twenty-first century. As the remnants of the baby-boomer generation reach retirement, the gaps in the facilities, resources and services needed to cater for the ageing population are becoming increasingly obvious, statistically. Fourteen percent of New Zealand's population in 2013 was 65 years and older (Statistics New Zealand, 2015). By 2032 this population bracket will account for up to 22% of the

population and increase up to 33% by 2068 (Statistics New Zealand, 2016). In 2013 the oldest 10% of the population was aged 69.5 years and over. In 2050, that is projected to rise to 80 years old and older. Before 2020, a historical first will occur in which people aged over 65 years old will outnumber those under the age of 5, worldwide (He, Goodkind, & Kowal, 2016).

Predicting the demands that the ageing population will place on health and social services resources is essential as living longer is associated with increased levels of disability and infirmity (Cornwall & Davey, 2004; He et al., 2016; Ministry of Health, 2012). A population that has an increasing proportion of older people will continue to result in increased costs in superannuation and other age related costs such as healthcare both in New Zealand and world-wide (Dale, 2015). Between 1996 and 2016, the amount of time spent in poor health by older adults has increased (Ministry of Health, 2018). Presently, females living in Aotearoa/New Zealand will spend over a decade of their life with poor health (11.6 years) and for males, it is slightly less (9.9 years). A consequence of potential resource limitations may see non-essential services reduced for the older people as resources are directed to essential services. This redirection of resources may result in reduced opportunity for interactions, support, and a sense of connectedness for individuals. Although advances in technology provide ways for the older people to feel connected with family and the community, it may also result in a loss of physical contact and reduced face-to-face interaction.

#### **1.3.4 Social isolation and loneliness as an emerging challenge.**

Lifestyle events and disruptions to an older adult's social world can be caused by a variety of factors. These may include death of a spouse, siblings, or friends, living alone, the transition from working to retirement, reduced financial resources, geographically shifting to be closer to family, and leaving lifetime friends. Other important factors associated with increasing levels of social isolation and loneliness in older adults are transportation issues, declining physical health with age, disabilities, or embarrassment about disabilities (Grenade & Boldy, 2008; Havens, Hall, Sylvestre, & Jivan, 2004;

Locher et al., 2005; Steed, Boldy, Grenade, & Iredell, 2007). Demographic trends, resource limitations and technology trends may also have an impact on current and future levels of social isolation in the ageing population (Ministry of Health, 2004). Current demographic trends such as increased life expectancy, increased divorce rates, a highly mobile society, and families having fewer children, may see more adults living alone, and less contact between family members due to geographic distance (Routasalo & Pitkala, 2003; Tomaka et al., 2006). This, in turn, may result in older adults having less opportunity to engage in previous social roles such as providing family support and childcare resulting in reduced interactions and familial support (Heller, 1993).

Studies have reported that marriage or a cohabitating partner appears to be a protective factor against loneliness and social isolation for older adults (Dykstra, van Tilburg, & de Jong Gierveld, 2005; Wenger, Davies, Shahtahmasebi, & Scott, 1996). A review of nine studies involving older adults living in Aotearoa/New Zealand had a similar finding that loneliness was associated with social isolation and living alone, alongside depression, suicidal ideation, being female, Māori and having a visual impairment (Wright-St Clair, Neville, Forsyth, White, & Napier, 2017). Data from Statistics New Zealand's census in 2013 indicated that of the 355,000 New Zealanders who lived alone; 44% (156,200) were aged over 65 years old. Nearly a third of the older New Zealand population signalled that they were non-partnered (widowed, divorced, surviving civil union partner, or never partnered) (Statistics New Zealand, 2015); this was predominantly due to being widowed or a surviving civil union partner (60%).

Living alone has been associated with a reduction in cognitive performance, specifically processing speed (Gow et al., 2013). Additionally, investigations have reported older adults who are married or have a cohabitating partner experience less cognitive decline than those who live alone (Fratiglioni et al., 2000; Helmer et al., 1999; Sundström, Westerlund, & Kotyrlo, 2016). A Finnish longitudinal study reported older men (70 – 89 years) who were living alone either for a five year period or had started to live alone

during a five year period had a greater decline in cognitive abilities over 10 years than those who lived with someone (van Gelder et al., 2006).

Loneliness has also been linked as a risk factor for poorer cognitive performance and increased rate of cognitive decline (Golden et al., 2009a; ÓLuanaigh et al., 2012; Wilson et al., 2007). This is concerning when the rates of loneliness in Aotearoa/New Zealand are considered. In a sample of 332 community dwelling older adults, 44% reported being moderately lonely, and 8% severely lonely (La Grow, Neville, Alpass, & Rodgers, 2012). A recent survey of 71,859 older adults (65 years and over) based in Aotearoa/New Zealand, reported that one in five (21%) experienced loneliness (Jamieson et al., 2018). In line with the 2013 New Zealand census, Jamieson and colleagues reported that nearly half of those adults experiencing loneliness lived alone (49.5%). Of those who resided by themselves 29% were lonely, yet, 14% of those who lived with others were also lonely (Jamieson et al., 2018). The findings by Jamieson et al. (2018) concur with those of other researchers who have found that not all older adults who live alone are socially isolated but loneliness is more common for those who live alone (Golden, Conroy & Lawlor, 2009b). However, as Jamieson et al. (2018) noted, living with someone else does not preclude a person from the experience of loneliness. In light of the demographic trends discussed above, the implications of the finding that social isolation and loneliness are related to cognitive performance and cognitive decline needs to be taken on board by policymakers (such as at central government level and health boards) and for those who work with the older population (general practitioners, social workers, and organisations providing services or interventions for social isolation and loneliness).



#### **1.4 Summary and Importance of the Current Study**

In conclusion, the proportion of older people is increasing in many countries<sup>2</sup>. Modern life in developed countries has increased the likelihood of older adults becoming/being socially isolated or lonely. Social isolation and loneliness appear to be risk factors for poorer physical and mental health, cognitive functioning, and undermine successful ageing.

There is also the possibility that if social isolation and loneliness are not addressed, there is a greater opportunity for the ageing population to experience higher levels of cognitive decline and poorer quality of life. The health, social, and economic challenges posed by an ageing population have prompted governments, research communities, and the medical fraternity worldwide to enhance their knowledge of the ageing process and age-related diseases, and understand the factors that undermine and contribute to successful ageing (Davey & Glasgow, 2006; Deary et al., 2009; Hendrie, Purnell, Wicklund, & Weintraub, 2010). Research on the social world of the older adult and the link between poor social relationships and cognitive ageing is an important piece in the quest to ensure more adults age successfully.

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<sup>2</sup> There are exceptions, with some countries in Africa (Eastern, Middle and Western African countries) and Asia (such as Afghanistan, Laos, Yemen have less than 5% of the total population aged 65 years or older, and expected to remain low in the foreseeable future (He, Goodkind & Kowal, 2016)

## **Chapter Two: Social Isolation, Loneliness and the Association with Cognitive Performance and Cognitive Decline**

**Chapter Overview:** This chapter discusses research that has investigated the effect of social isolation and loneliness on cognitive performance and cognitive decline in older adults. There is a focus on how studies have employed a variety of measures in their investigations of different forms of social isolation. It will be argued that the diversity in assessing social isolation and loneliness has resulted in mixed findings. Studies assessing different forms of social isolation and loneliness and cognition concurrently will also be highlighted as an area that would benefit from further examination. The chapter concludes with identifying questions that the current study aims to answer.

### **2.1 Social Isolation and Loneliness, the Association with Cognition**

Individuals' social environments are complex and multifaceted. The social world an individual inhabits encompasses structural and functional characteristics and unique perceptions. Structural characteristics refer to the size and density of social networks, length of relationships, types of connections and interactions and frequency of interactions. Functional characteristics focus on whether support (tangible or emotional) is available or received. Equally important is an individual's perception of their social networks. Perception includes feelings of loneliness, calibre of available support, satisfaction with relationships, quality of relationships and friendships. As will be discussed in Chapter Three, there is no universal definition of social isolation and loneliness. Consensus on these definitions is important due to the direct relationship between definitions and how to measure the construct under investigation.

A variety of social isolation and loneliness indicators have been used to investigate the relationships between social isolation, loneliness, and cognition. Measures of social isolation have included marital and cohabitation status, size of network, frequency of contacts, whether the network is predominantly family or other, and interactions with community groups (Bassuk, Glass, & Berkman, 1999; Beland, Zunzunegui, Alvarado,

Otero, & del Ser, 2005; Bennett, Schneider, Tang, Arnold, & Wilson, 2006; Zunzunegui, Alvarado, Del Ser, & Otero, 2003). Perceived measures of social isolation such as satisfaction with support received, perception of support available, and loneliness have also been utilised (Bennett et al., 2006; Ellwardt, Aartsen, Deeg, & Steverink, 2013; Fratiglioni et al., 2000; La Fleur & Salthouse, 2016; Wilson et al., 2007). Studies on social relationships and cognition have indicated that older adults' cognitive performance and rate of decline may be influenced by their social environment including their perceptions of their world (Bourassa et al., 2017; Donovan et al., 2017; Holwerda et al., 2014). However, there is a lack of consensus about whether all or just some aspects of social relationships influence cognitive functioning and, whether social relationships have a differential relationship with different cognitive domains such as memory, language, and executive functioning (Amieva et al., 2010; Bourassa et al., 2017; Donovan et al., 2017; Holwerda et al., 2014). The differences amongst studies (discussed in the following section) may partially explain why evidence appears to be inconclusive on the relationship between the concept of social isolation, loneliness and cognition.

### **2.1.1 Objective social isolation and cognitive performance.**

Objective social isolation measures used to investigate the relationship with cognition have ranged from number of close ties (Albert et al., 1995; Bennett et al., 2006), frequency of contact with family and friends within a time frame, such as weekly or monthly (Barnes, Mendes De Leon, Wilson, Bienias, & Evans, 2004; Seeman et al., 2010), to a combination of size of network and frequency of contact (Green, Rebok & Lyketsos, 2008; Holtzman et al., 2004). Other studies have used a combination of indicators including social engagement or activities, or a validated measure of social networks (Crooks, Lubben, Petitti, Little, & Chiu, 2008; DiNapoli, Wu, & Scogin, 2013; Seeman et al., 2001; Shankar, Hamer, McMunn, & Steptoe, 2013). The heterogeneity in findings for both cross-sectional and longitudinal studies can in part be accounted for by such a diverse range of indicators used to assess social isolation (Evans, Martyr, Collins, Brayne, & Clare, 2018).

For example, in one study of 354 older adults aged 50 years and over, larger social networks (measured by the number of relatives and family members outside the house, and number of friends and neighbours an older adult has contact with) were associated with better cognitive performance and less decline at the follow up 12 years later (Holtzman et al., 2004). In contrast, social network size (measured by number of children, immediate family and friends an older adult has contact with on a monthly basis) was not associated with cognitive performance in a cross-sectional study (Krueger et al., 2009) and cognitive decline in a longitudinal studies (Hughes, Andel, Small, Borenstein, & Mortimer, 2008). When reviewing the above studies, social network size can be narrowly measured by just including monthly contact with immediate family or friends (as measured by Krueger et al., 2009 and Hughes et al., 2008), or it may include a more wide ranging scope of the network as measured by Holtzman and colleagues (2004) who included relatives and members outside of the house, such as neighbours. Based on the above findings, it would seem that the broader the measure of social isolation is the more likely it captures the true extent of an individual's social network or their social integration.

It was suggested by O'Reilly (1988), in a review of the literature of social support and social networks, that "as long as conceptual and operational confusion remains, the predictive utility of the concepts will not progress to the stage where logical and meaningful interventions can be developed" (p. 872). Thirty one years later, the words of O'Reilly are just as relevant. The following examples demonstrate the difference between findings when one study uses a narrow view and the other a broad view of social isolation. In the Amsterdam Study of the Elderly social isolation was defined as someone living alone, not being married, or having no social support (Holwerda et al., 2014). By contrast, in an English study, social isolation was conceptualised as a combination of marital status, cohabitation status, low frequency of contact with family and friends, and low participation in a variety of social, recreational, religious, and community groups and clubs (Shankar et al., 2013). The findings of the two studies

differed with Holwerda et al. (2014) claiming that social isolation was not related to cognitive decline, and Shankar et al. (2013) reporting that those who were socially isolated were at greater risk of cognitive decline than those who were not. A notable difference between the indicators used to measure social isolation in these two studies is that one study captured participation and engagement within the broader community, and the other did not.

In a review of social isolation measures used internationally, it was noted that as interpersonal interactions take place across different levels (personal, family, friendship, and community), social isolation measures need to capture these multiple aspects of social networks for a fuller assessment of an individual's social connectedness or social isolation (Zavaleta, Samuels & Mills, 2016). That does not appear, however, to be the case; a scoping review of social isolation and health suggests that the majority of studies conceptualised social isolation in a unidimensional manner such as an objective measure of frequency of contact with family and friends (Courtin & Knapp, 2017). Another critique made by Courtin and Knapp (2017) is that most studies used indices, which were based on measures of relationship status, household composition, and size of network, with limited use of more comprehensive indices or developed scales, capturing outside of the home relationships or interactions.

One of the key areas of an older adult's social world, that appears to be missing in many studies on social isolation and cognition, is social integration or engagement with the wider community. Research has indicated that older adults who are engaged in social activities such as groups, hobbies, and religious organisations, and other forms of wider participation outside of immediate family have better cognitive performance and slower rates of cognitive decline than those who are not as socially engaged (Krueger et al., 2009; Small, Dixon, McArdle, & Grimm, 2012; Wang, Karp, Winblad, & Fratiglioni, 2002). The benefits to cognition may come through stimulation from novel interactions, or complex and challenging experiences. Research has shown that even brief social

interactions (less than five minutes), lead to increases in executive functioning performance on subsequent tests (Ybarra et al., 2008).

Older adults' social participation has also been associated with better psychological wellbeing (reduced rates of depression) because of an increased sense of belongingness and mutual proximity, sense of control or mastery through feelings of accomplishment, and positive and supportive actions, as well as enhanced self-esteem (Ashida & Heaney, 2008; Hao, 2008; Smith & Christakis, 2008; Thoits, 2011). Depression and poorer psychological wellbeing has been associated with poorer cognitive performance and increased rates of cognitive decline in a 26 year longitudinal study of dementia free adults (Dotson, Resnick, & Zonderman, 2008). It is important to use a broad conceptualisation of social isolation that enables comparisons of those who are socially connected across a variety of levels to those that are not. It was also noted in a meta-analysis of social isolation and mortality that studies using complex measures of social relationships, had greater effect sizes than single indicators of social isolation (Holt-Lunstad et al., 2015). Holt-Lunstad et al. (2015) suggested that multidimensional measures of social relationships may provide better predictors than unidimensional ones. Thus it is likely that the exclusion of social participation in studies on social isolation and cognition may result in an underestimation of the effects of social isolation on cognition.

### **2.1.2 Perception of one's social network and cognitive performance.**

Perception of one's social network social isolation or loneliness itself has been operationalised in a variety of ways. Loneliness and perceived social isolation are terms that have been used interchangeably in the literature on social relationships and cognitive performance. The concept of *perceived social isolation* or loneliness<sup>3</sup> is based on an individual's perception or subjective experience of their social network and

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<sup>3</sup> Loneliness has been described as a colloquial term for perceived social isolation (Cacioppo & Hawkley, 2009)

interpersonal interactions, rather than the actual availability or presence of their social network members or support systems.

In a four-year study of Chicago adults 65 years and older (Wilson et al., 2007), emotionally lonely people were found to have poorer cognitive performance at baseline for episodic memory, semantic memory, working memory, processing speed and visuospatial ability, and showed a more rapid decline in global cognition, semantic memory, perceptual speed, and visuospatial ability than non-lonely people, when network factors such as size and participation in activities were controlled for.

The importance of *perception* of one's social network on cognitive functioning was also reported by Amieva et al. (2010) based on data from a 15 year longitudinal study on cerebral and functional ageing in French residents aged over 65 years (n= 3,777). Amieva and colleagues assessed the influence of both structural and qualitative characteristics of social networks on cognitive decline. Findings from the study indicated that structural characteristics of social networks, such as size, social integration, or social engagement had no association with dementia, whereas the perception of one's relationships was determined to be a protective factor for dementia. Assessing reciprocity of social interactions, older adults who perceived they had received more in their lifetime from others than they had given out, had a 53% reduction in risk of Alzheimer's disease. Satisfaction with one's relationships reduced the risk of dementia by 23%. Amieva et al. concluded that their findings supported those of Wilson et al. (2007), postulating that the frequency of interactions or the number of people with whom one interacts in older age may be less important than the quality of interactions, such as being satisfied with the support available or the perception that the interactions met one's expectations or desires at that stage of life.

In other studies perception of one's social network, such as the perception of available emotional support or social support and loneliness, did not show an association with cognition in the ageing after controlling for confounders (Bassuk et al., 1999; Eisele et al., 2012; Gow et al., 2013; Yeh & Liu, 2003).

Though the terms have been used interchangeably, different measures have been used to evaluate perceived social isolation and loneliness. Studies have, for the majority, utilised the direct approach to identifying loneliness, using a single-item, self-rating measure which asks “Are you lonely” or some variation, such as “Do you feel lonely”. (Gow et al., 2013; Holmén, Ericsson, & Winblad, 2000; Yeh & Liu, 2003).

There has been less use of reliable and valid measures of loneliness such as the UCLA Loneliness scale (Russell, Peplau, & Cutrona, 1980; Russell, 1996), or the De Jong Gierveld Loneliness scale (de Jong Gierveld & van Tilburg, 1999) when assessing loneliness and cognition. These scales use an indirect approach to measure loneliness by not mentioning the word lonely or any derivative of it. Employing direct measure poses the issue that the respondent must be aware that they are lonely and respond accurately despite the social stigmatisation that may accompany this feeling. Accordingly, an older person may see loneliness as a stigmatizing concept and present a socially desirable answer, or reduce their loneliness ratings, rather than identify as experiencing loneliness (Victor, Grenade & Boldy, 2005a). Also, when using a single item direct measure of loneliness there is the assumption by researchers that all respondents share a common understanding of the concept of loneliness. Thus, although useful in large surveys, the simplistic nature of the single-item measure is a key weakness in studying loneliness (ÓLuanaigh & Lawlor, 2008).

A study which compared utility of a single-item direct measure of loneliness and the de Jong Gierveld Loneliness scale (indirect measure) in a sample of 293 participants reported that approximately 40% of respondents had a different classification on the two measures (Victor et al., 2005a). Of the 108 participants with differing classifications, 74 were rated as more severe on the de Jong Gierveld Loneliness scale than on the direct approach. Also 32% of participants who stated they were never lonely on the direct approach were categorised as moderately lonely on the de Jong Gierveld Loneliness scale. It has also been reported that there is a lack of concordance between a



direct question on loneliness and the UCLA loneliness scale indicating minimal agreement between the two classifications methods (Shiovitz-Ezra & Ayalon, 2011).

As previously noted older adults may not be aware they are lonely or do not want to admit to feelings of loneliness, which may explain the differences in findings in the study by Victor and colleagues. Another possible explanation is that of timeframes. The direct questions on loneliness are related to a specific timeframe (such as did you feel lonely in the last week, or are you lonely). In contrast, scales like the de Jong Gierveld Loneliness are asking *how often* the individual has felt experiences that relate to emotional or social loneliness, such as having no one to talk to or feeling rejected. The distinction between the two relates to the duration of loneliness as transient, situation or chronic (de Jong-Gierveld & Kamphuls, 1985). The direct question may reflect a transient experience of loneliness that has just occurred (unable to attend social activities or a friend not able to visit), whereas, scales such as the de Jong Gierveld Loneliness scale are capturing the more stable experience of loneliness, which is not regarded as temporary or situational. This indicates that depending on the instruments used for measuring loneliness, results may differ.

Secondly, an area that has not yet been widely studied is the relationship between different forms of loneliness and cognition. The influential work of Weiss (1973) conceptualised loneliness as having two dimensions. One being social loneliness (deficits in an individual broader circle of social contacts) and the other being emotional loneliness (lack of an intimate or confidant figure in one's life). Despite researchers in the field of loneliness suggesting that the distinction between emotional and social loneliness is relevant to the older population, there is a paucity of studies that have investigated simultaneously whether emotional loneliness or social loneliness predicts cognitive performance. For example studies have investigated whether variables such as cognition is a risk factor for emotional or social loneliness, or mediates the relationship between depression and emotional and social loneliness, or whether levels of emotional or social loneliness differ in demented and non-demented older adults, but do not

appear to have investigated whether emotional and social loneliness have a detrimental association with cognitive performance over time (Holmén & Furukawa, 2002; Peerenboom, Collard, Naarding & Comijs, 2015; Schnittger, Wherton, Prendergast, & Lawlor, 2012).

### **2.1.3 Studies of the relationships among social isolation, loneliness, and cognition.**

Another observation from the literature is that *perception* of one's social environment may be a better predictor of cognitive performance and rate of decline than objective social isolation. That is, evidence appears stronger for the idea that loneliness has a negative effect on cognition in the ageing than the claim that changes in cognitive are driven by the size of one's social network or frequency of contact with family and friends (Boss et al., 2015; Cacioppo & Hawkley, 2009). A current limitation of research investigating the relationship between social relationships and cognition is that most studies have assessed one element of the older person's social network in isolation rather than assessing a combination of elements. For example, a study may exclusively consider the relationship between loneliness and cognitive performance or social isolation and cognition. Though useful, concurrent assessment of objective social isolation and loneliness would determine if each have an independent contribution to cognitive performance, or whether one predominate, and accounts for the associations reported when the factors were considered individually? This would provide a more conclusive answer to whether different aspects of social relationships such as loneliness are more important for cognitive performance than others (objective social isolation). There are a few studies that have considered both objective social isolation and loneliness in the same sample, such as those previously mentioned studies by Shankar et al. (2013) and Holwerda et al. (2014), yet the findings reported conflict. To date there is not a clear direction on whether some aspects of social relationships are more important than others for cognition in older adults.

There is also a scarcity of studies that have considered the possible synergistic effect of loneliness and social isolation on cognitive performance. Shankar et al. (2013) investigated whether there was an interaction between loneliness, social isolation, and cognition but since then, few have followed with this line of questioning (McHugh, Lawlor, Steptoe, & Kee, 2016). Understanding the relationship that different levels of loneliness and social isolation have on cognition is important for understanding the mechanisms of these potential risk factors on cognitive performance. Therefore, further studies that concurrently analyse social isolation and loneliness in the same sample would be beneficial for increasing knowledge about the differential consequences of social isolation and loneliness on cognition. Furthermore, this may lead to the development and implementation of effective intervention strategies for both social isolation and loneliness and cognition.

#### **2.1.4 Confounders that may influence the association between social relationships and cognition.**

In a meta-analysis of social relationships and cognition, it was observed that many studies did not adjust for potential confounders such as depression, alcohol use and physical functioning (Kuiper et al., 2016). Kuiper and colleagues suggested lack of adjustment for confounders may result in overestimating the strength of the relationship between both structural and/or functional characteristics of social networks and cognitive performance in the ageing (Kuiper et al., 2016). As discussed in Chapter 1 Section 1.2.1 there is a relationship between poor physical and mental health and social isolation and loneliness, and many of those factors such as depression and heart disease are related to cognitive performance and decline. To ascertain whether social isolation and loneliness influence cognitive performance and rate of decline independently of other socio-demographic and psychosocial risk factors, studies need to control for confounding variables. Further discussion on the correlates of social isolation and loneliness, occurs in Chapter Three.

### **2.1.5 Cognitive domains and the relationship with social isolation and loneliness.**

A common approach to assessing cognitive outcomes and social isolation has been through the use of a global measure of cognitive ability or a summary score of different cognitive abilities. When reviewing the literature on the relationship between the social world of the older adult and cognition what becomes apparent is that few studies have examined the impacts of different forms of social isolation and loneliness on different cognitive domains (such as memory, language, executive functioning) in the same population. As will be discussed in Chapter five, cognitive functions have different developmental trajectories, and may respond differently to environmental factors. For example, social relationships that enable stress or stress responses to be reduced is proposed as having a benefit on memory and executive functioning (Kelly et al., 2017). Social interactions and participation in activities have been associated with improvements on global cognition, it has also been associated with verbal fluency (executive functioning domain) (Brown et al., 2012). Examining the response of different cognitive domains, such as memory, information processing speed, language, or visuospatial skills to social isolation and loneliness, could provide researchers with more detailed knowledge and insight into why an individual's social world may be a risk factor or protective factor for cognition.

### **2.1.6 Questions from the literature review.**

The following section outlines the questions that warrant further investigation in light of the review of the literature above. These questions have guided the design of the current thesis.

The key questions are:

- 1) What is the relationship between different aspects of an older adult's social world (objective social isolation, and loneliness) and cognitive performance when investigated simultaneously?

- 2) Do emotional and social loneliness have a differential relationship with cognitive performance?
- 3) Do different levels of social isolation moderate the relationship between loneliness and cognitive performance?
- 4) Is the relationship between social relationships and cognition over estimated due to confounding variables such as depression or alcohol use not being controlled for?
- 5) How are different cognitive domains influenced by social relationships?
- 6) How will the results for a study based on a sample from Aotearoa/New Zealand compare to other international studies?

#### **2.1.7 Summary of observations from the literature review.**

In conclusion, various studies have investigated whether the social world of the older adult is associated with cognitive performance or cognitive decline. Overall, the literature suggests that social relationships have an influence on cognitive functioning in the older adult. Yet, important questions, remained to be answered conclusively such as whether loneliness is more detrimental to cognitive performance than objective social isolation or is the association similar, whether different forms of loneliness (emotional and social) have the same strength of relationship with cognition or whether those who are lonely and socially isolated are more at risk than those who are lonely and not isolated have yet to be answered conclusively. The current study attempts to answer some of the questions and further elaboration occurs in Chapter Six.

House (2001) stated that analysing different aspects of social isolation does not allow for the identification of the “active ingredient” (p. 273), that accounts for the deleterious effect of social relationships on health. The same comment can apply today in regard to what is the active ingredient in social relationships that influences cognition. The benefit of examining the relative and synergistic relationship of social isolation and loneliness on cognitive performance cannot be underestimated when trends such as an older population, potential increase demand on financial and human resources to service the

needs of an older population and increased social isolation and loneliness are on the horizon. Robust evidence that allows policies and interventions to strategically target vulnerable people who are at risk or currently experience social isolation and loneliness may result in increased wellbeing cognitively, physically, and emotionally. Identifying what factors of social relationships are most detrimental to cognition will enable resources to be channelled to those areas most worthy of intervention. Valtorta and Hanratty (2012) note that although social isolation and loneliness have been studied from the various viewpoints of different disciplines (such as psychologist, gerontologist, sociologists and others), which has contributed to increased knowledge, there is a lack of a clear message from the current work. It is suggested by Valtorta and Hanratty that this lack of consensus has offered government and policy makers the opportunity to ignore the potential health gains from providing interventions to address loneliness and isolation.

## Chapter Three: Social Isolation and Loneliness

**Chapter Overview:** This chapter defines social isolation and loneliness and explains how they are related but distinct concepts. The Deficit Perspective and the Cognitive Perspective of loneliness will be discussed. Also outlined are the risk factors associated with loneliness and social isolation, with a brief discussion on how some risk factors are associated with cognitive performance.

### 3.1 Introduction to Social Isolation and Loneliness Literature

#### 3.1.1 Defining social isolation.

Social isolation has been defined in a myriad of ways. There is also inconsistency in the definitions. This inconsistency has methodological implications for research in understanding the consequences of social isolation on the cognitive performance for the older adult. The concept of social isolation first appeared in Berkman and Symes (1979) studies on social ties and mortality (Nicholson Jr, 2009). Social isolation was defined as the “irreversible loss of social attachments and community ties” (Berkman, 1983, p. 743), and measured by the number of one’s social ties (size of network). Similarly Wenger et al. (1996) defined social isolation “social isolation is an objective state of having minimal contact with other people” (p. 333). Both definitions employ a ‘*counting approach*’ and are able to objectively determine if a person is socially isolated.

The perception and feelings of the older adult, as well as the amount of control they had over their social isolation have also been referred to in definitions of social isolation. Lien-Gieschen (1993) defined social isolation as “a state in which an individual experiences a need or desire for contact with others but is unable for some reason to make contact” (Lien-Gieschen, 1993, p. 37). The above definition and other similar variations (Biordi, 1998) are suggestive of a lack of control at an individual level. Killeen (1988) suggested that social isolation caused by a lack of choice should be understood as loneliness; whereas social isolation due to choice be recognised as aloneness. The term

*social support* also appears in the literature alongside social isolation. For example social isolation was defined as “a term used to characterise older adults who have extremely limited social support networks” (Lubben & Gironda, 2003, p. 326). This definition takes into consideration the size of one’s network and the support available from the network. Other definitions in the literature include reference to, living without companionship, lack of meaningful and sustained communication, limited or low social support, and lack of social connectedness or involvement with either ones family and or the wider community (Grenade & Boldy, 2008; Hawthorne, 2006; Tilvis et al., 2012).

For the purposes of this thesis social isolation is regarded as concept that involves a lack of social resources and/or a lack of perceived social resources. Objective social isolation in one’s social world may be due to a limited social network, or lack of contact, a low level of frequency with contacts, or a lack of support received from those in one’s social network. By contrast, perceived social isolation is guided by an individual’s perception of their network and those relationships within it. Perceived social isolation encompasses attributes such as a perception that support, intimacy (physical or emotional), or social connectedness are unavailable or do not meet the individual’s needs, which in turn can lead to loneliness. The following diagram designed for this study (see Figure 1) demonstrates how social isolation is a broad multidimensional concept that is related to numerous other concepts that are presented in the diagram and defined below in Section 3.1.2.

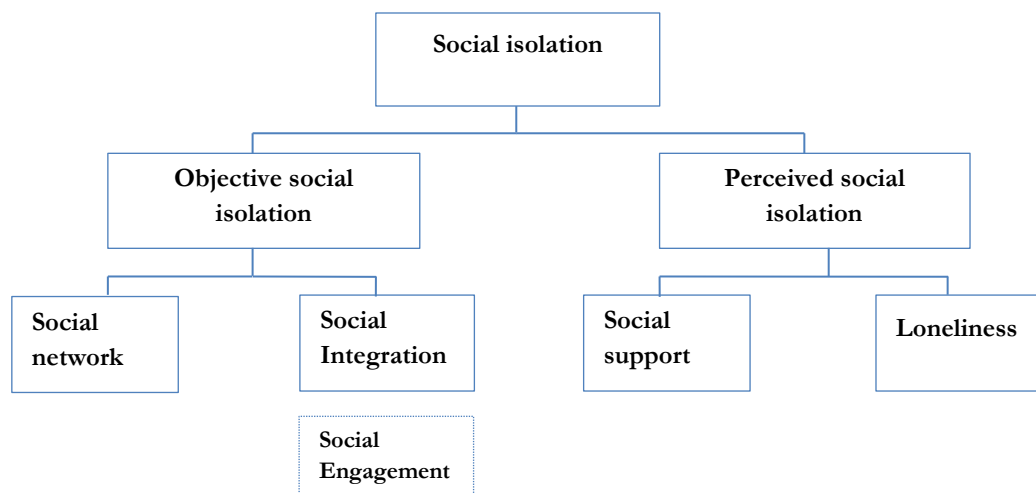


Figure 1. Model of the Objective and Subjective Components of Social Isolation



### **3.1.2 Social isolation and related concepts.**

This section will provide a brief description of social isolation and related concepts that are used in the literature and relate to Figure 1.

#### ***Objective social isolation***

*Objective social isolation* describes a state of having limited or low social support networks, living without companionship, or social connectedness (Hawthorne, 2006). It relates to the objective characteristics of a situation such as a lack of relationships with others (de Jong Gierveld, van Tilburg, Dykstra, 2006). Characteristics that have been associated with objective social isolation are living alone, the small size of one's social network, a lack of or minimal contact with family and friends, and low levels of involvement and social engagement with the wider community (Brummett et al., 2001; Fratiglioni et al., 2000; Havens et al., 2004). To measure social isolation, researchers have utilised the structural characteristics of an individual's social network (Havens et al., 2004; Shankar, McMunn, Banks & Steptoe, 2011).

#### ***Social network***

*Social network* is used to describe the structure and characteristics of an individual's social relationships and interactions. Social networks may be defined as "the web of social relationships that surround an individual and the characteristics of those ties" (Berkman et al., 2000 p. 847) and "an actual set of links of all kinds among a set of individuals" (Mitchell, 1973, as cited in Pillai & Verghese, 2009, p. 2). Social networks for the older person include relationships based on kinship, friendship ties, neighbourhood co-location, or professionally-based care (Victor et al., 2000). The extent of isolation or integration for an individual is determined by assessing structural features of social networks, such as number of ties, frequency of contacts, marital status, participation in activities, group membership, and living arrangements (Nicholson, 2009; Zunzunegui et al., 2003).

### ***Social integration***

*Social integration* is the extent to which an individual experiences social ties or connections. Socially integrated older adults are involved with family, friends, and employment, volunteer work, religious activities, clubs and various organisations, and may extend care to others. It is a multidimensional construct that includes both the behavioural component of social engagement in a wide range of activities and/ or social relationships, as well as the cognitive component of a sense of purpose that social roles provide (Brissette, Cohen, & Seeman, 2000; Thoits, 1983). Social integration is measured by: a) roles – the different types of social relationships such as parent, spouse, relative, friend, church member, volunteer, group member; b) participation - the frequency with which individuals engage in various activities such as visits with friends, going to church or a social organisation; c) perceived integration – the extent to which individuals believe they are embedded in a stable social structure and identify with their fellow community members and social positions; and d) a combination of information regarding social ties, community involvement and frequency of contact with friends and relatives (Brissette et al., 2000).

### ***Social engagement***

The term social engagement is incorporated under the umbrella concept of social integration. *Social engagement* refers to the meaningful participation in an activity with others, be it physical, recreational, or cognitive (Glass, Mendes De Leon, Bassuk & Berkman, 2006). Social engagement refers to the act of participation. Objectively socially isolated individuals often lack, or have very low participation, in socially engaging activities (Baum et al., 2000).

### ***Social exclusion***

The term social exclusion is not included in the diagram. Social exclusion appears to be a term that is rarely, if ever, used in the literature on the effects of social isolation and cognitive functioning in the ageing. Burchardt, Le Grand, and Piachaud (2002) identified four key areas from which people may be socially excluded: consumption (the capacity to purchase goods and services); production (participation in economically or

socially valuable activities); political engagement (involvement in local or national decision-making); social interaction (integration with family, friends, and community). The concepts of social isolation and loneliness are regarded as the predominant conceptualisation of exclusion from social relationships by Victor et al. (2005a).

### ***Loneliness (Perceived social isolation)***

Self-reports of loneliness have been associated with social network size, having a close friend (in comparison to not having a close friend), or cohabitation status (Andersson, 1998; Heylen, 2010; Pinquart & Sörensen, 2001; Victor, Scambler, Bowling, & Bond, 2005b). Yet, surprisingly perceived social isolation is weakly correlated with objective social isolation (Cornwell & Waite, 2009b). This suggests that the large amount of variance in loneliness is dependent on the individual's perception or subjective experiences of their interpersonal interactions (Laursen & Hartl, 2013). Although size of social network is often used to categorise an individual as either socially isolated or socially integrated, it provides no insight into the perceived quality of the relationships within that social network, nor how an individual perceives their interpersonal interactions with other social network members. For example, a large social network, may offer various forms of support to an individual but an individual may not perceive the network as supportive if the support does not match with what is required. As a consequence, the perception of the network may be negative and result in feelings of social isolation or loneliness (de Jong Gierveld et al., 2006). Social support and loneliness are principle indicators of perceived social isolation.

### ***Social support***

Social support is also linked to social isolation and loneliness. *Social support* has been described as an interactive process in which resources (tangible or emotional) or information is obtained from one's social network (O'Reilly, 1988), and such support is regarded as a basic requirement for existence (Machielse, 2006). Social support is best regarded as a function or provision of the network. Types of social support obtained from the network have been identified as: (1) emotional concern (liking, love, empathy);

(2) instrumental aid (goods or services such as providing food, running errands, taking a person to a doctor); (3) information (guidance about the environment or support in times of stress); and (4) appraisal (information relevant to self-evaluation) (Langford, Bowsher, Maloney, & Lillis, 1997).

Social support can be regarded as the antithesis of social isolation in as much as it reflects the reality of being linked to a social network. People must therefore be connected to a network or community in order to access and experience social support (Gottlieb, 1983). Social support has also been described as the opposite notion to loneliness. With social support being the positive and loneliness the negative of one's perception of social network (Andersson, 1998).

### **3.1.3 Defining loneliness.**

There is no universally agreed upon definition of the loneliness. Descriptions of loneliness include subjective feelings of aloneness, separation, feeling distant from others, losses or abandonment (De Jong Gierveld, Tilburg & Dykstra, 2006; Graneheim & Lundman, 2010; Karnick, 2005; Tilivis et al., 2012; Weiss, 1973). Two perspectives offered are the deficit perspective (a lack of certain relationships) and the perceived discrepancy perspective (differences between the desired relationships and those actually achieved).

### **3.1.4 Deficit perspective.**

In developing a theory of loneliness, Weiss (1973) posited that loneliness was not a desire for company in general, but a desire for a specific form of company. Loneliness is, therefore, a response to the absence of a particular relationship that provides social integration, nourishment, validation, a feeling of trust and help in stressful situations. This lack of, or deficiency in, social interactions is a pathway to loneliness. Weiss based his theory of loneliness on an interactionist approach which views loneliness as a combination of personality and situational factors, with neither working in isolation. With this, Weiss postulated that loneliness has two forms: loneliness of emotional

isolation and loneliness of social isolation. For example, the absence of a relationship that provides closeness, intimacy, or attachment, is the loneliness of emotional isolation characterised by anxiety and perceived isolation. Emotional loneliness is regarded as the painful form of isolation (Rubenstein & Shaver, 1982). Inadequate social networks, and the lack of satisfying and valued friendships within that network, result in the loneliness of social isolation which is characterised by feelings of boredom, social exclusion, weariness, and aimlessness. Each form of loneliness is distinct and is a response to a unique relational deficit. However, both share common symptoms demonstrated by lonely individuals: restlessness, a driving force, and a yearning to fill the void.

According to Heylen (2010), distinguishing between different forms of loneliness will provide a more in-depth understanding of the development of loneliness in older age, as well as the consequences of various types of loneliness. As suggested by Weiss (1973) and Hawkley, Browne & Cacioppo. (2005), social and emotional loneliness are separable dimensions of loneliness. Current research has shown that risk factors for social loneliness and emotional loneliness differ. Social loneliness has a higher correlation with social network size than emotional loneliness, and also with lack of contact with friends, lack of social integration, poorer health and age (Dahlberg & McKee, 2014; Drennan et al., 2008; Heylen, 2010; van Baarsen, Snijders, Smit & van Duijn, 2001). Emotional loneliness has a stronger association with marital status (Dahlberg & McKee, 2014; Drennan et al., 2008). Empirical evidence is supporting the conceptual separation of emotional and social loneliness. It seems prudent to investigate the different forms of loneliness and whether they differ in their association with cognitive functioning

### **3.1.5 Perceived discrepancy model of loneliness.**

On the other hand, Perlman and Peplau (1981, 1984), who are key proponents of the perceived discrepancy approach to loneliness, defined loneliness as “the unpleasant experience that occurs when a person’s network of social relationships is significantly deficient in either quality or quantity.” (1984, p. 15). This definition is based on a perceived discrepancy - attributional hypothesis of loneliness. That is, there is a

discrepancy between one's social relations and one's subjective standards or desires for relationships. With this approach, the focus is on the social relations, desires, or needs of the individual and not on the level of actual social contact. Individuals with extensive social networks would be deemed not lonely by an objective standard. However, many of those individuals may experience the pain of loneliness if those social relations do not meet their subjective standards.

The perceived discrepancy-attributional hypothesis also considers the influence of how cognitive processes such as causal attributions, social comparisons and perceived control mediate between perceived discrepancy and the individual's emotional response. This is based on self-discrepancy – attributional approach (Peplau, 1981). Attribution theory focuses on the way in which people intuitively try to explain the causes of their behaviour, attributing them to internal (dispositional) or external (situational) circumstances. Individuals, who attribute their loneliness to unchangeable personal characteristics or the situation, have lower expectations regarding the future and express greater pessimism and hopelessness (Michela, Peplau & Weeks, 1981). The perceived discrepancy in one's social relations on both a quality and quantity level are assessed by past experiences and social comparison. Past experience allows one to compare the present with the feelings and images associated with previous social relations. Thus, social comparison is the process of evaluating one's own social relations in comparison to others. For older people the comparisons could be with their aged counterparts, younger, or even previous cohorts. For the ageing, the concept of 'former self' was the major reference point for current evaluations (Lowenthal & Robinson, 1976). Loneliness is not static it can intensify or dissipate based on changes of our personal standards for relationships.

The perceived discrepancy perspective does not explicitly differentiate between emotional loneliness and social loneliness as discussed in the deficit perspective on loneliness.

Importantly, there is agreement amongst the diverse definitions on three points: a) the onset and origin of loneliness results from a deficiency in a person's social relationships; b) loneliness is a subjective experience not synonymous with objective social isolation, where people can be lonely though not alone, or alone but not lonely; and c) it is the subjective experience that is distressing and unpleasant (Marangoni & Ickes, 1989). Another consideration of loneliness is related to a time perspective. Loneliness may be temporary, unchangeable or one accepts it and attributes the cause to others.

A study examining the deficit and cognitive perspective of loneliness in divorced and married couples acknowledged that it was important to distinguish between social and emotional loneliness (Dykstra & Fokkema, 2007), which is in line with the deficit perspective offered by Weiss (1973). It was also reported that understanding the discrepancies between an individual's actual and desired relationships provided greater insight into loneliness than whether there was an absence or not of a partner or wider social network (Dykstra & Fokkema, 2007).

To date there has been no research comparing the different perspectives (deficit and perceived discrepancy) and their relationship to cognitive performance. The De Jong Gierveld Loneliness scale (de Jong Gierveld & van Tilburg, 1999), a measure of emotional loneliness and social loneliness, was developed based on the perceived discrepancy perspective, and influenced by the work of Weiss (1973). The use of such a measure would provide information on whether older adults who perceive there are deficits between their interpersonal affection and intimacy needs, and what they realize, influences cognitive performance, in a similar manner as a discrepancy in their perceived social needs and what they have. Assessing both emotional and social loneliness alongside a comprehensive measure of social isolation when investigating cognition will also provide insight into the relationship between perception of loneliness and actual social isolation levels. Therefore, in line with the work of Dykstra and Fokkema (2007), to gain greater insight into loneliness and cognitive ageing, the deficit perspective and

the perceived discrepancy theory are both considered as viable explanations of loneliness.

### **3.1.6 The relationship between social isolation and loneliness.**

Objective social isolation is not synonymous with loneliness, as the correlation between the two is weak to moderate (Cornwell & Waite, 2009a). In the Irish study of ageing, 60% of older adult who were regarded as “objectively socially isolated” reported that they did not experience loneliness (Timonen, Kamiya & Maty, 2011). Loneliness can be an outcome of social isolation, but it is not inevitable, as an individual may enjoy their own company and not feel separated from others or experience the pain and emptiness of feeling lonely. For others aloneness is a pathway to loneliness. The awareness of being separated from others may be acutely painful. Yet those who are socially integrated can also be lonely. Individuals differ to the extent in which they experience loneliness, and this may reflect different levels of susceptibility to loneliness.

Susceptibility to loneliness and the association it has with cognitive performance has been investigated. An Irish study created a metric of discordance between social isolation and loneliness and analysed the association with cognition in older adults (McHugh, Kenny, Lawlor, Steptoe, & Kee, 2017). It assessed individual’s levels of loneliness in comparison to their levels of social isolation and categorised respondents into four groups, (Concordant high and Concordant low - high or low levels of loneliness as expected based on social isolation status; Discordant susceptibility - lonelier than expected based on social isolation status, Discordant robust - less lonely than expected). The study found that those who were lonelier than expected as per their social isolation status (Discordant susceptibility), performed poorer on a global cognition measures than those who were less lonely than expected given their social isolation status (Discordant robust), and those who were categorised as highly lonely and isolated (Concordant high). These findings suggest social isolation for individuals with a low propensity for loneliness may in fact be viewed as solitude and not regarded as a negative experience, whereas those who have high propensity for loneliness may



find social isolation a negative experience and create the need or desire for increased social connections.

### **3.1.7 Summary of objective social isolation and loneliness.**

For the purpose of this study, an individual's objective social isolation state and the perception of their social relationships are regarded as important concepts in understanding how the social world of the older adult influences their cognitive performance. The reasoning for this is summed up by Lincoln (2000), that "simply assessing the structure of a person's social network e.g., size or number provides little information about the quality, amount and experience of positive and negative interactions" (p. 242). As mentioned in Chapter Two there are few studies that have assessed both objective social isolation and loneliness together concurrently on cognition which has inhibited commentary on their relative effect on cognition (Cornwell & Waite, 2009b; Kuiper et al., 2016). Such as, whether loneliness can account for the association between social isolation and cognition, or whether both loneliness and social isolation diminish cognitive ability. The current study aims to further investigate the interaction between loneliness (emotional and social) and social isolation on cognition. There is much to be gained from understanding how these two distinct but related concepts may influence cognition. Firstly, though elucidating the potential mechanisms of social relationships and cognition and secondly, by providing insight into how interventions should be tailored.

This section has described the different definitions of loneliness and objective social isolation and argued that importance of assessing the two distinct concepts. The following section will now describe the risk factors for objective social isolation and loneliness, which in many cases overlap.

## **3.2 Risk Factors for Social Isolation and Loneliness**

Overlapping risk factors for loneliness and social isolation in older adults have been identified as widowhood, no (surviving) children, living alone, declining health and life

events (e.g. loss and bereavement) (de Jong Gierveld et al., 2006; Heylen, 2010; Wenger, 1997; Wenger et al., 1996). A review of the key correlates follows, which are summarised into personal circumstances, resources and life events.

### **3.2.1 Personal circumstances.**

**Age.** Longitudinal studies have reported an increase in the proportion of older adults who report they are lonely as they age (Cohen-Mansfield, Shmotkin, & Goldberg, 2009; Dykstra et al., 2005; Jylha, 2004). Findings from cross-sectional studies have reported that the older the participants the more likely they self-report “loneliness” (Cornwell & Waite, 2009a; Fees, Martin, & Poon, 1999; Shiovitz-Ezra & Ayalon, 2011). Social isolation has also been reported as increasing with age in a twenty-year longitudinal study (Wenger & Burholt, 2004), and in cross-sectional studies older adults (85 years plus) were more likely to experience social isolation than their younger counterparts (Havens et al., 2004; Iliffe et al., 2007). There are two explanations that need to be considered when determining if age is a risk factor for loneliness or social isolation.

Increases in loneliness with advancing age have been attributed to interactions with other factors older people are more like to experience (Victor et al., 2005b). These experiences may include increase in physical disability or fragility, retirement, relocation, bereavement, loss of social roles and weakening of social ties that come with ageing (Golden et al., 2009a)

The second consideration is driven by socio-emotional selectivity theory, which suggests that as people age, the older person selectively chooses which relationships they want to invest in, value and get more pleasure from. This determines the size of their networks, as they will drop relationships that cause conflict or strain, or are not deemed important to them (Carstensen, Isaacowitz, & Charles, 1999).

**Gender.** No individual is immune to the experience of loneliness and social isolation; however, the majority of research finds it significantly more likely for women to report increased levels of social isolation and loneliness (Pinquart & Sörensen, 2001), although

no significant gender differences were found in a study of older Canadians adults (Havens et al., 2004). There appears to be a plausible explanation for women reporting more social isolation and loneliness than men. Firstly, women are living longer and more likely to be widowed, live alone, or experience more years of increasing health problems (Maxwell & Oakley, 1998) and therefore more opportunities to experience social isolation and loneliness. This explanation finds support in a 28 year longitudinal study on loneliness of Finnish older adults aged 60 - 86 years old (Aartsen & Jylhä, 2011). Women were found to have a 48% higher probability of becoming lonelier than men which was fully explained by the unequal distribution of risk factors between men and women rather than baseline levels of social and psychological resources available. That is, women were more likely to be exposed to the risk factors such as loss of a partner, decline in social activities, and increased feelings of nervousness, and physically disabilities that lead to loneliness.

**Living Arrangements.** Living alone has been used to assess social isolation in numerous studies (Fratiglioni, Paillard-Borg, & Winblad, 2004; Fratiglioni et al., 2000; Yeh & Sing-Kai, 2004). Living alone has been associated with poorer psychological wellbeing and loneliness (Vozikaki, Papadaki, Linardakis, & Philalithis, 2018; Wenger et al., 1996; Wright-St Clair et al., 2017). Loneliness has also been associated with worsening the psychological effects of living alone (Lim & Kua, 2011). Living alone for majority of older adults has been either due to death of a partner or dissolution of a relationship (de Jong Gierveld et al., 2006; Iredell, Grenade, Nedwetzky, Collins, & Howat, 2004). The effects of divorce or death of a partner has been associated with loneliness and the effects of the loneliness have been recognized over a long period of time. Although, older people who live with a spouse are less lonely than those who live alone (Holmén, Ericsson, Andersson, & Winblad, 1992), living with adult children in the adult child's home was associated with increased isolation and loneliness in a twenty year longitudinal study (Wenger & Burholt, 2004).

**Marital Status.** Marriage offers a protective factor from social isolation and loneliness with those that are married reporting less loneliness and social isolation than their non-married counterparts, regardless of gender (Andersson, 1998; Dykstra et al., 2005; Wenger et al., 1996). Being divorced, widowed, separated, and never married increases the risk of loneliness and social isolation (Hawthorne, 2008). In a seven year longitudinal study of older adults and correlates with loneliness, loss of a partner increased loneliness, whereas those who had a new partner did not have a significant decrease in loneliness (Dykstra et al., 2005). For older adults the advent of retirement and children leaving home is associated with an increased reliance placed on one's immediate social environment for social support and interaction. Studies have noted that in particular the attachment with one's cohabiting partner can provide a protective factor against loneliness and social isolation (de Jong Gierveld & Tilburg, 2010; Pinqart & Sorensen, 2000). Older adults in marriages that have a partner needing caregiving, or who has health problems, or is not emotionally supportive have higher incidences of emotional and social loneliness than other married couples (de Jong Gierveld, Broese van Groenou, Hoogendoorn, & Smit, 2009).

**Education.** Lower levels of education appears to be a risk for both social isolation and loneliness. Older adults in an American study with less than 12 years of education were 1.5 times more likely to be social isolated than their peers who had 12 or more years of education (Bassuk et al., 1999). Both social isolation and loneliness have inverse relationships with education as reported in an American study. Individuals who attended university were more socially connected and perceived themselves as less isolated than those who did not attend college (Cornwell & Waite, 2009b). For an older person the lower the levels of education the higher their loneliness scores (Savikko, Routasalo, Tilvis, Strandberg, & Pitkälä, 2005). It has been suggested that those with higher education and income have greater opportunity for a broader social network (Dykstra & De Jong Gierveld, 1999)

### 3.2.2 Resources.

**Social Networks and Friendships.** The initial view of research from the 1980s was that the larger an individual's social network the more protective it is against social isolation and loneliness. Follow up studies and increased understandings of social isolation and loneliness have challenged the relationship between size of network and support (Victor et al., 2000). Individuals with larger social network size may have more opportunity for availability of support, than for individuals with smaller social networks. However, evidence supports a stronger association between various outcomes of wellbeing and quality and perception one has of their network than the size of the network (Fiori, Antonucci, & Cortina, 2006; Pinqart & Sorensen, 2000; Tomaka et al., 2006).

Social networks change in size and structure for the ageing due to factors such as a decrease in outside connections as one retires, relocates, or loses a spouse, or becomes ill and relies more on one's immediate social network such as spouse, children, and family. Friendships are an invaluable source of emotional and social support. The benefits of friendship for the ageing are well documented, and can lower the risk of social isolation and loneliness (Blieszner & Adams, 1992; de Jong Gierveld et al., 2006). Friendships are particularly relevant for the childless or never partnered old adult, as they can provide kinships, become confidants, increase opportunities for social integration and alleviate emotional loneliness (Dykstra, 1995; Pinqart, 2003). However, the evidence about whether childlessness influences social isolation and loneliness is unclear. Childlessness was a risk factor for social loneliness in the ageing in a United Nations study of seven countries (de Jong Gierveld & Tilburg, 2010). Other studies have reported that lack of children may not lead to more loneliness as childless adults actively create other relationships through their lifespan (Routasalo & Pitkala, 2003). Adult children can provide various provisions of support, both instrumental and emotional, that help alleviate social isolation and loneliness to their parents. However, if

the relationship is strained and conflictual it may increase the feelings of loneliness in the parent (Routasalo & Pitkala, 2003).

### 3.2.3 Life events.

**Life-events, Loss and Bereavement.** Loss of jobs, relocation, retirement, loss of children and/or spouses, and decrease in health are some of the life and age-related losses that are associated with loneliness and social isolation (Havens & Hall, 2001; Nicholson Jr, 2009; Victor et al., 2000). Widowhood, for both men and women, has repeatedly been linked with increased experiences of social isolation and loneliness (Golden et al., 2009b).

**Health.** The relationships between social isolation, loneliness and poor physical and mental health is well documented with poor self-assessed physical health and illness chronicity showing positive correlations with social isolation and loneliness (Fees et al., 1999; Hawkey & Cacioppo, 2007; Holmén & Furukawa, 2002; Kawachi & Berkman, 2001). Physical disabilities, declining in functional health, reduced mobility, altered states of wellness and one's health status such as chronic, long term, or terminal illness are all physical barriers that can precede social isolation and loneliness (Luskin Biordi & Nicholson, 2009).

Individuals who are socially isolated or lonely, have increased risk of being inactive, smoking, and report multiple health-risk behaviours (Shankar et al., 2011). Furthermore, social isolation and loneliness in the older person increases risk for developing health problems (Tomaka et al., 2006), greater chance of hospitalisation, and increased mortality (Shiovitz-Ezra & Ayalon, 2010). Studies have also reported that loneliness is independently associated with increased elevated blood pressure (Hawkey, Thisted, Masi, & Cacioppo, 2010), morning rise in cortisol (Cacioppo & Hawkey, 2009) decreases in physical activity (Shankar et al., 2011) after controlling for social isolation and social support.

Depressive symptomology is significantly linked with social isolation and loneliness (Cacioppo et al., 2010; Golden et al., 2009a; Golden et al., 2009b). Studies on loneliness and social isolation need to adjust for depression, as it is a possible confounding variable in examining the relationship between social isolation, loneliness and cognition. Depression is a possible underlying mechanism through which loneliness and social isolation can affect cognition (Cacioppo et al., 2010; Gow et al., 2013; Hawkey & Cacioppo, 2010). However, loneliness has been found to influence cognition independently of depression (Shankar et al., 2013; Wilson et al., 2007).

#### **3.2.4 The relationship between poor health and loneliness and social isolation.**

While the research is consistent and conclusive that there is a strong and significant association between poor health outcomes and social isolation and loneliness Victor et al. (2000) state that there is still disagreement on whether poorer health status is caused by loneliness and/or social isolation or does loneliness/social isolation causes poor health. Health problems can lead to people to socially withdraw due to feeling fatigued, unsure of what is happening to their physical health, a sense of alienation from other, shame of their illness, increased sense of hopelessness, and loss of dependency, therefore placing themselves at risk for social isolation and loneliness (Luskin Biordi & Nicholson, 2009, Victor et al., 2000). Though this question has yet to be answered conclusively a recent meta-analysis noted that social isolation and loneliness was seen as a risk factor for acute myocardial infarctions and strokes, although 85% of the excess risk was linked to unhealthy lifestyle. This led to Hakulinen et al. (2018) stating that social isolation and loneliness are markers for more conventional risk factors for poorer physical and mental health outcomes, which in turn lead to disease. By not controlling for physical or mental health issue, and over-estimation of the relationship between social isolation, loneliness and cognition may occur.

### **3.2.5 Other risk factors for social isolation and loneliness.**

Though not a focus in the current study, it is worth noting that other risk factors for social isolation and loneliness include transportation issues, unsafe or deprived neighbourhoods and the older adult's perception of the quality of the neighbourhood, as well as environmental barriers (Johnson, 1999; Krause, 1993; Marottoli, Mendes de Leon, Glass, Williams, Cooney & Berkman, 2000; Mooney, 2003; Thompson & Krause, 1998).

Transportation issues or cessation of driving can have an effect on an older adult's level of social connectedness due to their role in providing access to an individual's social network (Mooney, 2003). Transportation issues can occur both in urban and rural environments. However, it has been suggested that a lack of transport may have a greater effect on social isolation and loneliness for those in rural communities than those in urban settings (Havens et al., 2004; Havens & Hall, 1999). Unsafe neighbourhoods have also been associated with social isolation and loneliness. Older adults who live in neighbourhoods characterised by high levels of disorder such as crime, vandalism, noise, and drug use have been reported to be at higher risk of social isolation and loneliness (Ross & Jang, 2000). Furthermore the perception an older adult has on their neighbourhood has also been associated with loneliness. Scharf and de Jong Gierveld (2008) reported that in England the older adult's subjective evaluation of their neighbourhood contributed to loneliness regardless of objective neighbourhood variables. Greater loneliness was reported for those who evaluated their neighbour negatively in comparison to those who evaluated their neighbourhood more positively.

Environmental barriers such as street conditions, traffic conditions and distance from services may also impact an older adult's loneliness and social isolation. Ability for a person to engage in out-of-home activities may be hampered by perceived environmental barriers, and therefore reduce opportunity for social engagement (Rantakokko, Iwarsson, Vahaluoto, Portegijs, Viljanen & Rantanen, 2014). A study reported that older adults who perceived they were constrained by environmental



barriers had higher levels of loneliness than those who did not perceived they had environmental constraints (Cohen-Mansfield, Hazan, Lerman, & Shalom, 2016).

### **3.2.6 Summary of social isolation and loneliness risk factors.**

In summary, various factors can increase the risk of social isolation and loneliness. There appears to be no one crucial factor that has been identified to explain it. In a Finnish study, older adults when asked ‘what they felt caused their loneliness’ were more likely to respond that their loneliness was caused by their own illness, death of a spouse, and lack of friends (Savikko et al, 2005). Other common causes are spouse’s illness, lack of transport, family problems, and retirement (Ministry of Health, 2004). Research on isolated and lonely older adults suggests that isolation and loneliness occurs through an accumulation of events, circumstances and personal characteristics which on their own would not be an inevitable pathway to either social isolation or loneliness (Machielse, 2006).

### **3.3 Relevance to the Current Study**

This chapter highlights how social isolation and loneliness are two concepts that have been conceptualised, defined, or measured, in a variety of ways and, though related, are distinct. It has been suggested that to gain greater understanding of how social relationships influence outcomes of interest (such as cognition), researchers should investigate social networks (objective social isolation) and loneliness (perceived social isolation) simultaneously (Machielse, 2006). Assessing objective social isolation will provide information on the levels of social isolation that one is experiencing, and how that influences cognition. Assessment of loneliness will provide information on how perception of one’s intimate and broader social network influences cognition. The two approaches complement each other and provide an overall analysis of the broad concept social isolation and the relationship with cognition.

The second component of this chapter focused on the different correlates associated with loneliness and social isolation. It is apparent that to determine the “pure”

association between concepts such as social isolation and loneliness, and cognition, confounding variables must be controlled for. In the previous section life events such as death of a partner, poor physical and mental health, and age are variables that if not controlled for may overestimate the relationship between social isolation, loneliness and cognition.

The following chapter will focus on how social relationships may influence cognition.

## **Chapter Four: Pathways: How Social Isolation and Loneliness may Influence Cognition**

**Chapter Overview:** This chapter aims to provide an overview of how social relationships may affect cognition through three identified pathways: behavioural, psychological, and physiological (Fratiglioni et al., 2004; Uchino, 2006). A model by Uchino (2006) that highlights potential pathways linking social relationships to health is utilised to demonstrate how social relationships may link to cognitive performance in the older adult. A discussion on the role of cognitive stimulation and cognitive reserve as a mechanism in which social relationships may influence cognitive performance and cognitive decline over time is also presented.

### **4.1 Introduction to how the Social World may Influence Cognition**

How an older adult's social world and his or her perception of their social interactions influences their cognitive functioning are poorly understood, as the current literature provides a lack of clarity of the mechanisms and causal links. As discussed in Chapter 1, this is in part due to the lack of consistency regarding definitions and measures of social isolation and loneliness alongside a lacuna in longitudinal studies (Boss et al., 2015; Courtin & Knapp, 2017). This limited understanding may also be attributed to numerous facets that comprise social relationships, such as loneliness, social isolation, social integration, social activities, social engagement, social support, which operate in an individual's social world in direct and indirect ways to affect cognition.

Three main pathways (cause and effect) through which an individual's social world may affect cognitive performance in the ageing have been identified. These are behavioural, psychological, and physiological pathways (Bennett et al., 2006; Cacioppo & Hawkley, 2009; Hertzog et al., 2009). These pathways, explaining how social isolation and loneliness status may influence cognitive performance, are not mutually exclusive. They often work simultaneously and can overlap and interact with each other over time. As they do not work in isolation from each other, an integrated model which demonstrates how different aspects of social relationships influence behaviours, psychological

processes and physiological mechanisms, which influence health outcomes will now be introduced.

#### **4.1.1 Broad model of how social relationships may influence cognition through behavioural, psychological and physiological processes.**

Uchino (2006) formulated a model that integrates different theoretical perspectives and evidence-based research about the association between social relationships and health. Depicted in Figure 2, is the model by Uchino which considers how both the structural features which relate to the structure of the network (such as network size or frequency of contact with family and friends, or engagement with wider community) and functional features which relate to the function and purpose of relationships (perception of support) of a social network may influence directly and indirectly health outcomes. The model has two distinct pathways through which an individual's social network may influence disease mortality and disease morbidity: behavioural processes and psychological processes which interact with physiological processes. Uchino makes two important points; first the behavioural and psychological pathways are considered distinct from each other but are not mutually exclusive of each other. The second point is that the association between social network (structure and function) and health outcomes are hypothesised to be mediated through physiological processes such as changes in cardiovascular, neuroendocrine and immune functioning.

#### **4.1.2 The first pathway – Behavioural processes.**

Uchino suggests that support from social networks members can facilitate healthier behaviours (such as physical activity, healthy diet, not smoking, and moderate alcohol use) and adherence to medical regimes which can influence health. How social networks influence health behaviours has its roots in social control theory, which proposes that relationships have a regulatory function and that individuals who are more socially integrated with friends, family, and the wider community are less likely than those who are socially isolated to engage in risky or deviant behaviour (Anson, 1989; Ewart, 1991).

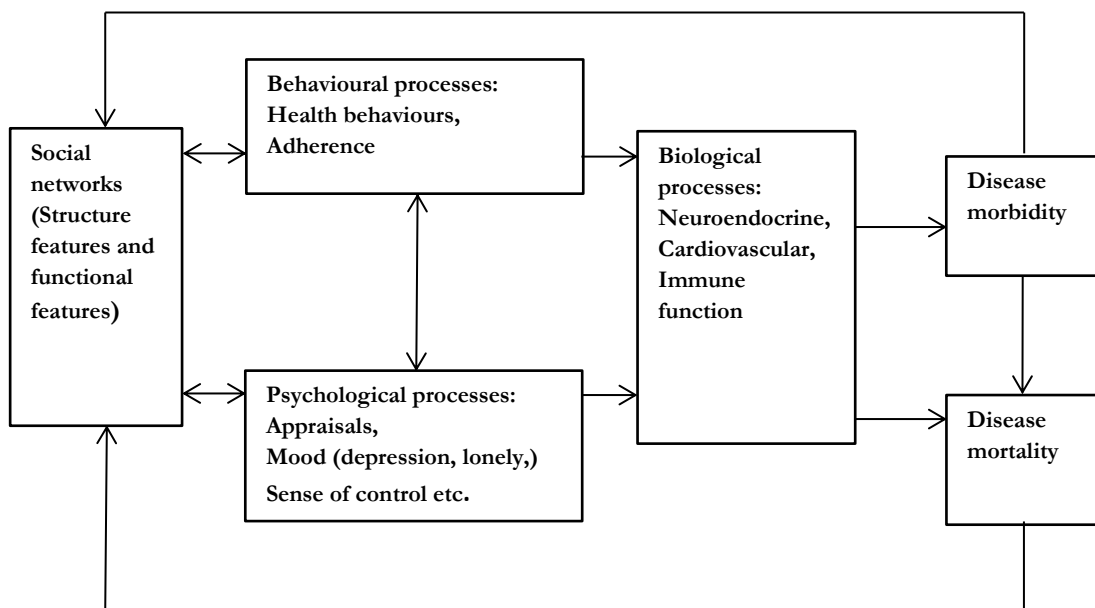


Figure 2. Broad Model Highlighting Potential Pathways Linking Social Support to Health (Uchino, 2006, p.378).

In relation to health behaviours, it is suggested that socially integrated individuals should be more likely to engage in healthy behaviours such as exercise, healthy eating habits, not smoking, and drinking moderately (Tucker, 2002). Social network members may influence an individual's health behaviours through direct or indirect social control (Rook, Thuras, & Lewis, 1990). *Direct social control* is through the use of social influence. Individuals who participate in a social network are subject to normative guidance and peer influence about health-related behaviours. Social network members may influence an individual on whether they exercise, eat healthily, smoke, or drink (Berkman et al., 2000), thereby possibly lowering the risk factors for conditions such as cardiovascular disease, diabetes and metabolic syndromes which are associated with poorer cognitive performance (Ng et al., 2016; Snyder et al., 2015; Wang et al., 2015). If the network has shared norms towards healthy behaviours this will more than likely have a positive influence on physical, mental, and cognitive health, however the converse can may also be true.

Influence by social networks members on an individual's choice to engage in lifestyle behaviours may come through *direct social control* in the way of requests, reminders, threats or rewards from significant others. The other way social network members can influence an individual is through indirect social control. *Indirect social control* is when engagement in a healthier lifestyle is centred on feelings of obligation or responsibility to significant others. Being integrated into a social network also increases opportunities for access to information (such as learning about beneficial behaviours that enhance physical, mental and cognitive wellbeing) and primary care medical services which may result in receiving treatment for a physical or mental illness earlier than if a person was socially isolated.

Social isolation and loneliness have been linked to physical inactivity and smoking in older adults when investigated independently (Shankar et al., 2011). However, in a combined model that included social isolation and loneliness, loneliness was no longer associated with smoking. Shankar and colleagues suggested those who were socially isolated had less opportunity to be influenced by social network members and the study's findings supported the link between behavioural processes to be linked with health outcomes. The evidence also indicated that loneliness is a risk factor for obesity (Petitte et al., 2015). Both social isolation and loneliness for risk factors for hazardous drinking (Kharicha et al., 2007; Petitte et al., 2015). Smoking, physical inactivity, obesity, and hazardous drinking have all been associated as risk factors for poorer cognitive performance (Engelhardt, Buber, Skirbekk, & Prskawetz, 2009; Hassing, 2018) and cognitive decline (Anstey, Mack, & Cherbuin, 2009; Anstey, von Sanden, Salim, & O'Kearney, 2007; Baumgart et al., 2015; Sabia et al., 2018) and with cardiovascular disease (Heffner, Waring, Roberts, Eaton, & Gramling, 2011; Kotseva et al., 2016) which is also associated with cognitive decline (Snyder et al., 2015).

A recent meta-analysis of longitudinal studies involving 11 coronary heart disease studies and 8 stroke studies, concluded that poor social relationships (loneliness or socially isolated) had a greater risk of incident of heart disease (29%) and a 32% increase

in risk of stroke, both risk factors for poorer cognitive performance and cognitive decline (Valtorta, Kanaan, Gilbody, Ronzi, & Hanratty, 2016). It was also noted by Valtorta and colleagues that social isolation and loneliness had a similar association with disease incidence, and one was not stronger than the other.

Poorer social relationships appear to have an association with unhealthy lifestyle behaviours, which in turn may have a direct and indirect effect on cognitive performance and cognitive decline. Evidence is suggestive that socially isolated people have poorer adherence to treatment than those who are socially integrated (De Freitas, Falls, Haque, & Bursztajn, 2013). In the case of adult renal transplant patients social isolation was associated with non-adherence to treatment (Denhaerynck et al., 2005).

Regardless of whether social network members influence an individual's behaviour through (direct or indirect social control), or providing of information, the behavioural pathway linking social relationships and health outcomes (cognitive functioning) are mediated by the physiological responses to those behaviours. As behaviours such as lack of activity, excessive eating or drinking alcohol induce physiological responses.

#### **4.1.3 The second pathway – Psychological processes.**

Uchino argues that the second pathway in which social networks may influence health outcomes, and mortality is through psychological processes. Psychological processes include but not limited to appraisals of situations, events, others, and self, mood (depression, loneliness, self-esteem, and feelings of mastery) and feelings of control. Uchino offers two explanations for how psychological processes influence health outcomes: the first is that perceived availability of social support from one's social network members will prevent or alleviate response to stressful events that are inimical to health. The second explanation is that perception of poor social relationships may have a detrimental influence on one's psychological state, which in turn can influence health outcomes.

#### **4.1.4 Social support may decrease the stress response.**

The first explanation suggests that the belief one's social network members will provide the necessary support/resources if needed to effectively manage or cope with a stressful event may lead to a more benign appraisal of the stressful situation and/or bolster one's ability to cope with the increased demands. This may lead to attenuating the stress response or preventing a stress response occurring at all (Cohen & Wills, 1985; Thoits, 2010; Wethington & Kessler, 1986). Also, perception of support has been associated with higher levels of feelings of control, self-efficacy and self-esteem, which may reduce affective or behavioural responses to stress, through activating more adaptive appraisals and proactive coping strategies. Stressful events can evoke negative emotional and maladaptive behavioural responses that may influence health such as, worry, stress, decreased sleep, smoking, increased alcohol use or substances uses, and activation of physiological systems (Cohen, 2004; Kirschbaum, Klauer, Filipp, & Hellhammer, 1995; Thoits, 2010; Uchino, Cacioppo, & Kiecolt-Glaser, 1996)

#### **4.1.5 Deficits in quantity and quality of social relationships may influence psychological states.**

The second explanation proposed by Uchino is based on the influence that perceived deficits in social relationships may have on psychological processes such as appraisals, emotions or mood (depression). Integration in a social network may be a determiner of generalised positive psychological states (sense of predictability and stability, a sense of purpose, belonging, and recognition of self-worth). Emotional regulation (increased positive affect and reduced intensity and duration of negative affective states) is also a benefit from positive social interactions with others (Cohen, 1988). The benefits created by such positive psychological states include: a reduction in psychological despair; increased motivation for self-care through healthy lifestyle habits; and a reduction in physiological processes such as suppressed neuroendocrine response and enhanced immune function (Cohen, 2004), all of which may offer protection against cognitive decline. Uchino suggests unfavourable evaluation of available social support, or being



socially isolated, causes negative psychological states (such as loneliness, depression, or a general negative affect, low self-esteem, a lack of perceived control, a sense of alienation, or social exclusion) which may lead to an increase in neuroendocrine and cardiovascular responses. Ongoing activation of neuroendocrine systems and cardiovascular systems have been linked with poorer cognitive performance (Ferrari & Magri, 2008; Lee et al., 2007). These detrimental responses may also suppress immune functioning which has been associated with poorer cognitive performance (Kiecolt-Glaser et al., 2003; Wichmann et al., 2014).

#### **4.1.6 The third pathway – Physiological processes: Stress, psychological processes, and physiological pathways leading to poorer cognitive performance.**

As one ages the brain becomes more sensitive to stress (Lupien, McEwen, Gunnar, & Heim, 2009). Many older adults deal with stressors such as poor health, ageism, financial strains and daily life hassles or acute stressors. Lonely people are more likely than non-lonely people to perceive daily events as more stressful and report more chronic stressors (Cacioppo, 1994; Cacioppo et al., 2000; Hawkey, Burleson, Berntson, & Cacioppo, 2003; Turner, 1989). There is robust evidence indicating that chronic stress is detrimental to cognitive functioning (Arnsten, 2009; Dickinson, Potter, Hybels, McQuoid, & Steffens, 2011; McEwen, 2002). Higher levels of perceived stress in older adults have been shown to be related to lower cognitive functioning as well as a risk factor for cognitive decline over a 7 year period (Aggarwal et al., 2014). Daily life hassles, such as not having enough money to live on, are associated with poorer performance on psychomotor tasks (Rosnick, Small, McEvoy, Borenstein, & Mortimer, 2007).

Current life stressors are also one of the main determinants of stress-related changes in the hypothalamic-pituitary-adrenal (HPA) axis (Stephens & Wand, 2012). Ongoing stress results in prolonged activation of the HPA axis (Glaser & Kiecolt-Glaser, 2005). Prolonged activation of the HPA axis has been found to induce excessive exposure to

glucocorticoids (GS), predominantly hydrocortisone (cortisol), and also dysregulates immune responses (Frodl & O'Keane, 2013). The ongoing exposure of GS has been associated with increased blood pressure and architectural changes in two areas of the brain that are particularly sensitive to GS; the hippocampus and prefrontal cortex, structures with a high concentration of cortisol receptors (Pillai & Verghese, 2009). Both animal and human studies have reported hypercortisolism leads to neuronal loss, dendritic atrophy, reduced hippocampal volume, and abnormal synapse formation (Arnsten, 2009; Ross, Gliebus, & Van Bockstaele, 2018). In examining a relationship between perceived stress and hippocampal volume it was reported that older adults whose responses indicated they were currently experiencing high levels of perceived stress had small hippocampal subfield volumes than those reporting lower levels of perceived stress (Zimmerman et al., 2016). The hippocampus is regarded as pivotal to learning and memory functions (Frodl & O'Keane, 2013). Sustained structural damage to the hippocampus has been proposed as a way psychosocial conditions (such as chronic stress or loneliness) adversely affect memory and executive functions. A four-year longitudinal study reported that older people, who had a significant increase in cortisol level over the years and high current basal cortisol levels, were impaired on tasks measuring explicit memory and selective attention when compared to age controlled subjects (Lupien et al., 1998). Other studies have also concluded that long-term exposure to stress increases risk of cognitive impairment (McEwen & Sapolsky, 1995; Wilson et al., 2003; Wilson et al., 2005).

#### **4.1.7 Social isolation and loneliness are also common sources of chronic stress.**

Evidence suggests that socially isolated and lonely individuals are more likely to have increased physiological and neuroendocrine responses to stressors than individuals who are socially integrated or not experiencing loneliness (Bhatti & Haq, 2017; Knox & Uvnäs-Moberg, 1998). Lack of intimate attachments, low social support and social isolation have been associated with increased urine levels of cortisol and norepinephrine

independent of the influence of stressful life events (Fleming, Baum, Gisriel, & Gatchel, 1982; Kiecolt-Glaser et al., 1984; Knox & Uvnäs-Moberg, 1998). This indicates that the experience of loneliness or objective social isolation may impact cognitive performance directly as a form of stress or through the association with greater arousal to stressful events. Cacioppo and colleagues (2006, 2009, 2012) claim that the characteristics of loneliness (heightened sensitivity and hyper-vigilance, and fear of negative evaluation) may activate neurobiological mechanisms such as increased sympathetic tonus and stimulation of the hypothalamic-pituitary-adrenal axis, as well as decreased inflammatory control, and sleep salubrity. Evidence indicates that socially evaluated threat elevates levels of salivary cortisol, and loneliness predicts increased cortisol-awakening responses, greater fibrinogen and natural killer cell responses (inflammatory responses) to stress (Blackhart, Eckel, & Tice, 2007; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004).

Thus, research suggests that the mechanism by which loneliness contributes to cognitive decline includes the on-going, elevated activation of the HPA axis and increased inflammatory responses in the brain. Inflammatory responses in the brain have an association with stress. An example of this is C - reactive protein (CRP), an immune protein and a non-specific marker of inflammation, which is released as a part of the large, systemic immune-cascade response to infection or injury. Chronic stress has been linked with increasing CRP concentrations (McDade, Hawkey, & Cacioppo, 2006). Furthermore, CRP is a risk factor for cardiovascular disease, neurodegeneration and diabetes, which that have been linked to cognitive decline (Kempuraj et al., 2016; Smith, Timpson, & Lawlor, 2006; Thorand et al., 2003).

#### **4.1.8 The pathways are not mutually exclusive.**

Uchino points out that the three pathways do not operate independently of each other. For instance, loneliness has been associated with reduction in capacity to self-regulate thoughts, feeling, and behaviours (Baumeister, DeWall, Ciarocco, & Twenge, 2005). Lonely adults apply less effort to express, enjoy, maintain, or optimise positive feelings

and use these feelings less to reduce a bad mood compared to non-lonely adults (Hawkey, Thisted, & Cacioppo, 2009). Self-regulation of emotion positively influences the ability to regulate other self-control behaviours. Diminished emotional self-regulation is associated with increased loneliness, reduced physical activity, and prediction of reduced physical activity (Hawkey et al., 2009). Another form of self-regulation is healthy eating and moderation of alcohol intake. Cacioppo and Hawkey (2009) suggest that self-regulation may play a part in the health behaviours of individuals, and that those who are socially connected, or perceive themselves to be so, may find it easier to engage in healthy behaviours compared to those who are isolated or lonely. As discussed earlier, lifestyle factors such as physical inactivity, diet, and alcohol use all affect cognitive health. Another example of how a psychological process may influence behaviour is that lonely people may engage in harmful health behaviours such as smoking, hazardous alcohol use, and unhealthy eating habits as a way to obtain psychological relief from the distress of loneliness (Leigh-Hunt et al., 2017).

Fratiglioni et al. (2004) suggested that individuals who are active and socially integrated have more opportunity for social engagement which leads to positive emotional states, leading to lower stress levels. Berkman and Glass (2000) proposed that social engagement provides meaningful social roles in older adults and viewed the social roles older adults occupy as a vehicle that provides a sense of identity, value, and belonging. In addition, social participation provides a sense of purpose, control, and overall self-efficacy (Bath & Deeg, 2005). For older adults who are socially integrated and participate in meaningful roles, there may be positive psychological consequences (such as increased self-esteem, improved mental health and perception of connectedness) which may result in the ability to actively cope or be more resilient to stressors, which consequently reduces exposure to detrimental physiological responses. Higher levels of stressors has been linked to increased risk of cognitive decline (Juster, McEwen & Lupien, 2010; Turner, James, Capuano, Aggarwal, & Barnes, 2016).

In summary, Uchino's model highlights how poorer social relationships can influence health outcomes. It provides explanations for how both deficits in quantity and quality of relationships can influence behavioural and psychological processes that interact with physiological processes. As mentioned in Chapter Two, the importance of concurrent assessment of social isolation, loneliness and health outcomes of interest (such as cognition) is need to determine the differential putative effects. This will allow for refinement of models on social relationships and health. One such study that assessed social isolation, loneliness and health concurrently reported that they influence different aspects of health. Social isolation was a better predictor of physical health and loneliness of mental health. In a study that assessed social isolation, loneliness and cognitive decline concurrently it was reported that loneliness not social isolation influenced cognition (Holwerda et al., 2014). One of the possible explanations for the lack of association between social isolation and cognitive decline suggested by Holwerda and colleagues was due to the study controlling for many medical variables such as cardiovascular disease, stroke and diabetes. Indicating that social isolation and loneliness may differ in how they influence cognition as they do health. This leads to another possible pathway for social relationships to influence cognition.

#### **4.1.9 Social relationships provide opportunity for cognitive stimulation: Another possible pathway (cause and effect).**

Another potential pathway from social relationship status to cognitive performance is through cognitive stimulation, which is not presented in the model by Uchino, but will be discussed in this section. *Cognitive stimulation* refers to activities that increase neural activity. It is suggested that when the neural circuits are stimulated by repeated use they process information more effectively, retrieval of memories is enhanced, and high-level problem solving is improved (Petrosini et al., 2009). Also, the more complex the tasks the more opportunity for activation and strengthening of neurobiological pathways (Hughes, Flatt, Fu, Chang, & Ganguli, 2013).

It has also been proposed by Fratiglioni et al. (2004) that older adults (who are socially connected and engaged with family, friends, and the wider community) are presented with an opportunity for cognitive stimulation from interactions with others. In essence they argue that interpersonal interactions are like other intellectually stimulating activities and can provide opportunity for cognitive stimulation. Social isolation decreases opportunity for interpersonal interactions, and lonely people are reported as withdrawing from interpersonal interactions, which as a consequence, may causes poorer cognitive performance. One hypothesis that suggests social interactions may maintain or enhance cognitive performance or delay cognitive decline is the cognitive reserve hypothesis. The following section will discuss cognitive reserve and how social interactions may enhance cognitive performance.

#### **4.2. The Cognitive Reserve Hypothesis and how Social Relationships may Directly Influence Cognition**

Cognitive reserve is proposed to account for individual trajectories of cognitive decline observed in older adults and the disjunction between age-related brain changes, brain pathology and the clinical manifestations of those changes observed (Katzman et al., 1988; Stern, 2002; Stern, Alexander, Prohovnik, & Mayeux, 1992). The cognitive reserve theory holds that cognitive stimulation encourages the development of neuroplasticity, which enhances brain resilience to age-related pathology. A more resilient brain can increase the length of time between the pathological and clinical expression of significant cognitive decline (Scarmeas & Stern, 2003). That is, older people who have pathological cognitive impairment, but are regarded as having a greater cognitive reserve (as measured by premorbid IQ, education, social engagement, and occupation attainment) do not show the same observable symptoms as a person with the same degree of cognitive impairment but lower cognitive reserve.

The concept of reserve includes ‘brain reserve’ and ‘cognitive reserve’ (Stern, 2009). *Brain reserve* refers to the individual differences in brain structure (brain size and/or

neuronal count) that account for differential susceptibility to functional impairment in the presence of brain pathology. Larger brains were suggested by Stern as having more capacity to tolerate pathology before clinical symptoms appeared due to having sufficient neurons or synapse to support normal functioning. *Cognitive reserve* refers to the individual differences in making flexible and efficient use of brain reserve when performing tasks. The cognitive reserve model describes the brain's capacity to actively compensate for age-related brain pathology in two ways: neural reserve and neural compensation (Stern, 2006, 2009). Stern argues that *neural reserve* is the difference between individuals in the resilience of pre-existing cognitive processes that underlie the performance of any task. The differences could be due to a more efficient manner in processing tasks or greater capacity of the pre-existing cognitive network when engaged to perform a task. *Efficiency* refers to the level of change in neural activity required for a change in task demand. For an equal task demand one individual may require a greater increase in neural activity than another thereby being less efficient in the manner in which they process a task. *Capacity* relates to task demands before neural capacity is reached. That is brain activation will level off when an individual's neural capacity for a task is reached. For example, older people may reach neural capacity for a memory task, whereas younger people may require greater task demand before neural capacity is reached. *Neural compensation* refers to the ability to shift operations to alternative neural networks when neural networks that would have normally been used for the task at hand are suffering from brain pathology. It is suggested that when the neural circuits are stimulated by repeated use they process information more effectively, retrieval of memories is enhanced, and high-level problem solving is improved (Petrosini et al., 2009).

Evidence for the cognitive reserve hypothesis has come from studies that have shown higher levels of social, recreational and intellectual activities to lead to greater tolerance against brain pathology (Scarmeas & Stern, 2003; Whalley, Deary, Appleton, & Starr, 2004). Likewise, there is a large body of evidence in support of the association between

education, occupational attainment and intelligence scores, and cognitive decline (Karp et al., 2004; Le Carret et al., 2003; Manly, Schupf, Tang, Weiss, & Stern, 2013; Richards & Deary, 2005). Support for the benefit of the social environment on the brain initially came from animal studies. For example, a study on brain plasticity noted that the stimuli required to encourage plasticity may be activity-dependent (van Praag, Kempermann, & Gage, 2000). Furthermore, exposure to an enriched environment providing opportunity for learning, social interaction, and physical activity produced structural and functional changes (enhanced memory and spatial ability) in the brain (Scarmeas & Stern, 2003; van Praag et al., 2000). Longitudinal studies in Sweden have reported that both social interactions and intellectual stimulation may help maintain the cognitive performance in the ageing, as engagement in mental, social and productive activities were associated with a decreased risk of dementia (Wang et al., 2002).

Social cognition provides an explanation on how the act of social interaction with others may stimulate or exercise general cognitive resources which promotes cognitive reserve. Social cognition refers to knowledge about one's self, perceptions of others, and interpersonal knowledge such as motivation (Adolphs, 2001; Amodio & Frith, 2006). All social interactions have some varying degree of complexity that involves the social cognitive processes (Fiske & Taylor, 1991). Processes involved in social cognition may be automatic or dependent on cognitive resources such as attentional capacity, working memory, and cognitive control, which are required for flexible goal-directed behaviour (Adolphs, 2001; Amodio & Frith, 2006; Ybarra et al., 2008). Cognitive control is a complex and demanding task as it requires coordination of thoughts and actions in relation to internal goals through selection of relevant information and organising and optimising information processing, which in turn subserves higher cognitive processes such as planning and reasoning (Miller, 2000; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Social cognitive neuroscience studies show that social cognition relies on the prefrontal cortex, with the medial frontal cortex suggested as having a special role in social cognition, as well as the limbic and associational cortical and



subcortical brain regions (Adolphs, 2001; Amodio & Frith, 2006; Grady & Keightley, 2002). These regions have traditionally been associated with executive functions, semantic memory and episodic memory, respectively (Bennett et al., 2006; Ybarra et al., 2008).

Social interactions may provide a similar level of cognitive stimulation, as intellectual activities, which have been reported as promoting cognitive reserve (La Rue, 2010). Some studies have indicated that larger social network sizes are associated with better cognitive performance as well as reduce rates of cognitive decline (Crooks et al., 2008; Sörman, Rönnlund, Sundström, Norberg, & Nilsson, 2017). A longitudinal study using post-mortem examination reported larger social network size was associated with better cognitive functioning even for individuals who were found to have severe Alzheimer's pathology (Bennett et al., 2006). Individuals, who are socially isolated or have limited experiences of novel social interactions (which may be more cognitively demanding than existing interactions with familiar others), may lack the ability to boost cognitive reserve, but also atrophy of cognitive skills due to a lack of use.

#### **4.3. Summary of how Social Isolation and Loneliness may Influence Cognition**

This chapter has highlighted how social network members support and perception of social networks can facilitate healthy behaviours, and is associated with emotional wellbeing, which can lead to better physical, mental and cognitive health. This chapter also discussed how social interactions may be a source of cognitive stimulation that increases cognitive reserve and provided a direct pathway in which social relationships may influence cognitive performance. Conversely socially isolated or lonely people were demonstrated to be at risk for cardiovascular disease, negative affect, obesity poorer immune functioning, and reduce cognitive stimulation all factors linked to poorer cognitive performance.

Evidence has indicated that social isolation and loneliness are associated with multiple risk behaviours for health. Importantly though when social isolation and loneliness were

studying concurrently, social isolation was more likely to affect health through biological process associated with cardiovascular disease (Shankar et al., 2011) than loneliness. Also, loneliness and social isolation were both argued in this chapter to be associated with increased stress responses that may result in chronic activation of the HPA axis and also had implications for cardiovascular disease. Investigating social isolation and loneliness and cognition concurrently will help make an informed decision on the aspects of social relationships that are a risk factor for cognitive performance. Also the concurrent examination of social isolation, loneliness and cognitive performance may offer opportunity to reduce speculation on the proposed pathways. Therefore, the proposed research investigates the association between different forms of social isolation and cognition at baseline and over a two year period in the older adult.

## **Chapter Five: Cognitive Ageing: If Cognitive Decline is Inevitable why the Heterogeneity in the Older Adult Population?**

*Although the primary cause of dysfunction is presumed to be age-related changes in neural structures, these do not always occur in isolation from environmental influences. Environmental or psychosocial factors may precipitate, enhance, retard or perhaps even reverse the neural degeneration and cognitive decline that accompanies old age. This point must be kept in mind to guard against the view that only biological factors are important.”*  
(Moscovitch and Winocur, 1992, p. 322)

**Chapter Overview:** This chapter defines *cognition*, and then discusses cognitive ageing or non-pathological cognitive decline. The question of whether cognitive decline is inevitable is discussed, with a focus on the evidence of the heterogeneity of the older populations’ cognitive performance and rate of change in cognition. Following this will see the introduction of the Scaffolding Theory of Ageing and Cognition (Park & Reuter-Lorenz, 2009; Reuter-Lorenz & Park, 2014) a conceptual model that incorporates a variety of factors (genetic and non-genetic) and experiences throughout life, that may explain why and how the older population’s individual differences exist. Social relationships are one of those factors that can be incorporated into the model to explain the heterogeneity.

### **5.1 Introduction to Cognitive Ageing**

Studies indicate that cognitive performance and change in the older population is heterogeneous (Evert, Lawler, Bogan, & Perls, 2003). Research on cognitive performance associated with normal ageing suggests that both the magnitude and rate of change differs significantly between older adults (Fillit et al., 2002; Hedden & Gabrieli, 2004; Lindenberger, 2014; Wilson et al., 2002). Studies that have examined the diversity of cognitive scores on crystallised intelligence, memory processing speed, and spatial ability in an older population report that the aged exhibit a higher degree of variability than younger adults (Christensen et al., 1999). Christensen and colleagues

(1999) reported there were a variety of variables such as genetics, health, and lifestyle factors that predicted the diversity of scores, though these differed across the cognitive domains. Many researchers have postulated that cognitive decline due to chronological age is neither universal nor inevitable (Rowe & Kahn, 1987; Zelinski, Gilewski, & Schaie, 1993).

### **5.1.1 What are cognition and cognitive ageing?**

Cognition refers to the “the activity of knowing: the acquisition, organization, and use of knowledge” (Neisser, 1976p. 1). The mental processes associated with cognition are commonly categorised into cognitive domains such as attention, learning, memory, language, visuospatial, information processing, perception and executive functions (Jurado & Rosselli, 2007). When discussing whether cognitive decline is inevitable researchers have focused on both general cognitive ability and individual cognitive domains such as language, memory or information processing. Terms used to describe non-pathological cognitive decline are normative ageing (Baltes & Nesselroade, 1979) or cognitive ageing. Cognitive ageing is defined by Salthouse (1991) as the “decrease in performance on various measures of cognitive functions associated with increasing ageing in the adult portion of the lifespan” (p. 2). This chapter examines non-pathological cognitive decline.

### **5.1.2 Is cognitive decline inevitable?**

In relation to the question ‘is cognitive decline inevitable?’ current evidence strongly suggests that there is an almost universal decline in cognitive performance with age (Park, O'Connell, & Thomson, 2003). Age-related declines in cognitive performance have been noted both in laboratory testing where individuals have had to respond to visual (Jost, Bryck, Vogel, & Mayr, 2011) or auditory stimuli (Andrews & Westerman, 2012) and in real world settings, such as when driving (Bao & Boyle, 2009), interacting with computer desktop systems (Sayers, 2004), and use of home medical devices (Mykityshyn, Fisk, & Rogers, 2002).

Equally important are findings from cross-sectional and longitudinal studies that show that cognitive functions have different development trajectories across the life span (Hedden & Gabrieli, 2004; Salthouse, 2009; Schaie, Willis, & Caskie, 2004). Studies such as the Berlin Ageing Study (Baltes & Mayer, 1999), and the Seattle Longitudinal Study (Schaie, 1996) have reported that cognitive decline in some cognitive domains begins as early as the middle twenties, whereas, other cognitive domains have increased improvement during the middle years of one's life. Age-prone cognitive functions are information processing speed, working memory capacity, inhibitory function, episodic memory, and spatial ability (Christensen, 2001; Salthouse, 2009, 2010). In a cross-sectional study Park et al. (2002) collected data from participants aged 20 – 92 years old. The participants were extensively tested through measures on perceptual speed, visuospatial working memory, verbal working memory, verbal and visuospatial recall and three vocabulary tests. Results showed that from young adulthood there was a continuous and gradual age-related decline in the cognitive mechanisms of speed, working memory and long term memory.

Cognitive functions such as vocabulary (stock of words known), word knowledge (such as meaning, spelling, pronunciation, use of word, grammatical knowledge), general knowledge, and comprehension have been identified as more age-resistant. Studies also report that exposure to education, cultural, and occupational experiences, can improve cognitive functions up to the sixth and seventh decade of one's life (Anstey & Low, 2004). Historically this has given rise to the traditional dichotomy between *fluid abilities* (cognitive processes that are used to acquire new concepts and adapt to new situations; e.g., fluid reasoning, working memory, processing speed, etc.), and *crystallised abilities* which refer to accumulated knowledge and expertise and are regarded as the stable residue of the interaction between one's previous fluid abilities and the environment. More recently it has been suggested that the use of this historic terminology is confusing in relation to cognitive ageing, because abilities such as perceptual speed and episodic memory which are distinguished from fluid abilities are highly age-prone and decrease

with age (Salthouse, 2010). Alternative terminology is offered by Salthouse which highlights the distinction between age-resistant and age-prone cognitive functions. These terms are *product* and *process*. Product refers to the outcome of cumulative processing carried out in the past, whereas process refers to the efficiency of processing carried out at the time of the assessment (Salthouse, 2010).

Though current evidence strongly suggests age-related cognitive decline to some degree is an inevitable process, data from longitudinal studies is often inconsistent with the data from cross-sectional studies. Cross-sectional studies consistently reveal a monotonic decline for the majority of cognitive domains that start when adults are in their 20's (Salthouse, 2009, 2014; Schaie, 2009). By contrast, longitudinal studies have reported that declines in cognitive performance for most domains often start much later in middle age and that for some people their performance with age is maintained or may even improve (Rönnlund & Nilsson, 2006; Rönnlund, Nyberg, Bäckman, & Nilsson, 2005; Schaie & Willis, 2010). Differences between cross-sectional and longitudinal studies on cognitive ability have been documented. In the Seattle Longitudinal Study of Ageing (SLS) findings from cross-sectional investigations reported that 25 was the peak age for inductive reasoning, spatial orientation, perceptual speed and verbal memory (Schaie, 2005). Yet in the SLS longitudinal studies peak ages were reported as perceptual speed 25 years old, inductive reasoning and spatial orientation 53 years old and verbal memory 60 years old. Similar differences were found by Rönnlund and colleagues (2005, 2006, 2008), with cross-sectional data for episodic memory and visuospatial ability indicating age related decrements from 35 years old. Longitudinal data found no decline before age 60 for episodic memory and little or no decline until age 55 for visuospatial ability. Rönnlund and colleagues reported that cohort differences in educational attainment accounted for the inconsistencies between the two study designs even when considering minor practice effects.

Studies that have focused on individual differences and differential patterns of change, such as the Seattle Longitudinal Study (SLS), reported that, when analysing individual differences at the age of 81, less than half of all observed individuals experienced reliable decremental change on a particular ability over the preceding seven years (SLS; Schaie et al., 2004, p. 310). Furthermore, very few individuals showed a decline across all cognitive abilities even by 80 years of age (Schaie, 1990). The findings from the Baltimore Epidemiological Catchment area study noted that 32% of their participants demonstrated no change in cognitive functioning or improved over a period of 11 years (Lyketsos, Chen, & Anthony, 1999). These findings are also supported by the work of Wilson et al. (2002) who investigated cognitive changes across domains such as episodic memory, semantic memory, working memory, perceptual speeds and visuospatial ability over a six-year period in cognitively intact older adults. They reported greater heterogeneity in the older adults' rates of change over the six-year period. A few experienced rapid cognitive decline, with the majority of older adults remaining stable, or presenting with a gradual trajectory of decline or slight improvement in their cognitive ability. Wilson and colleagues concluded that the significant heterogeneity in rate of change in cognitive functioning of older adults suggests a more person-specific cause than an inevitable or uniform decline due to a developmental process.

These findings of substantial heterogeneity in cognitive decline amongst the older adults are consistent with comments of MacDonald, DeCarlo, and Dixon (2011) who noted that, due to the considerable individual variation in rates, nature, timing, and extent of age-related decline in cognitive abilities, chronological ageing is not a causal mechanism underlying cognitive decline. They share the sentiment of Whalley et al. (2004), who viewed the relationship between cognitive decline and chronological ageing as not simply linear, but complex. Age could be seen as a vehicle that reflects the accumulation of biological, health, neurological, and environmental influences over a lifetime, and it is those factors that determine the variety in cognitive ageing (MacDonald et al., 2011; MacDonald, Dixon, Cohen, & Hazlitt, 2004). Other evidence to support the need to

identify person-specific lifestyle factors has arisen from recent longitudinal studies that have suggested the prevalence of dementia is on the decline, though not all studies agree (Langa et al., 2008; Matthews et al., 2013; Qiu, von Strauss, Bäckman, Winblad, & Fratiglioni, 2013; Rocca et al., 2011). Explanations for changes in dementia prevalence rates are due to long-term trends such as increased opportunity for education and level of education achieved, more cognitively stimulating employment challenges and decreased rates of childhood infectious diseases or person specific lifestyle and environmental factors (Langa et al., 2008; Matthews et al., 2013).

At first glance cognitive decline may seem inevitable, as many individuals will experience a decline in their cognitive performance as they age, yet cognitive performance for others may remain relatively stable. The individual differences in cognitive ageing trajectories and the heterogeneity of the older population has prompted researchers to understand what are the risk factors or protective factors that may explain the variation. In particular there is a focus on risk factors that are modifiable, as many of the identified risk factors for cognitive decline are not currently modifiable such as genetics or early life experiences (schooling, occupation) for the older adult. Social isolation and loneliness are potentially modifiable, which may present an opportunity to influence cognitive performance.

Investigating and understanding individual differences in the older population will help inform interventions and guide policies not only for the older adult but potentially for the wider population. Increasing evidence about the environmental factors that are protective or detrimental to cognitive performance or change will also help with informing new and evolving theories of cognitive ageing.

One such theory that has evolved in part from recent evidence on risk and protective factors for cognitive ageing is that proposed by Reuter-Lorenz and Park (2014) which is discussed in the following section.



## **5.2 A Theory of Cognitive Ageing that Considers Non-genetic Factors such as Social Relationships**

The following section discusses the Scaffolding Theory of Ageing and Cognition (STAC-r: Reuter-Lorenz & Park, 2014), which is also the conceptual framework for this thesis. In determining what theoretical foundation to use for the current study, guidance was found in the suggestion that whilst genetics play a large role in development of age-related changes or disease-related pathology, environmental factors may significantly contribute to the ‘expression’ of cognitive impairments (Mortimer, Borenstein, Gosche, & Snowden, 2005). The theoretical perspective proposed by Park and Reuter-Lorenz, (2009, 2014) may explain how an older adult’s social world affects the expression of cognitive performance in the older adult.

### **5.2.1 Adaptability of the brain.**

One of the most fundamental changes to theories of cognitive ageing attributed to the findings from functional neuroimaging, is that the rate of cognitive change in the older adult is not inevitably fixed as once thought (Park & McDonough, 2013). Behavioural and structural data have shown patterns of decline in the older adults, whereas functional imaging data has provided some evidence of higher levels of neural activity in prefrontal regions with age. That is, though structural changes such as decrease in grey and white matter occur, the brain responds to the neural degradation (such as cortical thinning, volumetric shrinkage, decrease in dopaminergic receptor and white matter integrity) and cognitive challenges through a dynamic model of adaptation. Adaptation that has been evidence in the adult brain is activation of new regions, great flexibility, and reorganisation in neural networks in response to experiences (Carlson et al., 2009; Kleim, Jones, & Schallert, 2003). The following section introduces STAC-r, a theory of ageing and cognition that has evolved from recent evidence that the brain attempts to adapt to bio-psychological changes that occur with age. The STAC-r is relevant to the current study as it incorporates how lifestyle and environmental factors can influence the rate of cognitive ageing

### 5.2.2 Scaffolding Theory of Ageing and Cognition-revised (STAC-r): Introducing modifiable factors into theories of cognitive ageing.

The Scaffolding Theory of Ageing and Cognition- revised (STAC-r) proposed by Park and Reuter-Lorenz (2009, 2014) states that observed aged differences in cognitive functioning may be explained by the relationship between adverse biological and neuropsychological factors as well as favourable influences on brain structure and brain function over the life course (refer Figure 3). The STAC-r is an integrated view of behavioural, structural, and functional changes that occur within the neurocognitive system with age and how those dynamic changes interact with putative compensatory processes also referred to as neuroplasticity<sup>4</sup> and other protective factors. Under the STAC-r model the brain is characterised as a dynamic and flexible structure that adapts to both positive and negative changes as one ages. The basic principles that the model conveys is discussed as follows:

1) The first principle of STAC-r is that the older brain is affected by varying degrees of neural deterioration of both neural structures and function. The neural degradation is categorised into either neural challenges or functional deterioration (Park & Reuter-Lorenz, 2009). *Neural challenges* represent structural declines that occur with normal ageing such as white matter changes, cortical thinning, and regional atrophy, dopamine depletion and amyloid depositions (Bishop, Lu, & Yankner, 2010; Driscoll et al., 2009; Grady, 2012; Hedman, van Haren, Schnack, Kahn, & Hulshoff Pol, 2012). By contrast, *functional deterioration* (maladaptive, age related brain activity) is a direct response to the neural challenges the older brain faces as it ages.

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<sup>4</sup> Neuroplasticity refers to the morphological changes that occur in the brain in response to internal and external stimuli (Kemperman, 2006; May, 2011). Specifically, it refers to the capacity of neural circuits to change in response to fluctuations in neural or glial activity (Kemperman, Gast & Gage, 2002). The increased neural or glial activity is associated with changes in synaptic connections between neurons, addition of new neurons (neurogenesis), increased myelination of axons, or changes in the shape or size of a neuron (Willis, Schaie, & Martin, 2009). Neuroplasticity provides the pathway by which the brain self-organises and reconfigures to meet environmental demands (Whalley, Deary, Appleton & Starr, 2004).

Functional deterioration indicators are reported as decreased specificity of ventral-visual and motor areas (such as decreases in specialised neural tissue to visual categories such as faces and house), decreased hippocampal recruitment, and dysregulation to the default network and poor structural connectivity (Bernard & Seidler, 2012; Grady, 2012; Nyberg, 2017; Park et al., 2004).

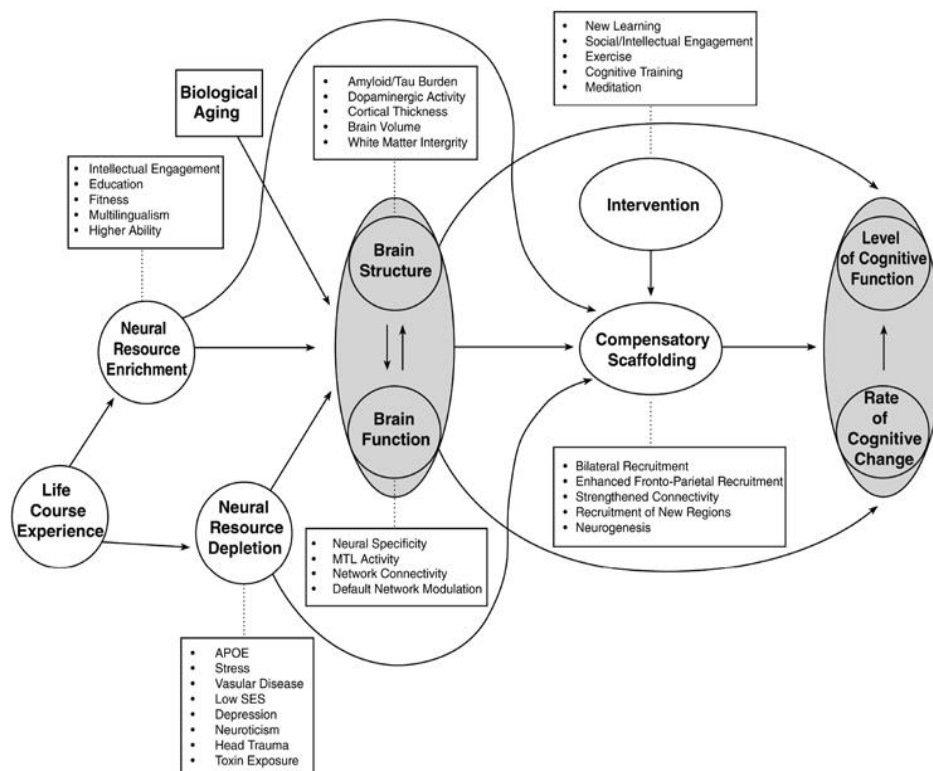


Figure 3. A life course model of the Scaffolding Theory of Aging and Cognition (STAC-r). Reprinted from Reuter-Lorenz PA & Park DC. How does it STAC up? Revisiting the Scaffolding Theory of Aging and Cognition. *Neuropsychology Review*, 2014; 24: page 360, with permission from Springer.

2) The second principle of the STAC model is that the cognitive performance level of an older individual is a consequence of the neural challenges and functional deterioration, co-jointly with a beneficial process that is referred to as *compensatory scaffolding*. Therefore, in the ageing the scaffolding process operates to compensate for or counteract the decline in the neural structure and associated functional decline (Reuter-Lorenz & Park, 2014). This compensatory scaffolding process is considered a form of

positive plasticity whereas the neural degradation of both brain structure and functioning is referred as negative plasticity (Cramer et al., 2011).

Scaffolding is described as the engagement of neural circuits such as existing ones to a larger extent, or complementary circuits to achieve a behavioural output or cognitive goal. That is, it provides further additional computational support to the declining networks, with majority of that support occurring in the prefrontal cortex (Park & Reuter-Lorenz, 2009). Evidence to support the concept of scaffolding have been observed in neuroimaging studies (Davis et al., 2009; Jolly et al., 2017). Older adults' use of additional neural circuits or over-activation of brain regions compared to younger adults while performing a range of cognitive tasks (such as perceptual, memory, and executive functions) has been found in the prefrontal brain regions and parietal regions (Ballesteros, Bischof, Goh, & Park, 2013; Ballesteros, Nilsson, & Lemaire, 2009; Toepper et al., 2014). This recruitment of contralateral resources when completing a cognitive task, is cognitive restructuring or as referred to by Park and Reuter-Lorenz, compensatory scaffolding to counteract current weakness within the brain.

The need for compensatory scaffolding is not unique to the biological changes posed by age but also by neural deterioration or insults that may occur through one's lifespan such as head trauma. Under the STAC-r model an individual who is endowed with favourable genetics, and has had a life involving positive health and lifestyle behaviours consistently and in a supportive and healthy environment, has an opportunity to present later in life with a more youthful neurobiological status than those who either had less favourable genetics and/or engaged in unhealthy behaviours and lifestyle factors. Which in turn would require less use for compensatory scaffolding and reorganisation of neural circuits to perform behaviour or cognitive goals. The term '*brain maintenance*' is suggested as a complementary concept that describes the youthful older brain that presents with a lack of pathology (Nyberg, Lövdén, Riklund, Lindenberger, & Bäckman, 2012).

Nyberg and colleagues postulate that older adults with better brain maintenance would be expected to have brain activation patterns that are more closely aligned to “youth-like” brain patterns than their same aged peers youthful with poor brain maintenance. This has been evidenced with a study showing a subgroup of older adults had brain activity profiles that resembled the younger group performing the same memory task (Duzel et al., 2011). In this subgroup of older adults there was no evidence of compensatory scaffolding in use when the task was being completed, unlike there same aged peers who evidence prefrontal over activity, which is regarded as compensatory scaffolding occurring.

Another important concept is that of brain efficiency. In the STAC-r model *brain efficiency* refers to the rate and quality of neural processing (such as speed of neural transmission and signal to noise ration) (See Neubauer & Fink, 2009; cf. Poldrack, 2015). Reuter-Lorenz and Park postulate that poor brain efficiency is responded to by compensation and adaptive networks. Compensatory circuits are regard though as less efficient than the primary network that would be activated if not damaged or inefficient.

The STAC-r takes into consideration that there are life-course influences extraneous to the brain that contribute to neural health. These have been categorised as *neural enrichment* and *neural depletion* in the model and either increase or decrease the capacity for compensatory scaffolding:

1. *Neural resource enrichment* is characterised by outside influences (such as intellectual engagement, education, fitness, multilingualism, and higher ability) that positively reinforce or strengthen brain structure (increased cortical thickness, or synaptic density) or function (efficient connectivity). There is evidence that synaptic formation in the adult cortex occurs in an experience-dependent manner. That is, exposure to stimuli or engaging in activities which promote brain health or provide challenges to existing neuronal connections may result in adaptive morphological changes in the brain such as stimulating neurogenesis or improving vasculature (Trachtenberg et al., 2002; Whalley et

al., 2004). Neural resource enrichment has also been referred to as positive neuroplasticity (Vance & Crowe, 2006).

2. *Neural depletion* refers to adverse influences on the brain that can directly influence brain structure and function, and therefore ultimately have a negative influence on cognitive performance. Examples are the ApoE  $\epsilon 4$  allele, stress, vascular disease, lower social economic status, depression, neuroticism, head trauma, and toxic exposure. The effect of these factors is the occurrence of morphological changes, such as a decrease in dendritic connections between neurons, atrophy of the brain, and weaker connections between neurons (Vance & Crowe, 2006). These negative life course factors may not only effect primary networks but also reduce the capacity for the brain to engage in compensatory scaffolding. This is because the neural depletion influencers result in a neural system that is more vulnerable to cognitive disruption and there are generally less efficient pathways available in communicating neural information.

Park and Reuter-Lorenz also consider the potential benefits conferred from intervention programmes that may enrich compensatory scaffolding and support cognitive function such as new learning social and intellectual engagement, exercise, formal cognitive training, and mediation. Thereby providing a model of ageing and cognition that suggests there are numerous variables that either enrich or deplete the neural resources available to an individual. The STAC-r is a model that acknowledges biological ageing, and that biological ageing affects brain function. Encompassing a lifecourse approach the STAC-r demonstrates the role of life experiences and genetic variables that account for cognitive function and rate of cognitive changes that occur over time.

Another important concept that the STAC-r provides explanation for is the heterogeneity in cognitive performance of the ageing and nonlinearity in individual trajectories that have been noted in longitudinal studies (as discussed earlier in Section 5.1.2). For example, as pointed out by Reuter-Lorenz and Park (2014) an individual may show very little cognitive change during a decade of older adulthood. However, a

serious illness or a significant change in their environment – for example loss of a partner – may result in increased stress or feelings of isolation or loneliness, which may influence their cognitive performance and rate of decline. Under this model it is surmised that potentially the individual may have a nonlinear decline in cognitive functioning.

An impetus for the development of the STAC-r model was to account for the findings that many healthy older adults with no clinical presentation of cognitive impairment were found at autopsy to have substantial amyloid deposition in their brains. This impetus for developing a theory of cognitive ageing and to account for individual differences in cognitive presentation shares many similarities with the cognitive reserve hypothesis. The similarities and differences between the two models will briefly be discussed.

### **5.2.3 Similarities and differences between STAC-r and cognitive reserve.**

The ideas in the STAC-r model are compatible to the concept of *cognitive reserve* as proposed by Stern (2009) and discussed in Chapter Four. Both models offer an explanation for the different levels of cognitive functioning at older age. The principles and mechanisms are similar in that extraneous variables to the brain will influence cognitive outcomes in later life and that the brain responds to influence through having reserve or scaffolding. One of the critical differences is that of compensation. The STAC-r views compensation as a mechanism that may involve the recruitment of either the existing neural networks though activated to a larger extent or activation of alternative neural networks for the task at hand. By contrast Stern's cognitive reserve hypothesis suggests that those with greater reserve have ability to activate alternative neural networks as a form of neural compensation only. Compensation is more narrowly defined in the cognitive reserve model. It has been suggested that the STAC-r is a dynamic model of cognitive ageing, with the inclusion of compensatory scaffolding (Festini, Zahodne & Reuter-Lorenz, 2018; Park & Reuter-Lorenz, 2014). That is, it

incorporates negative neurophysiological variables associated with biological ageing and neural resource depletion (refer Figure 3) and compensatory neural processes that operate simultaneously to predict cognitive function over time. The STAC-r modelling of ongoing dynamic responses to neural resource enrichment or depletion provides a sound framework for this thesis. Specifically the STAC-r takes into consideration the impact of psychological processes such as stress, and depression, and therefore it is plausible that loneliness and social isolation may also be neural depletion variables and in this model could thus be predictors of poorer cognitive performance over time.

### **5.3 Summary of Cognitive Ageing**

Over twenty five years ago La Rue (1992) said that, in the study of cognition and ageing, the lack of a one-to-one relationship between age and cognitive change should be the focus of investigation, rather than the view that cognitive decline is inevitable due to ageing. This suggestion has been heeded and researchers have investigated the influence of various factors that may contribute to the individual differences in cognitive performance amongst the ageing. Dynamic risk factors that have been investigated include education, socioeconomic status, occupational attainment, genetics, health conditions (cancer, heart attack, stroke, diabetes, metabolic syndrome, and hypertension), mental health, and lifestyle factors (smoking, physical activity, leisure activity, nutrition alcohol use, and obesity) (Anstey, von Sanden, Salim, et al., 2007; Baumgart et al., 2015; Ownby et al., 2006; Plassman et al., 2010). With the recent knowledge that aspects of social relationships, particularly loneliness and social isolation, may be detrimental to cognitive ageing, there is much to be gained from further enhancing the existing literature for both intervention and theories of cognitive ageing.

This chapter highlighted that with ageing comes changes in cognitive performance. On average older adult's cognitive performance will be poorer than younger adults on many cognitive tasks. However, the examination of individual differences between older adults indicates a different story. Many older adults will retain a relatively youthful



cognitive performance profile, while others have noticeable cognitive decline in performance. The STAC-r and cognitive reserve theory were discussed as they both suggest that different experiences across the lifecourse will either enrich or deplete neural resources which relate to cognitive functioning. Experiences such as loneliness, and social isolation, may affect both brain structure and brain function and therefore cognition performance and rate of change.

## **Chapter Six: The Current Research**

**Chapter Overview:** This chapter presents the aim, hypotheses, and rationale of the current research.

### **6.1. Overall Aim of the Study**

The aim of this study is to gain greater understanding of the association between emotional loneliness, social loneliness, objective social isolation, and cognitive performance, (after controlling for known environmental influences and sociodemographics) at baseline (Time 1) and at two year follow-up (Time 2)

### **6.2. Research Questions**

As discussed in Chapter Two questions from the literature that deemed further investigation are as follows:

- 1) What is the relationship between different aspects of an older adult's social world (objective social isolation, and loneliness) and cognitive performance and cognitive decline when analysed together?
- 2) Do emotional and social loneliness differ in their relationships with cognitive performance?
- 3) Do different levels of social isolation moderate the relationship between loneliness and cognitive performance?
- 4) Does the impact of different social relationships on cognition show similar patterns across different cognitive domains?
- 5) How will the results for a study based on a sample from Aotearoa/New Zealand compare to other international studies?

### **6.2.1 Rationale for the research questions.**

The rationale for the research questions is derived from the review of the literature. As discussed in Section 2.1.3 the current evidence suggests that older adult's perceptions of their social network members has a more consistent association with cognitive performance and cognitive decline than structural features of relationships such as size of network, or contact with others. However, as previously mentioned there are few studies that have concurrently assessed loneliness and objective social isolation and whether there is a relationship between levels of objective social isolation, loneliness, and cognition (see Section 2.1.4). The few studies that have assessed objective social isolation, measures of perceived social isolation (loneliness or perceived social support) and cognition are not consistent in their findings. Analysing the different aspects of social relationships and cognition together will provide important information on the relationship that each has with cognition relative to the other. Assessing whether different levels of social isolation moderate the relationship between loneliness and cognition, will tell us whether those who are lonely and social isolated are more at risk for poorer cognitive performance than those who are only experiencing loneliness.

There is also a lack of research that has assessed different forms of loneliness, such as emotional loneliness or social loneliness, which are regarded as distinct forms of loneliness (see Section 2.1.3 and 3.3.2). This would provide insight into whether different forms of loneliness have the same impact on cognition. Highlighted in section 2.1.5 and 3.4.5 was the importance of controlling for factors (physical health, medical conditions, alcohol use) that may inflate the association between social relationships and cognition. Finally, this study will illuminate social relationships and cognition in the older adult from Aotearoa/New Zealand.

The current study presents two sets of analyses, cross sectional and longitudinal, for the same set of questions.

### **6.3. First set of Hypotheses: Social Relationship Variables Differ in their Association with Cognitive Performance**

The first set of hypotheses predicts that although aspects of current social relationships will differ in their association with cognitive performance at baseline and two years later, emotional loneliness will have the strongest association with cognition. The rationale for this hypothesis is presented followed by the hypotheses themselves.

#### **6.3.1 Rationale for emotional loneliness having the strongest association with cognition.**

Chapter Three demonstrated that loneliness and objective social isolation are distinct concepts. An individual may be lonely but surrounded by others, alone and not lonely, or lonely and alone. Chapter Four highlighted that there are different pathways in which deficits in quantity or quality in social networks may lead to poor health including cognition. These pathways were behavioural (not engaging in health behaviours or adherence to medication due to lack of influence from social network members), psychological (lack of perceived support increase stress response, perception of deficits in social relationship increases loneliness, depression). As discussed each pathway, be it behavioural or psychological, interacts with physiological processes (cardiovascular responses, neuroendocrine and immune functioning) which mediated the relationship between an individual's social network and health outcomes. Social interactions were demonstrated as potentially being cognitive stimulating, and provide another pathway for how social networks may influence cognition. Chapter Five discussed cognitive heterogeneity in the older population and the STAC-r model which explains individual differences in the cognitive functioning of the older adult is a consequence of multiple factors which includes those that may have a negative influence on neural structures and function such as loneliness and social isolation. The evidence presented in this thesis indicates that loneliness and social isolation are potential risk factors for cognitive performance, however, this thesis proposes that loneliness may be more detrimental than objective social isolation.

Loneliness and social isolation have both been associated with poorer physical and mental health outcomes which influence cognitive performance. Social isolation, however, has been reported to have a stronger association with physical health, whereas loneliness has been reported as having a stronger association with mental health (Beller & Wagner, 2018; Elovainio et al., 2017). A study that concurrently assessed social isolation and loneliness and controlled for a variety of risk factors, such as physical health and depression, found that loneliness was a predictor of cognitive decline (Holwerda et al., 2014). Social isolation was not found to have an association in the final model. It was found that loneliness influenced cognitive decline independent of health conditions (physical or mental) and unhealthy behaviours whereas social isolation's association with cognition was accounted for by health factors. The findings by Holwerda and colleagues suggest that loneliness's association with cognition may occur through another mechanism rather than physical health or depression. As discussed in Chapter Four, deficits in perceived quality of social networks may increase stress responses. Lonely people are more likely to report stressors than non-lonely people independent of social isolation (Hawkey et al., 2008). Stress is associated with increased pro-inflammatory responses. Lonely people compared to non-lonely people were found to have higher indicators of inflammation in acute stressor situations and present with increases cortisol levels upon awakening independent of socio-demographics and lifestyle behaviours (Jaremka et al., 2013; Jaremka, Lindgren, & Kiecolt-Glaser, 2013; Steptoe et al., 2004). Stress and inflammation have been associated with poorer cognitive performance. Loneliness may have an association with cognition that is independent of physical outcomes and depression but related to some other mechanism such as stress. However evidence is suggestive that social isolation's association with cognition may be mediated by physical health outcomes and depression.

This leads to the conclusion that loneliness will have a stronger association with cognition than objective social isolation after controlling for confounding variables.

The current study, however, examines two measures of loneliness, emotional and social loneliness. As previously mentioned loneliness (unidimensional) is considered closer to the concept of emotional loneliness than social loneliness. Therefore, the measure of emotional loneliness is suggested at having a stronger association with cognition than objective social isolation.

It is an unknown whether emotional loneliness has a stronger association than social loneliness with cognition based on current research that has assessed loneliness and cognition. Theories of loneliness indicate that loneliness can be due to a deficit in a certain type of relationship (close intimate relationships or social relationships) or can be due to perception of one's emotional or social needs not being met (see Section 3.3). As postulated by Weiss (1973) the causes of emotional loneliness are different from those that cause social loneliness, and also associated with different feelings. Emotional loneliness is associated with feelings of desolation, insecurity, not having someone to turn to, and anxiety, whereas social loneliness is associated with boredom, lack of meaning, and lack of companionship (Dykstra, 2009; Weiss, 1973).

It is plausible that the feeling of anxiety and insecurity associated with emotional loneliness, which Weiss and Dykstra referred to, is similar to the hypervigilance and hypersensitivity that Cacioppo and colleagues postulate as characteristics of those who are lonely (Cacioppo et al., 2006). It is argued by Cacioppo and colleagues that hypervigilance and hypersensitivity are psychological states that lead to neurobiological responses that are detrimental to cognition. It is also plausible that feelings associated with emotional loneliness differ from those experienced with social loneliness. Two studies illustrate that different forms of loneliness may have different consequences. In a sample of 500 adults with an average age of 70 years, emotional loneliness, not social loneliness, was associated with depression (Peerenboom, Collard, Naarding, & Comijs, 2015). Emotional loneliness was also associated with higher neuroticism and lower mastery. Adults who endorse high levels of neuroticism are more likely to experience

stress and anxiety than those with lower levels of neuroticism. Depression, neuroticism, and anxiety are all states of psychological distress, a factor that may promote negative neuroplasticity or neural depletion (Reuter-Lorenz & Park, 2014; Vance, 2012; Wilson et al., 2007).

Likewise in a sample of nearly 4000 American adults aged between 18 – 70 years old, subtypes of loneliness had differential associations with wellbeing (Hyland et al., 2018). Using the de Jong Gierveld Loneliness scale, four subtypes were noted, ‘social and emotional loneliness’, ‘emotional loneliness’, ‘social loneliness’, and low levels of loneliness. The group of adults who were in the ‘social and emotional loneliness’ and ‘emotional loneliness’ class were both characterised by mean levels of psychological wellbeing, depression and anxiety that were reflective of psychiatric morbidity. The group of adults in the social loneliness class had similar levels of psychological wellbeing, depression and anxiety to those in the low levels of loneliness class, which did not reflect psychiatric morbidity. The results indicate that emotional loneliness, not social loneliness, is associated with mental health indicators (Hyland et al., 2018).

In section 5.2.2 of the thesis the STAC-r model posits that negative affect and depressive symptoms may result in neural depletion (weakening of brain structure and function). There is support for this claim in recent animal and human studies that have shown that chronic stress and major depressive disorder have deleterious effects on the brain, both structurally and functionally (Kays, Hurley, & Taber, 2012). This, in turn, may lead to poorer cognitive performance and/or faster cognitive decline. Based on this evidence the author of this study concludes that emotional loneliness has a stronger association with poorer cognitive performance than social loneliness.

### **6.3.2 Cross-sectional analyse hypothesis.**

It is hypothesised that emotional loneliness, social loneliness, and objective social isolation will differ in their association with cognitive performance. Emotional loneliness is hypothesised to explain more of the variance in cognitive performance,

than social loneliness or objective social isolation after controlling for socio-demographics, mental and physical health, and lifestyle variables.

### **6.3.3 Longitudinal hypothesis.**

It is hypothesised that emotional loneliness, social loneliness and objective social isolation at baseline will be predictive of poorer cognitive performance over a two year period, with the greater amount of variance explained by emotional loneliness, after controlling for socio-demographics, mental and physical health, and lifestyle variables.

## **6.4 Second set of Hypotheses: Does Objective Social Isolation Moderate the Relationship Between Loneliness and Cognitive Performance?**

The second hypotheses relate to whether different levels of objective social isolation moderate the relationship between loneliness and cognition. Both loneliness and social isolation have been linked with cognitive performance. Therefore the following hypotheses are proposed.

### **6.4.1 Cross-sectional analyses hypothesis.**

It is hypothesised that objective social isolation will moderate the effects of loneliness (emotional and social) on cognitive performance, in that those experiencing high levels of loneliness (emotional and social) and high levels of objective social isolation will have poorer cognitive performance than those who are experiencing high levels of loneliness (emotional and social) and low levels of objective social isolation.

### **6.4.2 Longitudinal analyses hypothesis.**

It is hypothesised that objective social isolation will moderate the effects of loneliness (emotional and social) on cognitive performance two years later, in that those experiencing high levels of loneliness (emotional and social) and high levels of objective social isolation on cognitive outcomes will have poorer cognitive performance two years later than those who are experiencing high levels of loneliness (emotional and social) and low levels of objective social isolation.



### **6.5 Third set of Hypotheses: Does Education Moderate the Relationship Between Loneliness, Objective Social Isolation and Cognitive Performance?**

The final set of hypotheses investigates whether education moderates the relationship between social relationships and cognition.

As discussed in Section 5.2.3 there are environmental factors such as education, fitness, stress, depression and disease that can either enhance or degrade brain structures and functions. Education is regarded as a factor that is cognitively stimulating and enhances brain structure and function (Adams, Blasey, & Bigler, 2003; Coffey, Saxton, Ratcliff, Bryan, & Lucke, 1999; Sole-Padulles et al., 2009). Education, is suggested as increasing synapse density, and viewed as an early form of cognitive stimulation in one's life that may promoting cerebral growth and enhance the capacity and efficiency of brain functioning when completing cognitive processes (Le Carret et al., 2003). Katzman (1993) suggested that engagement in higher levels of education may create opportunities for occupations or intellectual activities which are more cognitively demanding and may promote increased levels of neuronal activity than less demanding tasks. Education is regarded as a proxy of neural enrichment/cognitive reserve. This is illustrated in studies that report older educated adults have a higher cognitive functioning at baseline than their less educated peers (Alley, Suthers, & Crimmins, 2007; Wilson et al., 2009).

The Scaffolding Theory of Ageing and Cognition - revised and the cognitive reserve hypothesis claim that older adults with higher levels of education may be more resilient in later life against neural degradation which can lead to poorer cognitive performance than those with lower levels of education. It is plausible that loneliness and social isolation may lead to neural degradation whether it is through behavioural or psychological processes (see 4.1.2). Therefore, the third and final sets of hypotheses are as follows;

#### **6.5.1. Cross-sectional analyses hypothesis.**

It is hypothesised that education will moderate the effects of loneliness (emotional and social) and objective social isolation on cognitive performance, in that those with high levels of loneliness (emotional and social) or objective social isolation and lower levels of education have poorer performance than those with high levels of perceived and objective social isolation and higher levels of education.

#### **6.5.2. Longitudinal Analyses hypothesis.**

It is predicted that education will moderate the effects of loneliness (emotional and social) and objective social isolation on cognitive performance over time. That is, those with high levels of loneliness (emotional and social) or objective social isolation and lower levels of education at baseline are predicted to have poorer cognitive performance at follow-up (two years from baseline) than those with high levels of perceived and objective social isolation and higher levels of education at baseline.

The results for the hypotheses are presented in Chapter 8 and the findings are discussed in Chapter 9. The results and findings are organised into the hypothesis for the cross-sectional analysis and then the hypothesis for the longitudinal analyses are presented.

## Chapter Seven: Method

**Chapter Overview:** Data to address hypotheses was sourced from pre-existing longitudinal datasets of the New Zealand Longitudinal Study of Ageing. Therefore, the current study involves secondary data analysis. This chapter will first discuss the New Zealand Longitudinal Study of Ageing (7.1) and the relationship to the New Zealand Health, Work and Retirement Study as background to the current study (7.2). This is followed by describing the data collection procedures (7.3), representativeness of the current study's sample in comparison to the NZLSA sample and the New Zealand population (7.4). The measures used in the current study are discussed (7.5). The chapter will end with an explanation of the data analyses used which is pertinent to the current study (7.6).

### 7.1 Overview: The New Zealand Longitudinal Study of Ageing and the New Zealand Health, Work and Retirement Study

The New Zealand Health, Work and Retirement Study (HWR) was funded by the Health Research Council of New Zealand in 2005. The research programme's aim was to understand the experiences that occur for the older person whilst ageing, including the transition from work to retirement. The areas of interest being surveyed cover health and wellbeing, social participation and economic participation. The HWR was a collaboration involving The Massey University Health and Ageing Research Team (HART), the Research Centre for Māori Health and Development of Massey University and New Zealand Institute for Research on Ageing at Victoria University. The HWR collected two waves of data in 2006 and 2008 with a national postal survey of New Zealanders aged 55 – 70 years old. The HWR study expanded into the New Zealand Longitudinal Study of Ageing (NZLSA: 2009-2013). Funding for a further two waves of data (2010 and 2012) for NZLSA was provided by the New Zealand Foundation for Research, Science and Technology. The NZLSA research team comprised of researchers from, Massey University's HART team and the Family Centre Social Policy Research Unit. The NZLSA had two primary objectives. Firstly, the establishment of a

nationally representative longitudinal study on determinants (health, wealth and socioeconomic) that contributes to positive ageing in Aotearoa/New Zealand. The second objective was the collection of data that allowed cross-country comparisons, thereby enabling international perspectives to best inform public policy and practice. The NZLSA involved the use of both postal survey and face-to-face interviews. Further elaboration of the NZLSA data collection process occurs in the following section, as relevant to the current study.

The HWR study continued to gather data in 2014, 2016 and 2018 through postal survey on a variety of factors such as demographics and socioeconomic status, occupational and retirement status, attitudes towards retiring, physical and mental health, and psychosocial factors. To ensure the surveys allow for longitudinal analyses all waves have involved the gathering of core assessments. However, survey modules have been added or removed depending on cross-sectional research projects.

## **7.2. Current Study and New Zealand Longitudinal Study of Ageing**

The current study examines the relationship between different forms of social isolation and cognitive performance in the older adult aged 65 years and older at baseline and over a two-year period. The data used for this analysis is solely from the NZLSA (Towers et al., 2012) which as previously mentioned is a longitudinal study looking at the role of four broad areas economic participation, social participation, intergenerational transfer and resilience and health underpinning successful ageing in New Zealanders aged 50-84 years old.

The NZLSA sample subsumed the longitudinal subsample of the HWR study; which were participants in the HWR study Wave 1 data collection who had given prior consent to participate in longitudinal research. To increase sample size and broaden the age range to 50 – 84 years, new participants were included in the sample. The new participants came from 1) a Massey University cross-sectional study of retirement planning (Noone, Alpass, & Stephens, 2010), 2) participants from a pilot study on the

NZLSA questionnaire and, 3) from the New Zealand electoral roll via random selection. All NZLSA participants irrespective of being involved in the HWR or new were drawn from the New Zealand electoral roll using equal probability random sampling to ensure a nationally representative sample. For the NZLSA Māori oversampling was undertaken for both new participants and those involved in prior studies. This occurred due to the historically poor research participation rates found in older ethnic minority populations (Gorman, Scobie, & Towers, 2012; Moreno-John et al., 2004). The procedure used in the NZLSA involved first random selection from the general electoral role and then through use of a “Māori descent” indicator in the electoral roll database selection of a Māori subsample occurred. As the samples were inclusively community based, older adults in rest homes, dependent care, or prison were excluded.

### **7.3 Data Collection for Postal Surveys and Face-to-face Interviews**

The NZLSA data collections for Wave 1 (2010) and Wave 2 (2012) were based on two principal methods, postal survey and face-to-face interviews. The sample of 4,339 older New Zealanders were provided with questionnaires and invited to complete the first NZLSA postal data collection wave in 2010. Of those provided with a questionnaire, 3,311 older adults responded. All NZLSA participants completed a paper-based, retrospective, self-report postal survey focusing on six major domains: general health, social support, care-giving roles they may perform, financial well-being, characteristics of neighbourhood, and demographic information.

For the NZLSA survey the Tailored Design method (Dillman, 2000) was used in order to increase the response rate. This involved a five-stage posting schedule. First, a pre-notice letter was sent to potential participants informing them of the research and of their random selection from the electoral roll and that, a questionnaire would follow. Second, a week later a questionnaire, information sheet and freepost envelope was sent to the participants. Third, a reminder postcard was sent three weeks after the questionnaire. Fourth, three weeks later all participants who had not responded were

sent a replacement questionnaire. Finally, at week five a second reminder card was sent to all participants who had not yet responded. No further correspondence occurred after the five-week period.

The retention rate for the NZLSA data collection Wave 2 was 90%. Of the 3,311 respondents to the Wave 1 postal survey, 2,984 participated in Wave 2 postal survey. The sub-sample from previous HWR studies (2006 and 2008) had a higher retention rate at 94%, than new participants (recruited in 2010).

### **7.3.1 Face-to-face interview data collection.**

The NZLSA 2010 postal questionnaire included an item asking the participants if they would be willing to volunteer for a face-to-face interview in 2010 and 2012. Of the 3,311 who completed the questionnaire a subsample of 1,001 participated in a face-to-face interview at Wave 1. For the face-to-face interviews, a letter was initially sent thanking them for the participation in the postal survey and agreeing to take part in the interviews. The letter outlined the process of being contacted for an interview and was followed up with a phone call to confirm if the participant still wished to be interviewed. This was then followed up with another phone call to arrange an interview time and place, which would be at the participant's place of choosing. A final phone call was made one day before the interview to confirm that the participant was happy and able to continue with the appointment. The following day the participant was interviewed. All interviews occurred in the participants own home. Interviewers were under the management of the Family Centre Social Policy Research Unit. All interviewers underwent training for interview techniques, administration of questionnaires and tests and correct procedures for the cognitive assessment with adherence to test manual instructions. The author was not an interviewer. Participants were geographically spread throughout New Zealand.

The face-to-face interviews included the use of a cognitive instrument in both Wave 1 and 2. Other measures incorporated into Wave 1's face-to-face interviews were socio-

demographics, mental health, personal and household wealth and well-being. One thousand and one participants were interviewed before the cut-off date of 1 December 2010. Of those interviewed in Wave 1, 903 were re-interviewed in Wave 2. The current study of 418 includes all participants in Wave 1 and Wave 2 who a) completed the postal survey b) were interviewed face-to-face; and c) were 65 years or older as at 7 March 2010.

#### **7.4 Representativeness of the Current Sample in Comparison to the NZLSA Sample and New Zealand National Population**

The characteristics of the sample to be used in the current study were compared to the NZLSA sample and the New Zealand population data from the 2006 census (see Table 1). Divergence was noted in all areas (gender, age, highest qualification, and marital status). The current sample had a slightly lower participation of female both Māori and non-Māori compared to the NZLSA population (NZLSAP) and national population (NP) for Māori and non-Māori. For age the current sample had a greater percentage of older adults in the 65-74 age range for Māori (86%) and non-Māori (81%) compared to the NP, with Māori (75%), and non-Māori (60%). The current sample are more likely to be married/partnered for Māori and non-Māori than the NP. The current sample also had higher educational attainment for both Māori and non-Māori than the NZLSAP and NP.

#### **7.5 Measures**

The measures for the current study were included in the NZLSA postal survey (2010) and the face-to-face interviews in Wave 1(2010) and Wave 2 (2012) (see Appendix A). The data for ACE-R total score and the cognitive domains, mental health, relationship status, cohabitation status and education status were collected from the face-to-face interviews. The social isolation variables, medical conditions, physical activity, alcohol use, and current smoking status were collected from the postal survey data. The measures are described below and the specific questions are available on the Health and Ageing Research Team website (<http://www.massey.ac.nz/?h4d295120s6.7.1>).

Table 1

*Demographic Characteristics of the Current Sample Maori and Non-Maori Participants in Comparison with Aged-Matched NZLSA 2010 Participants and NZ National Population, N= 418.*

	Maori Ethnicity (N = 101)			Non-Maori (N=317)		
	Current Sample (Aged 65-84)	NZLSA (aged 65 - 84)	NZ aged 65- 84 (2006)	Current Sample (aged 65-84)	NZLSA (aged 65 -84)	NZ aged 65-84 (2006)
<b>Sex</b>						
Male	49% (50)	45% (459)	47% (36762)	49% (157)	45% (998)	48% (473631)
Female	51% (51)	55% (572)	53% (41115)	51% (160)	55%	52% (510681)
<b>Age(year groups)</b>						
65-69	45% (59)	44% (237)	46% (10158)	45% (128)	40% (411)	33% (132744)
70-74	41% (54)	39% (209)	29% (6513)	36% (103)	34% (356)	27% (106086)
75-79	10% (13)	12% (61)	17% (3807)	13% (36)	17% (172)	23% (93567)
80-84	4% (6)	5% (28)	8% (1764)	6% (19)	9% (93)	17% (67659)
<b>Marital Status</b>						
Partnered	58% (59)	66% (807)	51% (37413)	71% (224)	78% (1557)	67% (638388)
Separated	15% (15)	13% (155)	22% (16197)	8% (26)	8% (168)	15% (145155)
Widowed	20% (20)	14% (169)	16% (11400)	17% (54)	10% (196)	12% (118974)
Never Married	7% (7)	8% (100)	11% (7593)	4% (12)	4% (85)	6% (55290)
<b>Educational Qualifications</b>						
No secondary	30% (30)	37% (452)	54% (35418)	20% (62)	20% (409)	34% (305265)
Secondary	19% (19)	20% (245)	19% (12603)	24% (76)	24% (489)	28% (249111)
Post-Secondary	24% (24)	23% (282)	20% (13071)	28% (89)	29% (579)	26% (230472)
Tertiary	27% (28)	21% (261)	6% (3867)	28% (88)	26% (525)	12% (108798)

### 7.5.1 Cognitive performance.

To assess cognitive performance at baseline (time 1) and follow-up (time 2) the Addenbrooke's Cognitive Examination-Revised (ACE-R) was utilised. The ACE-R is a brief sensitive and specific test battery to detect early cognitive dysfunction (ACE-R; Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006). The NZLSA obtained permission to use the "Kiwi" ACE-R, which is a modified version of the ACE-R for use with the Aotearoa/New Zealand older population (Taylor, 2008). Adaptions of the ACE-R to make it more culturally acceptable to the Aotearoa/New Zealand population were carried out in accordance with the developer's recommendations. These included modifications of specific anterograde, retrograde and delayed recall memory



components, such as allowance to use a New Zealand address in memory tasks, and recalling the current New Zealand Prime Minister rather than the President of the United States of America. The guidelines for modifying the ACE-R have been utilised by other countries with reports of limited change to the psychometric properties (Alexopoulos, Mioshi, Greim, & Kurz, 2007; García-Caballero et al., 2006).

The ACE-R assesses five cognitive domains, attention and orientation, memory, fluency, language and visuospatial abilities. Each domain has its own score and the sum of all five domains contribute to a total score of a possible 100 for global cognitive performance. A higher score reflects better cognitive performance in each domain or globally.

**Attention and orientation:** Questions asked include “What is the date?”, where the participant is currently located, as well as working memory tasks such as counting backwards from 100 in sevens. The total possible score for attention and orientation is 18.

**Memory:** Memory assessment involves having to remember an address given during testing and recall it after a period. There are also questions such as “Who is the current Prime Minister of New Zealand?”, or questions on very well-known people such as the royal family. The total possible score for memory is 26.

**Fluency:** Fluency involves providing as many words that begin with a letter such as “P” in 60 seconds, and category fluency, which involves providing the name of as many animals as possible in 60 seconds. The total possible score for fluency is 14.

**Language:** Language assesses comprehension such as following an instruction, ability to write a sentence, and correctly providing the name of unfamiliar objects from pictures for example ‘accordion’. The total possible score is 26.

**Visuospatial:** The last domain visuospatial abilities requires abilities that involve, for example, a clock to be drawn with a time on it and copying of diagrams and writing. The total possible score is 16.

**MMSE:** The ACE-R also has the Mini Mental State Examination (MMSE, Folstein, Folstein & McHugh, 1975) embedded into it. The MMSE will also be used as an outcome measure.

As mentioned the ACE-R is a cognitive screening tool and designed with cut-off points to determine an individual's cognitive status. In the current study the ACE-R was not used as a cognitive screening tool, but rather as a measure of cognitive performance. Therefore the total score and subscales were analysed with no reference to cut-off points as has been the case in previous research (Mathew, Bak, & Hodges, 2011; Ordonez, Yassuda, & Cachioni, 2011). The ACE-R has been used in clinical research to assess cognitive change over time (Hsieh, Hodges, Leyton, & Mioshi, 2012; Rittman et al., 2013). In the current study the alpha coefficient for the ACE-R total scores score for baseline and follow-up data was,  $\alpha = 0.72$  and  $\alpha = 0.77$ , respectively, and derived from totals of sub-domain items ( $n = 26$ ). The alpha level is slightly higher than published alpha levels of the Kiwi ACE-R .70 (Callow, Alpass, Leathem, & Stephens, 2015). However, the alpha level is slightly lower than the reported ranges of .80 - .92 based on the non-modified ACE-R (García-Caballero et al., 2006; Larner, 2007; Mathuranath et al., 2007; Mioshi et al., 2006). This may be due to the population being a community-based non-clinical population resulting in less variance amongst test items and greater propensity for a ceiling effect (Callow et al., 2015). Furthermore the current study's measure of internal consistency for the ACE-R at baseline and is above the recommendations of alpha 0.70 (Cronbach, 1951; McDowell & Newell, 1996).

### **7.5.2 Objective social isolation measures.**

The NZLSA postal questionnaires included multiple assessments of social isolation including assessing social support network type, perception of the level and function of

social support, and subjective perceptions on the level and type of emotional and social loneliness. A description of each measure follows.

***Introduction into the development of Objective Social Isolation Index (OSII).***

The present study worked within the constraints of a pre-existing data set, and there was no formal measure of objective social isolation such as the Berkman-Syme Social Network Index (Berkman & Breslow, 1983) or the Lubben Social Network Scale (Lubben, 1988) included in the NZLSA. Therefore to measure social isolation in the older adult for the current study an ‘Objective Social Isolation Index’ (OSII) was developed. The development of the OSII for the current study was guided by available data, previously published studies on social isolation and cognition, and recommendations from the literature on social isolation indicators (Shankar et al., 2013; Shankar et al., 2011; Steptoe, Shankar, Demakakos, & Wardle, 2013; Zavaleta et al., 2017). One of the critiques of studies assessing social isolation and cognition is the lack of ability to compare findings due to the diversity in social isolation indicators used. Therefore a decision was made to create an OSII for the current study, based on a social isolation index that was developed by Shankar and colleagues and used in similar studies on social relationships, health and cognition (Shankar et al., 2013; Shankar et al., 2011; Steptoe et al., 2013). The items included by Shankar and colleagues in their social index are presented, as follows:

- 1) If respondents were not married or did not have a cohabitating partner (scored 1; 0 otherwise);
- 2) Had less than monthly contact (including face-to-face, telephone, or written/email contact) with children (scored 1 if yes; 0 otherwise);
- 3) Had less than monthly contact (including face-to-face, telephone, or written/email contact) with other immediate family (scored 1 if yes; 0 otherwise);
- 4) Had less than monthly contact (including face-to-face, telephone, or written/email contact) with friends (scored 1 if yes; 0 otherwise);

- 5) Did not participate in any organisations, religious groups, gyms/sports clubs or committees (scored 1 if yes; otherwise 0).

The above items used by Shankar and colleagues had comparable items in the NZLSA 2010 survey, which are included in the OSII, though with one main modification, as will be discussed.

The purpose of the OSII is to assess the presence or absence of relationships (with family, friends or the wider community). The question in regard to marital status and or cohabitating partner utilised by Shankar and colleagues, does not allow the consideration of an older adult living with another who is not a spouse or partner. Therefore a person who is living with others (non-intimate spouse/partner) would be scored a 1, indicating they are comparatively isolated. An older adult living with others may have greater access to social interaction, support or cognitive stimulation from the interaction, regardless of whether the person they live with is a partner or not. As the aim of the study is to determine if objective social isolation is an indicator of poorer cognitive performance, it was deemed appropriate to distinguish between those who live alone and those who live with another or others.

### ***Items utilised in the Objective Social Isolation Index***

The next section will describe the questions that were selected for the OSII from the NZLSA 2010 postal survey. This is followed by a description on how response categories were modified to include in the development of the OSII for the current study.

*Relationship status.* Participants were provided with a list of relationships status: 1 = single, 2 = married, 3 = civil union, 4 = de-facto, 5 = divorced/permanently separated, 6 = widowed, 7 = other.

*Cohabitation status.* To assess cohabitation status participants were asked whether lived alone, lived with a partner, lived with a partner and other, or lived with others but not a partner.

*Social contact.* To assess the participants' social frequency contact, items were selected from the Wenger's Practitioner Assessment of Network Type (PANT; Wenger, 1991) which was employed in the postal survey. The PANT measures the size, composition and function of the older person's community-based support network (Wenger, 1991; Wenger, 1997). The PANT included items such as the frequency of face-to-face contact with family, friends, and neighbours (e.g., "How often do you speak to or do something with children?"); and of social participation within the community and religious groups (e.g., "Do you attend any of the following, religious meetings?").

### ***The Objective Social Isolation Index variables.***

The following discussion outlines how the response categories were modified for utilisation in the OSII, and the questions and scores are presented in Table 2.

*Relationship Status/Cohabitation status:* For the OSII the following occurred, relationship status categories were dichotomised into the presence of a current spouse/partner = 0 or currently unpartnered = 1. Cohabitation categories were dichotomised into living with others = 0 or living alone = 1. Relationship status and cohabitation status were then compounded into one variable called relationship/cohabitation status. All participants who had identified the presence of a current spouse/partner and/or had identified living with others were recoded into presence of a partner/others = 0 and unpartnered/lives alone = 1.

*Social Contact:* The following items from the PANT were used for the OSII; 1) How often do you speak to or do something with a) any of your children or relatives b) any friends in your community/neighbourhood c) any of your neighbours? Response options were daily, 2 – 3 times a week, at least weekly, at least monthly, less often, never, I have none. For use in the OSII responses were categorised into two groups for each

item based on occurrence; being monthly or more = 0 and less than monthly = 1. Each item was individually included in the social isolation index.

Table 2

*Objective Social Isolation Index items and Scoring Criteria (OSII)*

<b>Item</b>	<b>Scoring Criteria</b>
Presence of a partner/Living arrangements	Not Married and Living Alone was scored as 1; otherwise scored as 0
Frequency of contact with children or relatives	Less than monthly was scored 1; other more than monthly scored as 0
Frequency of contact with friends in community/neighbourhood	Less than monthly was scored 1; other more than monthly scored as 0
Frequency of contact with neighbours	Less than monthly was scored 1; other more than monthly scored as 0
Attendance at religious meetings	Occasional or nil attendance was scored as 1; otherwise regular attendance scored as 0
Attendance at community/ neighbourhood meetings or social groups	Occasional or nil attendance was scored as 1; otherwise regular attendance scored as 0

*Broader social participation:* Two questions from the PANT were used; Do you attend any of the following a) religious meetings b) meeting of community/neighbourhood or social groups? Responses options were Yes regularly, Yes on Occasion, No. Those responses were dichotomised into yes regularly = 0 and occasionally and no = 1. The two items scores were summed (0-2). A score of 0 indicated that the participant had regular attendance at both religious meetings and some form of social group, a score of 1 indicated that the participant identified with regular attendance at one of the choices and a score of 2 indicated no regular attendance at either of the choices. For the social isolation index the scores were recoded with those who scored 0 or 1 being grouped (regular attendance = 0) and those with a 2 (occasional or nil attendance).

### **7.5.3 Perceived social isolation/Loneliness – de Jong Gierveld Loneliness Scales.**

The subjective experience of emotional and social loneliness was assessed using the 11-item de Jong Gierveld Loneliness Scale (de Jong-Gierveld & Kamphuls, 1985; de Jong Gierveld & van Tilburg, 1999). The development of the de Jong Gierveld Loneliness scales was based on Weiss's (1973) distinction between social and emotional loneliness. The experience of loneliness is viewed as existing on a continuum of deprivation from severe feelings of loneliness to less intense feelings of loneliness. Six of the 11 items are negative worded items which assess aspects of emotional abandonment and missing companionship (de Jong Gierveld & van Tilburg, 1999). Examples of negative items are "I miss having people around" and "I experience a general sense of emptiness". The total of the negative items produces a score for the emotional loneliness subscale with a range from 0 (not emotionally lonely) to 6 (severe emotional loneliness). The remaining five positive items measure feelings of sociability and meaningful relationships. Positive items include "There is always someone I can talk to about my day to day problems" and "There are enough people I feel close to". The total of the positive items produces a score for the social loneliness subscale with a range from 0 (not socially lonely) to 5 (severe social loneliness). The scores are transformed so they can be interpreted in the same direction with a higher the score indicating either higher emotional or social loneliness. The two subscales, emotional loneliness and social loneliness, can be used as separate measures of different forms of loneliness or the subscales can be combined to provide an 11-item loneliness scale.

The present study utilises the emotional loneliness subscale and social loneliness subscale as two separate measures enabling greater insight into how different forms of loneliness may influence cognitive performance in the older person over time (ÓLuanaigh & Lawlor, 2008; van Baarsen et al., 2001). The emotional and social loneliness subscales are reported as being valid and reliable measurement instruments (de Jong Gierveld & Van Tilburg, 1999, van Baarsen et al., 2001). The alpha level in the

current study for the emotional loneliness and social loneliness subscales were  $\alpha = 0.83$  and  $\alpha = 0.82$  respectively. The emotional loneliness subscale's alpha level in the current study is consistent with other research, however the social loneliness subscale's alpha level is higher (de Jong Gierveld et al., 2009; van Baarsen et al., 2001).

#### **7.5.4 Covariates.**

As factors other than loneliness and social isolation have been associated with cognitive performance, variables that are considered as potential confounders were controlled for to reduce the possibility of spurious associations. Potential confounders were selected if they have been shown to be associated with cognitive decline, commonly controlled for when assessing cognitive performance in the older adult (Park et al., 2003; Plassman et al., 2010) and/or if not included may in part overestimate the effects of social isolation on cognitive performance in the older adult.

When examining cognitive performance over time it was recommended by Park et al. (2003) that age, gender, and education must be addressed. In a meta-analysis of social relationships and cognitive decline, Kuiper et al. (2016) concluded that studies which did not control for depression, alcohol use and physical functioning (involving at least one of the following variables (i) physical activity; (ii) functional disability; or (iii) or traumatic brain injury, cardiovascular disease or cerebrovascular accident) overestimate the effect of social relationships on cognitive decline. It was suggested by Kuiper and colleagues this was due in part to an association depression, alcohol use and physical functioning have with social isolation and loneliness. Finally, other potential confounds controlled for in this study were drawn from a systematic review of factors associated with cognitive decline (Plassman et al., 2010), and previous studies. Based on 127 observational studies, 22 randomised controlled trials, and 16 systematic reviews, factors such as diabetes, metabolic syndrome conditions, depression and smoking were identified as have an association with cognitive decline. Ethnicities were also included, which is common practice when researching social isolation and cognition (Ertel,



Glymour, & Berkman, 2008; Seeman et al., 2001; Wilson et al., 2007). In conclusion the following potential confounders for the current study were baseline cognition, age, gender, education, ethnicity, depression, physical activity level, medical conditions (diabetes, heart conditions, and stroke), current alcohol use, and current smoking status. The measures of all control variables are discussed below.

### ***Age.***

Participants were asked to provide their date of birth (day, month and year), and age was generated by subtracting this from the year face-to-face interview occurred (2010).

### ***Gender.***

Participants were asked to identify as female or male. For use in the multiple regression analyses, the variables were coded: 0 = female, 1 = male.

### ***Education.***

Educational attainment has been associated with cognitive performance and decline, therefore it is regarded as an important variable to control for. However educational attainment is also one of the components of socioeconomic status along with occupation, income and wealth (Coburn & Pope, 1974; Jang, Choi, & Kim, 2009). Education has been used as a proxy measure for socioeconomic status and is considered more relevant than measures such as income or occupation for older adults who have retired from the workforce (Montez, Hummer, & Hayward, 2012).

Education level obtained were assessed with a forced choice question in the face-to-face interview Wave 1. Participants were asked to identify whether they had “no qualifications”, “secondary school qualifications”, “post-secondary qualification” (certificate, diploma or trade diploma), or “university degree”. For the regression analyses, education was transformed into a dichotomous variable. Participants with no qualifications or secondary school qualifications were recoded as 0 = “up to secondary school qualification” and post-secondary school qualification and those with university degrees were recoded to 1 = post-secondary qualification.

### ***Ethnicity.***

Response categories for ethnicity consisted of Māori, New Zealand European, Pasifika, Asian, Other. The categories were collapsed into dichotomous categories (0 = non-Māori, 1 = New Zealand Māori) for the multiple regression analyses.

### ***Depressive symptomology.***

Depression has been identified as having an association with both cognitive performance and objective and perceived social isolation (Adams, Sanders, & Auth, 2004; Austin, Mitchell, & Goodwin, 2001; Porter, Bourke, & Gallagher, 2007; Tiikkainen & Heikkinen, 2005; Wilson et al., 2007). Depressive symptomology has also been described as a ‘probable’ risk factor for cognitive decline in the ageing (Plassman et al., 2010; Saczynski et al., 2010).

The Centre for Epidemiologic Studies Depression Scale 10 item short version was used to assess depressive symptomology in those who participated in face-to-face interviews at baseline (CESD-10; Kohout, Berkman, Evans, & Cornoni-Huntley, 1993; Radloff, 1977). The CES-D was developed for use in epidemiologic studies of depressive symptomology in the general population and has been widely used in clinical and community based studies, as well as studies examining structural and functional characteristics of social relationships and cognition (Beekman et al., 1997; Bisschop, Kriegsman, Beekman, & Deeg, 2004; Cacioppo et al., 2010; Cornwell & Waite, 2009b). The psychometric properties of the CES-D10, indicate satisfactory test-retest correlations and good predictive accuracy for depression in the older population (Andresen, Malmgren, Carter, & Patrick, 1994; Irwin, Artin, & Oxman, 1999). The CES-D10 items include “I feel depressed”, “I felt everything I did was an effort” or “I could not get going”. Participants responded based on their experiences over the last seven days. Responses are recorded using a four-point Likert scale from rarely or none of the time, some or a little of the time, occasionally or a moderate amount of time, all of the time. Responses are summed across the 10 items to provide a total CES-D10 score ranging from 0-30, with higher scores indicating greater depressive symptomology.

One of the ten items in the CES-D10 ask the participants to identify how lonely they felt over the last seven days. In the current study loneliness is being examined as a potential predictor of cognitive changes, therefore, in order to decrease the overlap between the CES-D10 and the measures of loneliness, the ‘felt lonely’ question was deleted prior to computing the total score on the CES-D10. This is consistent with previous studies (Cacioppo et al., 2010; Cornwell & Waite, 2009b). The removal of the lonely item reduces CES-D10 internal consistency from Cronbach  $\alpha=0.80$  to Cronbach  $\alpha=0.72$  (Cornwell & Waite, 2009b). A decrease in internal consistency was also noted in the current study with alpha level reducing from  $\alpha = 0.74$  to  $\alpha = .72$  CES-D10 modified scale is referred to as CES-Dmodified for this study.

### ***Medical Conditions.***

Diagnosed medical conditions controlled for in the current study were diabetes, heart disease and stroke. All three conditions are possible consequences of metabolic syndrome risk factors, which is a constellation of cardiovascular risk factors. The risk factors for metabolic syndrome include abdominal obesity, high triglyceride levels (fat in blood), low high-density lipoprotein (HDL) levels (good cholesterol), hypertension and hyperglycaemia (fasting plasma glucose). Metabolic syndrome has also been associated with acceleration of cognitive ageing, and increased risk of global cognitive decline and visual working memory (Raffaitin et al., 2011; Yaffe, 2007). In the NZLSA postal survey a list of medical conditions were included and participants were asked to identified through ticking “yes” which medical condition they had been informed they had by a health profession. Each medical condition (diabetes, heart disease and stroke) was dichotomised for the multiple regression analyses as a dummy variable with No condition = (0) and Medical condition Yes = (1).

### ***Physical activity levels.***

To assess the level of physical activity, participants were asked, how often they take part in sports or activities that are mildly energetic, moderately energetic and vigorously energetic. Examples were provided for each level of activity. Responses available were

“More than once a week”, “Once a week” “One to three times a month” “Hardly ever or never” For the multiple regression analyses the responses from the mildly energetic were dichotomised and recoded as follows; (0) = More than once a week, and (1) = Once a week or less.

### ***Smoking.***

The NZLSA asked the question “Have you, at any stage of your life, ever been a regular smoker? The response options were Yes = (1) and No = (2). For the multiple regression analyses the responses were coded: Not ever been a regular smoker = (0) and, been a regular smoker = (1).

### ***Alcohol.***

To assess alcohol use The Alcohol Use Disorders Identification Test alcohol consumption questions (AUDIT-C) was employed as a binary indicator two binary indicators of Hazardous Drinking. The AUDIT-C asks the participant questions such as how often they had a drink containing alcohol, with responses being never, monthly or less, two to four time per month, three to three time per week, four or more times a week. Depending on responses further questions would be asked. For example if a participant responded that they never have a drink containing alcohol they were then asked whether alcohol had been consumed in the past. For those participants who identified as currently having a drink which contains alcohol, two further questions were asked of them, namely the number of drinks containing alcohol they consumed on a typical day drinking and how often would they have had six or more drinks on one occasion. A score is computed from the responses. A threshold for hazardous drinking was determined by the researchers of the NZLSA study and this threshold was used in the current study. A score of 4 or more was chosen as an indicator of hazardous drinking (Stevenson, 2014). For the multiple regression analysis the variables were 0 = non-hazardous drinking and 1 = hazardous drinking.

## 7.6 Data Analyses

To test the hypotheses analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 24.0 for Windows software (IBM Inc, Chicago IL, USA). Testing of the main hypotheses required multivariate analyses; hierarchical linear regression was the method chosen. The use of hierarchical linear regression enabled all control variables that are known to be related to cognitive performance to be accounted for in the first instance. Thereby any unique variance explained by the social isolation variables is independent of the control variables. For the cross sectional data this resulted in all covariates entered first into the model, with social isolation variables entered into the second step. A third step was also used for the product terms of loneliness (emotional and social) and objective social isolation, and loneliness (emotional and social), objective social isolation and education.

Product terms were created by the following method. The mean centering procedure was used for the product terms (emotional loneliness x OSII and social loneliness x OSII). This involved subtracting the sample mean from each observed value of the predictor and moderator variable. Then the predictor and moderator variable were multiplied to create new variables labelled 'emotional loneliness X OSII' (Step 3a) and 'social loneliness X OSII' (Step 3b). These variables were entered into Step 3 individually. For the product terms 'emotional loneliness x education', 'social loneliness x education' and 'OSII x education', education was dichotomised into high and low, and then multiplied with the predictor variables. These variables were entered into Step 3 individually.

As an aim of the study was also to assess whether social isolation variables at baseline predicted cognitive performance at a two year follow-up, the longitudinal data analyses required baseline cognitive performance scores to become a control variable. This approach controlled for variations in baseline cognitive performance. By controlling for baseline cognitive performance, the unique variance in cognitive scores at follow-up

explained by the social isolation variables is independent of cognitive performance at baseline. This method of measuring change over time is viewed as appropriate for studies analysing outcomes and the consequences of change (Cronbach & Furby, 1970; Gillespie & Streeter, 1994). Finally, using multiple regression to analyse data and thereby draw conclusions about a population requires attendance to practical issues such as missing data and sample size and the testing of assumptions such as normality, linearity and homoscedasticity. The following chapter will discuss these issues and assumptions in relation to the dataset.

## Chapter Eight: Results

**Chapter Overview:** This chapter will firstly provide detail into the data screening and initial data analysis (8.1), such as missing data, sample size, outliers, assumptions of multivariate analyses and multicollinearity. The chapter then moves on to discuss the sample description, and explains the differences between participants who dropped out after the first collection of data, and those that remained for the second collection of data (8.2.1). This is followed by the presentation of results from univariate analyses on all variables, and bivariate associations among the control and predictor variables, and outcome variables. The cross-sectional analyses investigating how loneliness and social isolation impact cognition are described, followed by how loneliness and social isolation at baseline (time 1) impact current cognition at follow-up (time 2).

### 8.1 Data Screening

#### 8.1.1 Missing data.

As the main investigation of this study is whether different forms of social isolation effects cognitive performance over time in the older adult, only data from participants aged 65 years or old in 2010 whom completed both surveys and face-to-face interviews for 2010 and 2012 were utilised. This resulted in 418 general sample participants.

Analysis of missing data of the final sample included determining the quantity and pattern of missing data. A common missing data classification system is as follows; missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR; Tabachnick & Fidell, 2013). When the distribution of missing data is unpredictable and therefore not related to the other variables, then the data is classified as MCAR. Data that is missing and the pattern can be predicted from other variables is MAR. This final classification is when the distribution of missingness is related to the variable itself.

Missing values analyses were used to examine covariates, independent and dependent variables. All variables had less than 4% data missing. The control variable physical activity level had the highest amount of missing data at 3.9% (missing data for 16 participants), followed by global cognition score at Time 2 with 3.1% (missing data for 13 participants) and emotional loneliness subscale with 2.9% (missing data for 12 participants). All other variables had 0% to 2.9% missing data. Little's MCAR test revealed the data was missing completely at random with a reported non-significant result ( $\chi^2 = 134.85$ ,  $df = 131$ ,  $p = .391$ ). To determine the significance of missingness further tests were carried out. Dummy variables were created for the measures, physical activity level, ACE-R total score Time 2 and emotional loneliness subscale, with each variable recoded into; 0 = missing, 1 = non missing. For all variables t-tests and chi-square analyses were then performed. All continuous variables were examined; no tests of missingness were significant for physical activity levels and emotional loneliness dummy variables. However, those with missing data on ACE-R total scores at Time 2 were older ( $M = 74.00$ ) than those with data ( $M = 70.81$ ), and this difference was significant ( $t = 2.522$ ,  $df = 416$ ,  $p < .05$ ); the effect size was small (eta squared = .01). In addition, participants missing data on ACE-R total score at follow-up had poorer visuospatial scores at baseline ( $M = 14.15$ ) compared to their peers with data ( $M = 15.20$ ) and this difference was significant ( $t = 3.072$ ,  $df = 415$ ,  $p < .01$ ); the effect size was small (eta squared = .02). There was also a significant difference found for the predictor variable emotional loneliness. Those with missing data in ACE-R total score experienced lower levels of emotional loneliness ( $M = .50$ ) in comparison to those with data ( $M = 1.4223$ ). This difference was significant ( $t = 3.722$ ,  $df = 14.747$ ,  $p < .01$ ); the effect size was small (eta squared = .03). The mean differences for all other continuous variables were not significant.

Chi-square tests of independence were used to examine the relation between missingness for the three variables, physical activity level, ACE-R total score at Time 2



and emotional loneliness subscale, and all categorical variables; no statistically significant relationships were found.

### **8.1.2 Sample size.**

For multiple regression analysis guidelines of sample size required per predictor are offered by Stevens (1996) of 15 participants per predictor and Tabachnick and Fidell's (2013) being the formula of  $N > 50 + 8m$  (where  $m$  = number of independent variables used). Both guidelines were exceeded in the current study with 26 participants available per predictor, and using the formula of Tabachnick and Fidell's, which suggests a sample size of 178 based on the current study's use of 16 predictors; therefore the current study exceeds with a sample size of 418. If sample sizes are small, it may impede the ability to obtain a repeated result with other samples.

### **8.1.3 Outliers.**

All continuous variables were assessed for potential outliers. Univariate detection of outliers involved converting the data to standard scores (z-scores), which have a mean of 0 and a standard deviation of 1. Threshold determination is dependent on sample size, with guidelines suggesting larger sample sizes such as the current study the threshold value is set at 4 ( $p < .001$ , two tailed) and all observations with z scores in excess of 4 were analysed to ensure observations were valid (Hair, Black, Babin, & Anderson, 2014). In addition, the Median Absolute Deviation was also used. Both methods resulted in the identification of 3 to 7 outlying cases for cognitive performance scores at baseline and follow-up (ACE-R total scores, MMSE, memory, fluency, language, visuospatial). For example the identified univariate outliers for the ACE-R total scores were observed as follows; 52, 58 and 59. These scores are extremely low and further examination using histograms, it was noted the outliers were detached from the distribution.

However, determining the course of action a researcher should take when outliers are detected is complicated and dependent on the data analysis undertaken. In the current study as the data analysis used is multiple regression, rather than focus on univariate outliers, it was deemed more appropriate to analyse multivariate outliers. Bearing in mind that outliers may in some cases have a strong influence on the results of a regression analysis, yet removal of an outlier may not be justified if there is not a valid reason to view the value as an invalid observation. In discussing outliers Hair et al. (2014) stated that their belief is the removal of outliers should only occur if through demonstrable proof they are “truly aberrant and not representative of any observations in the population” (p. 76). Furthermore, removing of outliers may improve the multivariate analysis, however this may be at the cost to data generalisability to the entire population (Aryani, 2009; Hair, Black, Babin & Anderson, 2014).

In summary, where univariate outliers were identified, a review of the 2012 cognitive performance scores indicated they were consistent with scores obtained in 2010 for the same individual. Demonstrating that though scores were classified as an outlier they were representative of observations in the population. A decision was made to retain the outliers.

Following the decision to retain univariate outliers, the next step was to investigate multivariate outliers. The detection of multivariate outliers and their influence on the model fit occurred through the use of Mahalanobis distance, Cook’s distance, and Leverage values (commonly known as hats values). The Mahalanobis values were analysed using the  $\chi^2$  distribution with alpha set at a level of .001 for each multiple regression reported. All cases that had values above the cut-off point were investigated to determine if any had undue influence over the parameters of the models. Cook’s distance is a measure of the overall influence of a case on the model. Values greater than 1 are deemed to require greater analysis and maybe cause for concern (Cook & Weisberg, 1982). Analysis of Cook’s distance for all regression reported in the current

study showed that no cases had an undue influence on the models, with the highest value .206 being considerably lower than 1. Leverage values were also reviewed. Leverage values gauges the influence of the observed value of the outcome variable over the predicted values (Field, 2016). Any cases that are three times the average should be investigated. Examination of leverage values showed that all cases were less than three times the average leverage value of .1237. Finally, analyses were run with and without outliers. There were no changes in outcomes for each model (no overall findings changed from significant to non-significant or non-significant to significant). Therefore with model outcomes being the same, and the observations being valid, all univariate and multiple variate outliers were retained.

#### **8.1.4 Assumptions of multivariate analyses.**

The use of multiple regression analyses requires testing of assumptions such as normality, linearity, homoscedasticity. Analysing scatterplots of residuals allows for the testing of the assumptions of normality, linearity and homoscedasticity between the predicted dependent variable scores and errors of prediction (Tabachnick & Fidell, 2013; Williams, Grajales, & Kurkiewicz, 2013), there were no violations of the multiple regression assumptions. Therefore, there was no transformation of data.

#### **8.1.5 Multicollinearity.**

Multicollinearity was assessed by examining variance inflation factors (VIF) and tolerance levels. The assessment of multicollinearity is important as a consequence of multicollinearity is a reduction in an independent variables unique variance, and increases in shared prediction from three or more independent variables. If multicollinearity is occurring it thereby makes it difficult to determine the role of independent variables in explaining the variance in the dependent variable. All multiple regression analysis data with VIF values below 5.0 were accepted as were tolerance levels above 0.2; values well within the recommended levels (Bowerman & O'Connell, 1990; Myers, 1990). A review of the variables in the analysis revealed that the highest

VIF value was 2.059, well below the level of 5.0, and the lowest tolerance level was 0.486, well above the 0.2, for the hierarchical multiple regressions that did not involve an interaction effect. For the testing of an interaction effect between loneliness and objective social isolation, a review of variables, specifically the interaction variable did reveal VIF values above 5.0. To reduce multicollinearity the variables emotional loneliness subscales, social loneliness subscales and OSII were centred, as this can enhance interpretability of coefficients and reduce multicollinearity (Afshartous & Preston, 2011) which it achieved. After centring there were no variables found to have a VIF value above 5.

## **8.2 Data Analyses of Initial Sample and Final Sample, and Descriptive Statistics of Final Sample**

This section will describe the findings between those who completed the face to face interview for both 2010 and 2012, and non-completers. The importance of assessing baseline differences between those who dropped out and those who completed the study, can provide information on the generalisability of the findings. This is followed by a section on the demographics of the current sample, and summary on the loneliness, social isolation and cognitive measures. All conclusions reached in the current study, cannot be assumed to extend beyond the group described in this section.

### **8.2.1 Sample description.**

Independent-sample t-tests and Chi Square test for independence were used to compare socio-demographic variables, mental health, loneliness (emotional and social), objective social isolation and cognitive performance between those who completed the face-to-face interviews in 2010 but did not participate in face-to-face interviews in 2012. The importance of assessing baseline differences between those who drop out and those who completed the study can provide information on the generalisability of the findings. Independent-samples *t*-tests indicated that older adults who did not go on to complete the 2012 interviews were older ( $M = 72.98$ ) than those with non-missing data ( $M =$

70.91) and this difference was significant ( $t = -3.19$ ,  $df = 473$ ,  $p < .01$ ). The effect size was small (eta squared = .02). Those who did not complete 2012 face-to-face interviews also had poorer performance on the ACE-R total cognition ( $M = 90.00$ ) than those who completed face-to-face interviews ( $M = 91.98$ ) and this differences was significant, ( $t = 2.15$ ,  $df = 472$ ,  $p < .05$ ). The effect size was small (eta squared = .01).

Chi-square tests for independence indicated that those who participated in the 2010 interviews only were more likely to be non-partnered [ $\chi^2 (1, n = 472) = 6.79$ ,  $p = .009$ ,  $phi = .127$ ], Māori ( $\chi^2 (1, n = 464) = 8.5$ ,  $p = .004$ ,  $phi = .143$ ), and have smoked at some stage of their life ( $\chi^2 (1, n = 471) = 5.28$ ,  $p = .022$ ,  $phi = .113$ ) than those who participated in 2010 and 2012 interviews.

### **8.3 Descriptive Statistics of Final Sample Population**

#### **8.3.1 Descriptive statistics for demographic control variables.**

The following results are from the final sample of 418 participants (see Table 3). There were similar proportions of women (50.5%) and men (49.5%). New Zealand European (65.3%) was the largest identified ethnicity group. The majority of participants (54.1%) had continued studying after secondary school, with the largest group having a post-secondary certificate or diploma (37.8%), followed by those with no qualifications (22.9%), and secondary qualifications (22.7%). As previously mentioned, this group had a higher percentage than the national population of tertiary educated adults with 16%. In this sample of older adults, the majority reported being in a relationship (67.9%), mostly married (64.1%). There were 17.5% who identified as a widow or widower and 6.2% as single or never married.

Table 3

*Descriptive Statistics for Demographic Control Variables at Baseline (Time 1), N = 418*

		Range	Mean	Standard Deviation
Age		65-83	70.91	4.50
		Frequency		Percentage
Gender	Female	211		50.50
	Male	207		49.50
Ethnicity	New Zealand European	299		65.30
	Maori	101		24.20
	Pacific People	3		.07
	Other	15		3.60
	Missing	1		.02
Educational Level	No Qualifications	96		22.90
	Secondary School	95		22.70
	Post-Secondary certificate	158		37.80
	University Degree	68		16.30
	Missing	1		.02
Relationship Status	Married	268		64.10
	Civil Union/De-facto	16		3.80
	Divorced/Separated	35		8.40
	Widow/Widower	73		17.50
	Single/Never Married	26		6.20

### 8.3.2 Descriptive statistics for depression, physical and lifestyle variables.

The scores for the mental health, physical and lifestyle variables at baseline are suggestive of a group of relatively physically and mentally healthy older adults (see Table 4). Further analysis of the CES-D showed that 14.1% of participants would have been categorised as having scores that indicated depression. The majority of participants were non-smokers (81.1%) and most engaged in mildly energetic physical activity more than once a week (71.1%). The medical condition most reported was heart disease at 19.9%. The majority of older participant's responses to alcohol use indicated non-hazardous alcohol use (56%), there was however, a large group (41.1%) who were classified as having hazardous alcohol use as per the threshold used by the NZLSA (Stevenson, 2014).

Table 4

*Descriptive Statistics for Depression, Physical Health and Lifestyle Control Variables at Baseline (Time 1)*

		Range	Mean	Standard Deviation
CES-Dmodified <sup>1</sup>		0-25	5.09	3.76
CES-D <sup>2</sup>		0-27	5.54	4.05
		Frequency	Percentage	
Smoking	Non-smoker	339	81.1	
	Smoker	78	18.7	
	Missing	1	.02	
Alcohol Use	Non-hazardous drinking	234	56.0	
	Hazardous drinking	172	41.1	
	Missing	12	2.9	
Heart disease	No	335	80.1	
	Yes	83	19.9	
Stroke	No	395	94.5	
	Yes	23	5.5	
Diabetes	No	376	90.0	
	Yes	42	10.0	
Mild Physical Activity	Weekly or less	104	25.1	
	More than weekly	295	71.1	
	Missing	16	3.9	

<sup>1</sup>CES-D modified range is 0 – 27. <sup>2</sup>CES-D range is 0 – 30.

### 8.3.3 Descriptive statistics for social isolation variables.

Analysing the scores of the social isolation measures suggested that the majority of older adults in this cohort were not reporting high levels of objective social isolation or loneliness (see Table 5). The range for both emotional loneliness and social loneliness subscales included all possible scores (ranging from 0-6 to 0-5 respectively). Reviewing the frequency of scores, 50% of older adults received a score of 0 indicating they were not experiencing any symptoms of emotional loneliness. In contrast, 3.2% of participants received a maximum score of 6 for emotional loneliness, which is suggestive of those participants perceiving themselves as experiencing severe emotional loneliness. Furthermore, a quarter (25.1%) of older adults scored three or more on the emotional loneliness subscale, indicating they had experienced moderate levels of emotional

loneliness. Social loneliness subscale scores were similar, in that more older adults (32.9%) reported no symptoms of social loneliness, in comparison to 10.6% of older adults who perceived themselves as being severely socially lonely (received the maximum score of 5). Over 30% of the older adults experienced three or more symptoms of social loneliness.

The majority of older adults reported lower levels of objective social isolation than higher levels, based on scores of the OSII. There were 26.6% of respondents whose responses indicated they had frequent contact with family, friends, neighbours, a marital partner and involvement in some form of social activity. There were 1% of older adults whose responses suggested they were experiencing extreme social isolation. The majority of the remaining participants scored lower levels of social isolation with 35.7% receiving a score of 1, and 24% received a score of 2.

Table 5

*Descriptive Statistics for Social Isolation Variables at Baseline (Time 1)*

	<i>n</i>	Range	Mean (SD)
Emotional Loneliness subscale	406	0-6	1.40 (1.80)
Social Loneliness subscale	414	0-5	1.72 (1.70)
Objective Social Isolation Index (OSII)	417	0-5	1.31 (1.14)

#### **8.3.4 Descriptive Statistics for cognitive performance outcome variables and initial analyses.**

##### ***Descriptive statistics for baseline and follow-up.***

As can be seen in Table 6, the overall mean scores for the cognitive measures at baseline showed that many of the participants had high-functioning cognitive ability (the higher the score the better the cognitive performance). Furthermore, comparison of the ACE-R total mean score ( $M = 90.41$ ) to the guideline ACE-R cut-off score at 88, which is shown to have 94% sensitivity and 89% specificity for indicating potential dementia (Mioshi et al., 2006), is also suggestive of most of the current cohort having high-functioning cognitive ability. The mean scores at follow-up declined for all cognitive



outcomes other than fluency, which increased. Paired-samples t-test were performed to determine if the changes in cognitive outcome scores over time were statistically significant. As displayed in Table 6, results show that some cognitive domains decreased over time being global cognition scores as measured by ACE-R total, memory and visuospatial, and the other cognitive domain scores (MMSE, fluency and language) remained relatively static.

Table 6

*Descriptive Statistics and t-test Results for ACE-R total, MMSE, Memory, Fluency, Language, and Visuospatial*

Outcome	Time 1				Time 2				95% CI for Mean Difference		
	Range	<i>n</i>	<i>M</i>	<i>SD</i>	Range	<i>n</i>	<i>M</i>	<i>SD</i>		<i>t</i>	<i>df</i>
ACE-R Total	56-100	417	91.84	6.18	52-100	404	90.41	7.43	0.96, 1.90	5.60***	403
MMSE	22-30	418	28.69	1.46	22-30	410	28.57	1.61	-0.04, 0.29	1.48	409
Memory	8-26	418	23.33	2.98	5-26	414	22.49	3.52	0.55, 1.12	5.82***	413
Fluency	0-14	417	10.89	2.40	0-14	417	10.92	2.50	-0.22, 0.17	0.27	416
Language	14-26	418	24.67	1.68	10-26	411	24.55	1.99	-0.05, 0.31	1.39	410
Visuospatial	10-16	418	15.18	1.210	8-16	415	14.75	1.41	0.30, 0.55	6.58***	414

\*\*\*  $p < .001$

#### 8.4 Bivariate Analyses

Bivariate analyses were carried out to examine the relationships between the control variables at baseline and cognitive outcomes for both baseline line (time 1) and follow-up (time 2). Bivariate analyses were also used to investigate the association between control variables at baseline and loneliness and social isolation measures at baseline, and between loneliness and social isolation measures. In the current study, bivariate analyses were not used to determine which control variables or predictors would be in the final model for the multivariate analyses. All control variables and predictors had been chosen based on either theory or to ensure consistency with previously published studies on social relationships and cognition. The bivariate analyses are presented as the introductory chapters discussed relationships between demographics, environmental factors and the association with both cognition and loneliness and social isolation. The

following analyses provided information on whether those relationships were similar for the current study's population.

#### 8.4.1 Relationship between baseline control variables and baseline cognitive outcomes.

The key findings from the bivariate analyses between control variables at baseline and cognitive scores at baseline (see Table 7) are as follows. Older age was correlated with lower levels of cognitive performance for global cognition, and all domains other than memory. There was no association between increasing age and memory performance. Higher levels of education were correlated with higher levels of cognitive performance with global cognition and all cognitive domains. Also higher levels of activity and lower levels of depression were two other control variables that had a relationship with majority of the cognitive outcomes. All other variables demonstrated inconsistencies across the cognitive domains, or lacked an association with the cognitive outcomes.

Table 7

*Bivariate Analyses of Control Variables and Cognitive Outcome Variables at Baseline (Time 1)*

	ACE-R total	MMSE	Memory	Fluency	Language	Visuospatial
Age	-.147**	-.107*	-.082	-.121*	-.107*	-.151**
Education	.255***	.154**	.155**	.210***	.138**	.206***
Heart-trouble	-.019	-.056	.029	-.010	-.038	-.102*
Stroke	-.154**	-.055	-.090	-.182***	-.061	-.067
Diabetes	-.105*	-.074	-.133**	-.058	-.065	.007
Alcohol Use	.015	-.001	-.029	.031	.035	.004
Physical Activity	.169**	.147**	.176***	.134**	.036	.054
CESD	-.188***	-.078	-.176***	-.132**	-.067	-.126**
Smoking	-.105*	-.065	-.073	-.094	-.059	-.076
Gender	-.096	-.066	-.148**	-.095	.034	.007
Ethnicity	-.066	-.084	-.095	-.063	-.036	.075

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ . Education = Up to secondary school qualifications/Post-secondary school qualifications; Heart trouble, Stroke, Diabetes = No diagnosis/diagnosed; Alcohol use = Non-hazardous/Hazardous; Physical activity level = Mildly energetic less than weekly/More than weekly; Smoking = Non-smoker/Smoker; Gender = Female/Male; Ethnicity = Non-Māori/Māori

#### 8.4.2 Relationship between control variables at baseline (time 1) and cognitive outcomes at follow-up (time2).

Age and education at baseline were significantly related to all of the cognitive measures at follow-up (refer Table 8). Increasing age was associated with decreasing scores in the cognitive measures. Also, the strength of the correlation increased between age and cognitive scores at follow-up in comparison to baseline for all cognitive outcomes other than visuospatial, which slightly weakened. Having a post-secondary school qualification was associated with better cognitive performance for the older adults than having secondary qualifications or less. Increased levels of depression were associated with poorer global cognitive performance as indicated by the ACE-R total, memory, fluency and visuospatial ability. For all other control variables the relationships were mixed. However, heart trouble had a statistically significant relationship with all of the outcome variables other than memory, and this variable had a far stronger relationship with the cognitive outcomes at follow-up than baseline.

Table 8

*Bivariate Analyses of Control Variables at Baseline (Time 1) and Cognitive Outcome Variables at (Time 2)*

	ACE-R total	MMSE	Memory	Fluency	Language	Visuospatial
Age	-.201***	-.168**	-.151**	-.142**	-.174***	-.081
Education	.235***	.169***	.185***	.178***	.140**	.158***
Heart-trouble	-.138**	-.107*	-.045	-.118*	-.087*	-.176***
Stroke	-.203***	-.073	-.142**	-.207***	-.056	-.227***
Diabetes	-.096	-.024	-.054	-.145**	-.060	-.020
Alcohol Use	.053	.070	.066	-.013	.041	.047
Physical Activity level	.191***	.149**	.222***	.082	.076	.110*
CESD	-.153**	-.085	-.112*	-.161**	-.086	-.128**
Smoking	-.029	-.025	.028	-.074	-.030	-.052
Gender	-.110*	-.100*	-.112*	-.169**	.010	.067
Ethnicity	-.069	-.109*	-.064	-.069	-.043	-.043

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ . Education = Up to secondary school qualifications/Post-secondary school qualifications; Heart trouble, Stroke, Diabetes = No diagnosis/diagnosed; Alcohol use = Non-hazardous/Hazardous; Physical activity level = Mildly energetic less than weekly/More than weekly; Smoking = Non-smoker/Smoker; Gender = Female/Male; Ethnicity = Non-Māori/Māori

In summary the bivariate analyses between control variables and cognitive scores at baseline and follow-up were similar, with age and education, having a consistent relationship with the cognitive outcomes in comparison to all other control variables.

### 8.4.3 The relationship between control variables and social isolation variables at baseline.

As indicated in Chapter 4, social isolation and loneliness have been associated with depression, unhealthy lifestyle habits, such as lack of physical activity, alcohol use and smoking. Chapter 3 also discussed evidence in the literature on age and social isolation and loneliness. These bivariate analyses will provide information on the relationship between the control variables and loneliness and social isolation for older adults in New Zealand. The findings of the bivariate analysis between control variables and social isolation variables at baseline are presented in Table 9.

Table 9.

*Bivariate Analyses of Control Variables and Social Isolation Predictors at Baseline (Time 1)*

	Emotional Loneliness <sup>1</sup>	Social Loneliness <sup>1</sup>	Objective Social Isolation Index <sup>1</sup>
Age	-.017	-.030	-.025
Post-secondary education	-.070	.033	-.071
Heart trouble	.063	.020	.006
Stroke	.136*	.061	.063
Diabetes	.093	-.053	-.043
Hazardous Drinking	-.004	.067	.011
High Physical Activity Level	-.201***	-.240***	-.198***
CES-Dmodified	.412***	.346***	.177***
Smoker	.003	.005	.002
Male	.076	.097*	.033
Non-Maori	-.016	-.105*	.012

*Note:* \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ . <sup>1</sup> Higher levels of emotional and social loneliness and objective social isolation results in a higher score.

Physical activity levels and depressive symptomology levels were the only two variables that had a consistent association with loneliness and social isolation. Higher levels of physical activity were associated with lower levels of emotional loneliness, social loneliness and objective social isolation. Age was not shown to be related to any of the social isolation variables. Having had a stroke was associated with higher levels of emotional loneliness. Being male and Maori was associated with higher levels of social loneliness.

#### 8.4.4 Bivariate analyses between social isolation variables.

As mentioned in previously published research the correlations between loneliness and objective social isolation are modest. This analysis was to determine what the correlations were for the two forms of loneliness and social isolation measures and if there were capturing different constructs. The findings from the bivariate analyses of the social isolation variables are shown in Table 10 and, indicate that the emotional loneliness subscale and social loneliness subscale were moderately correlated. Increasing levels of objective social isolation was associated with increasing levels of both social loneliness and emotional loneliness. However, the relationship between social isolation and social loneliness was slightly stronger than that of social isolation and emotional loneliness. The results demonstrated that though all three variables are distinct they are related.

Table 10.

*Bivariate Analyses of Emotional Loneliness, Social Loneliness and Objective Social Isolation Index*

	Emotional Loneliness Scale	Social Loneliness Scale	Objective Social Isolation Index
Emotional Loneliness Scale	1	.507***	.291***
Social Loneliness Scale	.507***	1	.336***
Objective Social Isolation Index	.291***	.336***	1

*Note:* \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

#### 8.4.5 Bivariate analyses of social isolation variables and cognitive outcome variables.

The final bivariate analyses undertaken are between the social isolation variables and cognitive outcomes which are summarised in Table 11 (baseline/time 1) and Table 12 (follow up/time 2).

Emotional loneliness at baseline was significantly related to ACE-R total scores, MMSE and the four cognitive domains (memory, fluency, language and visuospatial) for both baseline (refer Table 11) and follow-up (refer Table 12). Social loneliness and objective social isolation were not found to have a statistically significant bivariate relationship with any cognitive outcome variables (refer Table 11 and Table 12).

Table 11

*Bivariate Analyses between Social Isolation Variables at Baseline (Time 1) and Cognitive Outcome Variables at Baseline (Time 1)*

	ACE-R total	MMSE	Memory	Fluency Time	Language	Visuospatial
Emotional Loneliness Scale	-.238***	-.192***	-.148**	-.181***	-.187***	-.120*
Social Loneliness Scale	-.034	-.030	-.061	-.018	.027	-.016
Objective Social Isolation Index	-.006	-.057	-.025	-.072	.057	.090

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\*  $p < .001$ .

Table 12

*Bivariate Analyses of Social Isolation Variables at Baseline (Time 1) and Cognitive Outcome Variables at Follow-up (Time 2)*

	ACE-R total	MMSE	Memory	Fluency	Language	Visuospatial
Emotional Loneliness Scale	-.248***	-.160**	-.162**	-.203***	-.188**	-.207***
Social Loneliness Scale	.008	.040	-.004	.012	.047	-.021
Objective Social Isolation Index	-.056	-.015	-.047	-.044	-.015	-.040

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\*  $p < .001$ .

### **8.5 Cross-sectional Hypotheses - Multivariate analyses: Hypothesis Testing of the Relationship Between Emotional Loneliness, Social Loneliness, Objective Social Isolation at Baseline (Time 1) as Predictors of Cognitive Performance at Baseline (Time 1)**

A hierarchical linear regression was employed for all cross-sectional analyses (Hypotheses 1, 2, and 3) as it allows for the covariates to be placed in the first step, and provides the variance in cognitive performance that is explained by covariates; these results are displayed under Model 1 of the multiple regression tables. The following variables were controlled for in all analyses in the following order; age, education, heart trouble, stroke, diabetes, alcohol use, depressive symptomology, physical activity levels, smoking, gender, ethnicity. Though the bivariate analyses suggested that some of the covariates and predictors such as objective social isolation and social loneliness was not related to the cognitive outcome variables, it was deemed appropriate to place all variables of interest in the multiple regression, based on theory and previous research.

The second step was entering the social isolation indicators (emotional loneliness, social loneliness, and objective social isolation), creating a final model (Model 2). The final model (Model 2) was used to examine Hypotheses 1 as it enables the examination of the overall variance in the cognitive performance measures (ACE-R total, MMSE, memory, language, fluency and visuospatial) that is explained by the social isolation indicators after controlling for all potential covariates. These results are displayed in Tables 13-18.

For Hypothesis 2 a third step was added in to examine whether objective social isolation levels moderated the relationship between loneliness (emotional and social) and cognitive outcomes. The three predictor variables were centred to reduce multicollinearity, as previously mentioned. The final models for Hypothesis 2 is model 3a and Model 3b. The results are displayed in Tables 13-18.

Hypothesis 3, also involved a third step. To determine whether education moderated the relationship between the predictors (emotional loneliness, social loneliness and objective social isolation) and cognitive outcome a third step was required. The product

terms (emotional loneliness x education; social loneliness x education; and OSII x education) were individually added in on Step 3. This produced final models being Model 3c, Model 3d, and Model 3e. The results for Hypothesis 3 are displayed in tables 19-24.

For ease of reading, a summary of the results for the cross-sectional baseline data is presented first, and more detailed information follows including the tables for each multiple regression.

#### **8.5.1 Summary of results for Hypothesis 1.**

The results for Hypothesis 1 are displayed in Tables 13-18, and refer to Model 1 and 2. Hypothesis 1 was supported in that measures of loneliness (emotional and social) and objective social isolation differed in their association with cognitive performance; and that emotional loneliness explained more of the variance in cognitive performance than social loneliness and objective social isolation. Emotional loneliness had a significant association with five out of six of the cognitive outcomes (ACE-R total, MMSE, fluency, language and visuospatial scores) after controlling for covariates. Emotional loneliness did not have a statistically significant association with memory. Social loneliness was not associated with any of the measures of cognitive performance after controlling for covariates. Objective social isolation was associated with visuospatial performance positively after controlling for covariates but not with any of the other cognitive measures. Memory was the only cognitive measure that was not related to loneliness or social isolation measures.

#### **8.5.2 Summary of results for Hypothesis 2.**

Hypothesis 2 predicted that older adults who experienced high levels of loneliness would have lower cognitive performance scores if they also experienced high levels of objective social isolation than lonely adults who were experiencing low levels of objective social isolation was not supported The findings displayed in Tables 13-18



Model 3a and 3b were that levels of objective social isolation moderated the relationship between emotional loneliness and ACE-R total, MMSE, language, and visuospatial scores, however not as predicted. Though, there were statistically significant findings, the results suggest that as emotional loneliness increases, the negative effect on cognitive performance is *greater* for older adults who are *not* socially isolated than those who are socially isolated.

### **8.5.3 Summary of results for Hypothesis 3.**

The results for Hypothesis 3 are displayed in Tables 19-24. It was predicted for Hypothesis 3 that higher levels of education would dampen or lessen the negative consequences of increasing levels of loneliness or objective social isolation on the cognitive performance of the older adult, due to its reserve building capacity, was not supported. Education did not moderate the relationship between loneliness (emotional and social) and any of the cognitive outcomes. For objective social isolation, education moderated the association between objective social isolation and visuospatial ability, though in the opposite direction as predicted. As levels of objective social isolation increased, for those with post-secondary school qualifications, scores remained static. Yet for older adults with secondary school qualifications or no qualification, as objective social isolation increased, visuospatial scores increased, which was the opposite of what was hypothesised.

The following section will go into detail of the findings for each model. The multivariate analyses for each cognitive outcome that provided the results to answer Hypotheses 1 are now discussed. This is followed by the findings for Hypotheses 2 and 3.

### **8.5.4 Hypothesis 1: Predicting global cognition performance from emotional loneliness, social loneliness and objective social isolation.**

To determine whether loneliness and social isolation measures had an association with global cognitive performance after controlling for covariates a hierarchical linear

regression was carried out (see Table 13). Socio-demographics, mental and physical health, and lifestyle variables alone explained 13.8% of variance (*adjusted R*<sup>2</sup>) in ACE-R total cognition scores,  $F(11, 379) = 6.691, p < .001$ , as shown in Model 1. After entry of emotional loneliness, social loneliness, and objective social isolation at Step 2, the total variance explained in ACE-R total scores at baseline by the social isolation variable predictors as a whole was 16.8% (*adjusted R*<sup>2</sup>),  $F(14, 376) = 6.623, p < .001$  (see Model 2). In Model 2, after controlling for socio-demographics, mental and physical health and lifestyle variables, emotional loneliness ( $\beta = -.220, p < .001$ ) is the only statistically significant predictor of the ACE-R total scores.

The R squared change between Model 1 and Model 2 was significant after the addition of the social isolation and loneliness variables,  $R^2 \text{ change} = .035, F \text{ change}(3, 376) = 5.500, p < .01$ .

Covariates that were statistically significant in Model 2 were age ( $\beta = -.150, p < .01$ ), post-secondary education ( $\beta = .213, p < .001$ ), higher physical activity levels ( $\beta = .110, p < .05$ ), and being male ( $\beta = -.114, p < .05$ ). The inclusion of the social isolation measures in step two reduced the statistically significant effect of depression in Model 1 to statistically non-significant and physical activity level increased to a statistically significant effect in Model 2.

Table 13

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Mental and Physical Health, Lifestyle, Social Isolation Measures, and Interaction of Loneliness Measures and Objective Social Isolation on ACE-R Total Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.20(0.07)	-0.15**	-0.20(0.06)	-0.15**	-0.20(0.06)	-0.14**	-0.20(0.06)	-0.15**
	Post-secondary education	2.71(0.59)	0.22***	2.65(0.59)	0.22***	2.71(0.58)	0.22***	2.63(0.59)	0.21***
	Heart trouble	0.76(0.75)	0.05	0.82(0.74)	0.05	0.65(0.74)	0.04	0.83(0.74)	0.05
	Stroke	-2.36(1.30)	-0.09	-1.94(1.29)	-0.07	-1.82(1.28)	-0.07	-1.96(1.29)	-0.07
	Diabetes	-1.46(0.98)	-0.07	-0.92(0.97)	-0.05	-0.90(0.97)	-0.05	-0.88(0.98)	-0.04
	Hazardous drinking	0.58(0.61)	0.05	0.45(0.60)	0.04	0.50(0.60)	0.04	0.43(0.60)	0.03
	High physical activity level	1.46(0.69)	0.10*	1.56(0.69)	0.11*	1.59(0.69)	0.11*	1.59(0.69)	0.11*
	CES-Dmodified	-0.22(0.08)	-0.13**	-0.15(0.09)	-0.09	-0.17(0.09)	-0.10	-0.15(0.09)	-0.09
	Smoker	-0.98(0.75)	-0.06	-1.04(0.74)	-0.06	-1.08(0.74)	-0.07	-1.09(0.74)	-0.07
	Male	-1.43(0.61)	-0.12*	-1.34(0.60)	-0.11*	-1.38(0.60)	-0.11*	-1.31(0.61)	-0.11*
	Non-Māori	-0.70(0.69)	-0.05	-0.71(0.68)	-0.05	-0.77(0.68)	-0.05	-0.64(0.68)	-0.05
Step 2	Emotional Loneliness			-0.75(0.20)	-0.22***	-1.18(0.28)	-0.24***	-0.75(0.20)	-0.22***
	Social Loneliness			0.37(0.21)	0.10	0.38(0.21)	0.11	0.40(0.21)	0.11
	Objective Social Isolation Index (OSII)			0.43(0.27)	0.08	0.09(0.37)	0.05	0.50(0.28)	0.09
Step 3	Emotional loneliness x OSII					0.25(0.13)	0.10		
Step 3	Social loneliness x OSII							-0.12(0.14)	-0.04
R		0.403***		0.445***		0.454***		0.446***	
Total R <sup>2</sup>		0.163***		0.198***		0.207***		0.200***	
Adjusted R <sup>2</sup>		0.138***		0.168***		0.176***		0.168***	
R <sup>2</sup> change				0.035**		0.010		0.002	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

### **8.5.5 Hypothesis 1: Predicting MMSE performance from emotional loneliness, social loneliness and objective social isolation.**

The results of the analysis are displayed in Table 14. All covariates (socio-demographic, medical conditions, alcohol use, depression, physical activity level and smoking variable) were entered at Step 1, and explained 4.4% of the variance (adjusted  $R^2$ ) in MMSE scores,  $F(11, 379) = 2.616, p < .01$ . The inclusion of loneliness and social isolation measures in Step 2 resulted in model explaining 6.5% of the total variance in MMSE scores (adjusted  $R^2$ ),  $F(14, 376) = 2.952, p < .001$ . Emotional loneliness ( $\beta = -.209, p < .01$ ) was the only statistically significant social isolation predictor of MMSE scores and accounted for 2.09% unique variance in MMSE scores after controlling for covariates. The R squared change, in Model 2 with the inclusion of the social isolation variables was significant,  $R^2 \text{ change} = .028, F \text{ change}(3, 376) = 3.962, p < .01$ .

Age ( $\beta = -.107, p < .05$ ), post-secondary education ( $\beta = .138, p < .01$ ) and higher physical activity levels ( $\beta = .113, p < .05$ ) were the only statistically significant covariates in Model 1 and Model 2.

Table 14

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Mental and Physical Health, Lifestyle, Social Isolation Measures, and Interaction of Loneliness Measures and Social Isolation on MMSE Scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.03(0.02)	-0.10*	-0.03(0.02)	-0.11*	-0.03(0.02)	-0.10*	-0.03(0.02)	-0.11*
	Post-secondary education	0.43(0.15)	0.15**	0.41(0.15)	0.14**	0.43(0.15)	0.15**	0.40(0.15)	0.14**
	Heart trouble	-0.07(0.19)	-0.02	-0.06(0.19)	-0.02	-0.12(0.19)	-0.03	-0.05(0.19)	-0.01
	Stroke	-0.02(0.33)	0.00	0.09(0.33)	0.01	0.13(0.32)	0.02	0.09(0.33)	0.01
	Diabetes	-0.21(0.25)	-0.04	-0.11(0.25)	-0.02	-0.11(0.24)	-0.02	-0.11(0.25)	-0.02
	Hazardous drinking	0.05(0.15)	0.02	0.02(0.15)	0.01	0.04(0.15)	0.01	0.01(0.15)	0.01
	High physical activity level	0.40(0.17)	0.12*	0.38(0.17)	0.11*	0.39(0.17)	0.12*	0.38(0.17)	0.11*
	CES-Dmodified	-0.01(0.02)	-0.03	0.01(0.02)	0.02	0.00(0.02)	0.01	0.01(0.02)	0.03
	Smoker	-0.14(0.19)	-0.04	-0.16(0.19)	-0.04	-0.17(0.18)	-0.05	-0.16(0.19)	-0.04
	Male	-0.18(0.15)	-0.06	-0.15(0.15)	-0.05	-0.16(0.15)	-0.06	-0.14(0.15)	-0.05
	Non-Māori	-0.25(0.17)	-0.07	-0.26(0.17)	-0.07	-0.28(0.17)	-0.08	-0.25(0.17)	-0.07
Step 2	Emotional Loneliness			-0.17(0.05)	-0.21***	-0.19(0.05)	-0.24***	-0.17(0.05)	-0.21***
	Social Loneliness			0.07(0.05)	0.08	0.07(0.05)	0.09	0.07(0.05)	0.08
	Objective Social Isolation Index (OSII)			0.00(0.07)	0.00	-0.05(0.07)	-0.04	0.01(0.07)	0.01
Step 3	Emotional loneliness x OSII					0.09(0.03)	0.16**		
Step 3	Social loneliness x OSII							-0.01(0.04)	-0.01
R		0.266**		0.315***		0.347***		0.315***	
Total R <sup>2</sup>		0.071**		0.099***		0.121***		0.099***	
Adjusted R <sup>2</sup>		0.044**		0.065***		0.085***		0.063***	
R <sup>2</sup> change				0.028**		0.021**		0.001	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

### **8.5.6 Hypothesis 1: Predicting memory performance from emotional loneliness, social loneliness and objective social isolation.**

For the memory score regression analysis,  $R$  was significantly different from zero at the end of each step. The results of this analysis are provided in Table 15. Step 1 saw the covariates (socio-demographic, medical, alcohol use, depression, physical activity level and smoking variable) explaining 10.1% of variance (adjusted  $R^2$ ) in memory scores,  $F(11, 379) = 4.964, p < .001$ . Entrance of loneliness (emotional and social) and OSII, results in the total variance explained in memory scores *decrease* to 9.8% (adjusted  $R^2$ ),  $F(14, 376) = 4.035, p < .001$ , though as stated the model as whole remained statistically significant. The  $R$  squared change after the inclusion of social isolation measures was not significant,  $F$  change  $(3, 376) = .0046, p = .568$ . The significant variables that accounted for the variation in memory scores after social isolation measures had been entered were post-secondary education ( $\beta = .126, p < .05$ ), heart trouble ( $\beta = .100, p < .05$ ), high physical activity level ( $\beta = .119, p < .05$ ), depression ( $\beta = -.122, p < .05$ ), and male ( $\beta = -.154, p < .01$ ). The inclusion of the social isolation variables resulted in diabetes no longer being significant in Model 2.

Table 15

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Mental and Physical Health, Lifestyle, Social Isolation Measures, and Interaction of Loneliness measures and Social Isolation on ACE-R Memory Scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.06(0.03)	-0.09	-0.06(0.03)	-0.09	-0.06(0.03)	-0.09	-0.06(0.03)	-0.09
	Post-secondary education	0.76(0.28)	0.13*	0.76(0.30)	0.13*	0.78(0.30)	0.13**	0.75(0.30)	0.13*
	Heart trouble	0.74(0.37)	0.10*	0.75(0.37)	0.10*	0.69(0.37)	0.09	0.75(0.37)	0.10*
	Stroke	-0.62(0.65)	-0.05	-0.56(0.65)	-0.04	-0.51(0.65)	-0.04	-0.56(0.65)	-0.04
	Diabetes	-1.03(0.49)	-0.10*	-0.94(0.49)	-0.09	-0.93(0.49)	-0.09	-0.92(0.49)	-0.09
	Hazardous drinking	0.06(0.30)	0.01	0.04(0.30)	0.01	0.06(0.30)	0.01	0.03(0.31)	0.01
	High physical activity level	0.78(0.34)	0.11*	0.81(0.35)	0.12*	0.82(0.35)	0.12*	0.81(0.35)	0.12*
	CES-Dmodified	-0.11(0.04)	-0.14**	-0.10(0.04)	-0.12*	-0.10(0.04)	-0.13*	-0.10(0.04)	-0.12*
	Smoker	-0.32(0.37)	-0.04	-0.33(0.37)	-0.04	-0.34(0.37)	-0.04	-0.34(0.37)	-0.04
	Male	-0.92(0.30)	-0.16**	-0.91(0.30)	-0.15**	-0.92(0.30)	-0.15**	-0.90(0.31)	-0.15**
	Non-Māori	-0.55(0.34)	-0.08	-0.56(0.34)	-0.08	-0.58(0.34)	-0.08	-0.54(0.35)	-0.08
Step 2	Emotional Loneliness			-0.12(0.10)	-0.07	-0.15(0.10)	-0.09	-0.12(0.10)	-0.07
	Social Loneliness			0.05(0.10)	0.03	0.05(0.10)	0.03	0.06(0.11)	0.03
	Objective Social Isolation Index (OSII)			0.11(0.14)	0.04	-0.06(0.14)	-0.02	0.13(0.14)	0.05
Step 3	Emotional loneliness x OSII					0.09(0.06)	0.16		
Step 3	Social loneliness x OSII							-0.04(0.07)	-0.03
R		0.355***		0.361***		0.367***		0.362***	
Total R <sup>2</sup>		0.126***		0.131***		0.135***		0.131***	
Adjusted R <sup>2</sup>		0.101***		0.098***		0.102***		0.097***	
R <sup>2</sup> change				0.005		0.004		0.001	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

### **8.5.7 Hypothesis 1: Predicting fluency performance from emotional loneliness, social loneliness and objective social isolation.**

For the fluency score regression analysis,  $R$  was significantly different from zero at the end of each Model. The results of this analysis are provided in Table 16. Socio-demographic, medical, alcohol use, depression, physical activity level and smoking variables entered into for Step 1, explained 9.5% of variance (*adjusted R*<sup>2</sup>) in fluency scores,  $F(11, 379) = 4.741, p < .001$ . After inclusion of loneliness (emotional and social) and objective social isolation measures the total variance explained in fluency scores increased to 10.7% (*adjusted R*<sup>2</sup>),  $F(14, 376) = 4.344, p < .001$ . Emotional loneliness scores ( $\beta = -.158, p < .01$ ) were statistically significant predictors of variation in fluency scores after controlling for covariates. Social loneliness and objective social isolation scores were not statistically significant. The  $R$  squared change after the inclusion of social isolation measures was significant,  $R$  squared change = .018,  $F$  change (3, 376) = 2.661,  $p < .05$ . Covariates that were significant in the final model accounting for the variation in fluency were age ( $\beta = -.125, p < .05$ ), higher education ( $\beta = .167, p < .001$ ), stroke ( $\beta = -.114, p < .05$ ), and male ( $\beta = -.121, p < .05$ ).

### **8.5.8 Hypothesis 1: Predicting language performance from emotional loneliness, social loneliness and objective social isolation.**

A hierarchical multiple regression was used to determine the ability of social isolation measures to predict language scores after controlling for covariates (see Table 17). The results indicated that the covariates were only able to explain 1.4 % of variance (*adjusted R*<sup>2</sup>) in language scores,  $F(11, 379) = 1.496, p < .130$ .  $R$  was not statistically significantly from zero for Model 1, with the covariates included. However, the inclusion of social isolation variables resulted in  $R$  being significantly different from zero at the end of Model 2. The total variance explained in language scores (Model 2) as a whole was 6.0% (*adjusted R*<sup>2</sup>),  $F(14, 376) = 2.769, p < .01$ . In Model 2, Emotional loneliness recorded the highest beta value ( $\beta = -.267, p < .001$ ) of all variables entered into the model; and was the only social isolation variables that was statistically significant. The  $R$  squared change



was significant after the addition of the social isolation measures,  $R$  squared change = .052,  $F$  change (3,376) = 7.168,  $p < .001$ . Covariates that were statistically significant in the final model were age ( $\beta = -.102$ ,  $p < .05$ ), and post-secondary education ( $\beta = .117$ ,  $p < .05$ ).

#### **8.5.9 Hypothesis 1: Predicting visuospatial performance from emotional loneliness, social loneliness and objective social isolation.**

For the visuospatial score regression analysis,  $R$  was significantly different from zero at the end of each Model. The results of this analysis are provided in Table 18. The covariates entered into Model 1, explained 6.7% of variance (adjusted  $R^2$ ) in visuospatial scores,  $F(11, 379) = 3.541$ ,  $p < .001$ . After inclusion of the social isolation measures the total variance explained in visuospatial scores increased to 8.7% (adjusted  $R^2$ ),  $F(14,376) = 3.646$ ,  $p < .001$ . The  $R$  squared change after the inclusion of social isolation measures was statistically significant,  $R$  squared change, = .026,  $F$  change (3, 376) = 3.749,  $p < .05$ .

The social isolation variables that were that were significant predictors of visuospatial scores after controlling for covariates in Model 2, were emotional loneliness ( $\beta = -.127$ ,  $p < .05$ ) and objective social isolation scores ( $\beta = .147$ ,  $p < .01$ ). Age ( $\beta = -.139$ ,  $p < .01$ ) and higher education ( $\beta = .199$ ,  $p < .001$ ) were also statistically significant predictors of visuospatial scores in the final model. Inclusion of the social isolation variables did not result in any significant changes to the covariates.

Table 16

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Mental and Physical Health, Lifestyle, Social Isolation Measures, and Interaction of Loneliness Measures and Social Isolation on ACE-R Fluency Scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.07(0.03)	-0.12*	-0.07(0.03)	-0.13*	-0.07(0.03)	-0.13*	-0.07(0.03)	-0.13*
	Post-secondary education	0.85(0.24)	0.18***	0.81(0.24)	0.17***	0.81(0.24)	0.17***	0.80(0.24)	0.17***
	Heart trouble	0.31(0.30)	0.05	0.33(0.30)	0.05	0.33(0.30)	0.05	0.33(0.30)	0.05
	Stroke	-1.37(0.52)	-0.13**	-1.24(0.52)	-0.12*	-1.24(0.52)	-0.12*	-1.24(0.52)	-0.12*
	Diabetes	-0.22(0.39)	-0.03	-0.09(0.39)	-0.01	-0.09(0.40)	-0.01	-0.07(0.40)	-0.01
	Hazardous drinking	0.29(0.25)	0.06	0.25(0.24)	0.05	0.25(0.25)	0.05	0.24(0.25)	0.05
	High physical activity level	0.41(0.28)	0.08	0.40(0.28)	0.07	0.40(0.28)	0.07	0.41(0.28)	0.08
	CES-Dmodified	-0.06(0.03)	-0.09	-0.04(0.04)	-0.06	-0.04(0.04)	-0.06	-0.04(0.04)	-0.06
	Smoker	-0.34(0.30)	-0.06	-0.37(0.30)	-0.06	-0.36(0.30)	-0.06	-0.38(0.30)	-0.06
	Male	-0.59(0.25)	-0.12*	-0.57(0.24)	-0.12*	-0.57(0.25)	-0.12*	-0.56(0.25)	-0.12*
	Non-Māori	-0.30(0.28)	-0.05	-0.27(0.28)	-0.05	-0.27(0.28)	-0.05	-0.25(0.28)	-0.04
Step 2	Emotional Loneliness			-0.21(0.08)	-0.16**	-0.21(0.11)	-0.16**	-0.21(0.08)	-0.16**
	Social Loneliness			0.15(0.08)	0.11	0.15(0.08)	0.11	0.16(0.09)	0.11
	Objective Social Isolation Index (OSII)			-0.04(0.11)	-0.02	-0.03(0.15)	-0.02	-0.05(0.11)	-0.01
Step 3	Emotional loneliness x OSII					0.00(0.05)	-0.01		
Step 3	Social loneliness x OSII							-0.05(0.06)	-0.04
R		0.348***		0.373***		0.373***		0.375***	
Total R <sup>2</sup>		0.121***		0.139***		0.139***		0.141***	
Adjusted R <sup>2</sup>		0.095***		0.107***		0.105***		0.107***	
R <sup>2</sup> change				0.018*		0.000		0.002	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 17

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Mental and Physical Health, Lifestyle, Social Isolation Measures, and Interaction of Loneliness Measures and Social Isolation on ACE-R Language Scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.04(0.02)	-0.10*	-0.04(0.02)	-0.10*	-0.04(0.02)	-0.10	-0.04(0.02)	-0.10*
	Post-secondary education	0.41(0.17)	0.12*	0.39(0.17)	0.12*	0.41(0.17)	0.12*	0.39(0.17)	0.12*
	Heart trouble	-0.07(0.22)	-0.02	-0.05(0.21)	-0.01	-0.10(0.21)	-0.02	-0.05(0.21)	-0.01
	Stroke	-0.17(0.38)	-0.02	-0.03(0.37)	0.00	0.01(0.37)	0.00	-0.03(0.37)	0.00
	Diabetes	-0.27(0.29)	-0.05	-0.09(0.28)	-0.02	-0.08(0.28)	-0.02	-0.08(0.28)	-0.01
	Hazardous drinking	0.10(0.18)	0.03	0.06(0.17)	0.02	0.08(0.17)	0.02	0.06(0.17)	0.02
	High physical activity level	0.07(0.20)	0.02	0.10(0.20)	0.03	0.11(0.20)	0.03	0.11(0.20)	0.03
	CES-Dmodified	-0.02(0.02)	-0.04	0.00(0.03)	0.01	0.00(0.03)	0.00	0.01(0.03)	0.01
	Smoker	-0.18(0.22)	-0.04	-0.19(0.21)	-0.05	-0.21(0.21)	-0.05	-0.20(0.21)	-0.05
	Male	0.08(0.18)	0.02	0.11(0.17)	0.03	0.09(0.17)	0.03	0.11(0.17)	0.03
	Non-Māori	-0.10(0.20)	-0.03	-0.10(0.20)	-0.03	-0.12(0.20)	-0.03	-0.09(0.20)	-0.02
Step 2	Emotional Loneliness			-0.25(0.06)	-0.27***	-0.27(0.06)	-0.29***	-0.25(0.06)	-0.27***
	Social Loneliness			0.12(0.06)	0.12	0.12(0.06)	0.12*	0.12(0.06)	0.12*
	Objective Social Isolation Index (OSII)			0.15(0.08)	0.10	0.10(0.08)	0.07	0.17(0.08)	0.11*
Step 3	Emotional loneliness x OSII					0.08(0.04)	0.12*		
Step 3	Social loneliness x OSII							-0.03(0.04)	-0.04
R		0.204		0.306**		0.324***		0.307**	
Total R <sup>2</sup>		0.042		0.093**		0.105***		0.095**	
Adjusted R <sup>2</sup>		0.014		0.060**		0.069***		0.059**	
R <sup>2</sup> change				0.052***		0.012*		0.001	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 18

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Mental and Physical Health, Lifestyle, Social Isolation Measures, and Interaction of Loneliness Measures and Social Isolation on ACE-R Visuospatial Scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.04(0.01)	-0.14**	-0.04(0.01)	-0.14**	-0.04(0.01)	-0.13**	-0.04(0.01)	-0.14**
	Post-secondary education	0.48(0.12)	0.19***	0.48(0.12)	0.20***	0.50(0.12)	0.20***	0.48(0.12)	0.20**
	Heart trouble	-0.26(0.15)	-0.08	-0.25(0.15)	-0.08	-0.29(0.15)	-0.09	-0.25(0.15)	-0.08
	Stroke	-0.02(0.27)	0.00	0.01(0.27)	0.00	0.04(0.27)	0.01	0.01(0.27)	0.00
	Diabetes	0.10(0.20)	0.02	0.17(0.20)	0.04	0.18(0.20)	0.04	0.18(0.20)	0.04
	Hazardous drinking	0.05(0.13)	0.02	0.04(0.13)	0.02	0.05(0.12)	0.02	0.04(0.13)	0.02
	High physical activity level	0.05(0.14)	0.02	0.10(0.14)	0.03	0.10(0.14)	0.04	0.10(0.14)	0.04
	CES-Dmodified	-0.03(0.02)	-0.09	-0.02(0.02)	-0.08	-0.03(0.02)	-0.09	-0.02(0.02)	-0.08
	Smoker	-0.15(0.15)	-0.05	-0.15(0.15)	-0.05	-0.16(0.15)	-0.05	-0.15(0.15)	-0.05
	Male	-0.01(0.13)	-0.01	0.00(0.13)	0.00	-0.01(0.12)	0.00	0.00(0.13)	0.00
Step 2	Non-Māori	0.23(0.14)	0.08	0.22(0.14)	0.08	0.21(0.14)	0.07	0.23(0.14)	0.08
	Emotional Loneliness			-0.09(0.04)	-0.13*	-0.10(0.04)	-0.15*	-0.09(0.04)	-0.13*
	Social Loneliness			0.03(0.04)	0.04	0.03(0.04)	0.04	0.03(0.04)	0.04
Step 3	Objective Social Isolation Index (OSII)			0.16(0.06)	0.15**	0.12(0.06)	0.11*	0.16(0.06)	0.15*
	Emotional loneliness x OSII					0.06(0.03)	0.12*		
Step 3	Social loneliness x OSII							-0.01(0.03)	-0.02
R		0.305***		0.346***		0.363***		0.346***	
Total R <sup>2</sup>		0.093***		0.120***		0.132***		0.120***	
Adjusted R <sup>2</sup>		0.067***		0.087***		0.097***		0.085***	
R <sup>2</sup> change				0.026*		0.012*		0.000	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

#### **8.5.10 Hypothesis 2: Objective social isolation moderates the relationship between loneliness (emotional and/or social) and cognitive performance.**

It was predicted that levels of objective social isolation would moderate the relationships between loneliness (emotional and social) and cognitive performance scores. Specifically older adults who were experiencing loneliness and high levels of objective social isolation would perform poorer on cognitive outcomes, than older adults who were also experiencing loneliness but were not socially isolated. The hypothesis predicted that the potential negative effect of being emotionally or socially lonely, would be exacerbated by the potential negative effects of objective social isolation. Hierarchical multiple regression analysis was performed to test the hypothesis. Emotional loneliness, social loneliness and objective social isolation variables were centred and then emotional loneliness and objective social isolation were multiplied to produce the product term as was social loneliness and objective social isolation. The main effects and product term were used in a hierarchical multiple regression to predict cognitive outcomes, after controlling for known covariates (i.e., age, heart disease, diabetes, stroke, alcohol use, physical activity levels, depression, smoking, gender and ethnicity). The product terms were added in Step 3 of the final models.

Tables 13-18, Models 3a and 3b display the findings of the product term of emotional loneliness x OSII, and social loneliness x OSII, on cognitive outcomes at baseline.

There were statistically significant effect for the term, emotional loneliness x OSII, for MMSE scores ( $\beta = .160, p < .01$ ) (Table 14), language scores ( $\beta = .120, p < .05$ ) (Table 17) and visuospatial scores ( $\beta = .120, p < .05$ ) (Table 18). There were no statistically significant effect noted for the product term emotional loneliness x OSII, for ACE-R total score (Table 13), memory (Table 15) or fluency (Table 16).

The product term social loneliness x OSII did not result in statistically significant findings for the six cognitive outcomes measured (Refer Table 13 18, Model 3b).

***The moderating effect of objective social isolation on emotional loneliness and MMSE scores.***

Table 14, Model 3a reports the findings for the significant interaction between emotional loneliness x OSII for MMSE scores. Figure 4 displays the interaction effect.

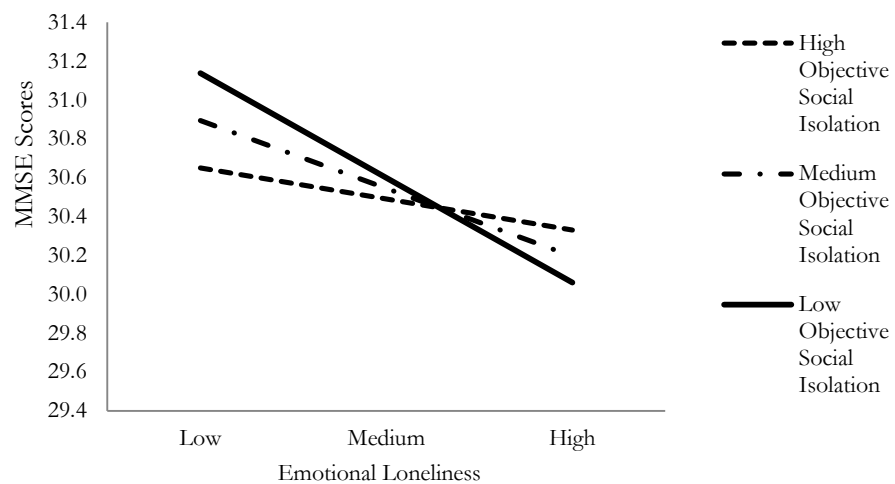


Figure 4. Effect of emotional loneliness on MMSE scores by level of objective social isolation. MMSE scores at baseline, adjusted for age, heart-disease, stroke, diabetes, physical activity, alcohol use, depression, smoking, gender and ethnicity.

The findings indicate that  $R$  was significantly different from zero for Model 1 (inclusion of all control variables), Model 2 (control variables and social isolation variables) and Model 3a, which included all control variables, main effects and the product term (emotional loneliness subscale x OSII). Model 3a explained 8.5% of the variance (adjusted  $R^2$ ) in MMSE scores,  $F(15, 375) = 3.370, p < .001$ . The  $R$  squared change in Model 3a with the inclusion of the product term was significant,  $R$  squared change = .021,  $F$  change  $(1, 375) = 8.400, p < .01$ . In Model 3a, the main effects show emotional loneliness was observed as being a statistically significant predictor of MMSE scores and accounted for 2.39% ( $\beta = -.239, p < .001$ ) unique variance in MMSE scores after controlling for covariates. This significant main effect signified that increasing scores in emotional loneliness decreased MMSE scores. Objective social isolation did not have a

statistically significant main effect ( $\beta = -.037, p = .494$ ). The product term was also statistically significant ( $\beta = .155, p < .01$ ). For MMSE scores simple slope analysis for low levels of objective social isolation were  $-.29, p < .001$ , medium levels of objective social isolation were,  $-.19, p < .001$  and for high levels of objective social isolation a non-significant results for simple slope analysis occurred,  $-.08, p = .088$  (refer Figure 4). The findings indicate that the relationship between increasing levels of emotional loneliness and poorer MMSE scores is strongest for individuals who report low levels of objective social isolation, and weakest for those who report high levels of objective social isolation.

***The moderating effect of objective social isolation on emotional loneliness and language scores.***

Table 17, Model 3a reports the findings for the significant interaction between emotional loneliness and objective social isolation for language scores. Figure 5 displays the interaction effect. Model 1, which included control variables only was not statistically significant thereby indicating that  $R$  was not significantly different from zero. However inclusion of the social isolation variables resulted in  $R$  being statistically different from zero.  $F, (14, 376) = 2.76, p < .01$ . The interaction term was included in Step 3 and shown in Model 3a. The final model for the interaction term explained 6.9% of the variance (adjusted  $R^2$ ), in language scores,  $F (15, 375) = 2.926, p < .001$ . The  $R$  squared change, in Model 3a with the inclusion of the interaction term was significant,  $R$  squared change = .012,  $F$  change  $(1, 375) = 4.882, p < .05$ . The main effects findings were that emotional loneliness ( $\beta = -.290, p < .05$ ), was a statistically significant predictor of language scores and accounted for 2.90% unique variance after controlling for covariates. This significant main effect signified that increasing scores in emotional loneliness decreases language scores. Objective social isolation did not have a statistically significant main effect ( $\beta = .07, p = .200$ ). The interaction effect was however, statistically significant ( $\beta = .120, p < .01$ ).

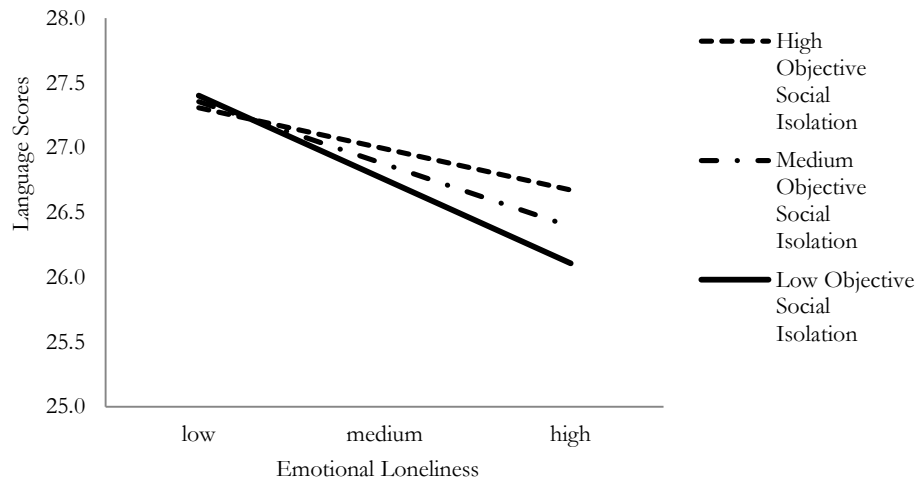


Figure 5. Effect of emotional loneliness on language scores by level of objective social isolation. Language scores at baseline, adjusted for age, heart-disease, stroke, diabetes, physical activity, alcohol use, depression, smoking, gender and ethnicity.

For language scores and emotional loneliness, simple slope analysis for low levels of objective social isolation were  $-.36, p < .001$ , medium levels of objective social isolation were,  $-.27, p < .001$  and for high levels of objective social isolation,  $-.18, p < .01$ . Thereby indicating that the negative relationship between emotional loneliness and language scores is strongest for individuals who report low levels of objective social isolation, and weakest for those who report high levels of objective social isolation.

***The moderating effect of objective social isolation on emotional loneliness and visuospatial scores.***

Table 18, Model 3a reports the findings for the significant interaction between emotional loneliness and objective social isolation for visuospatial scores. Figure 6 displays the interaction effect.



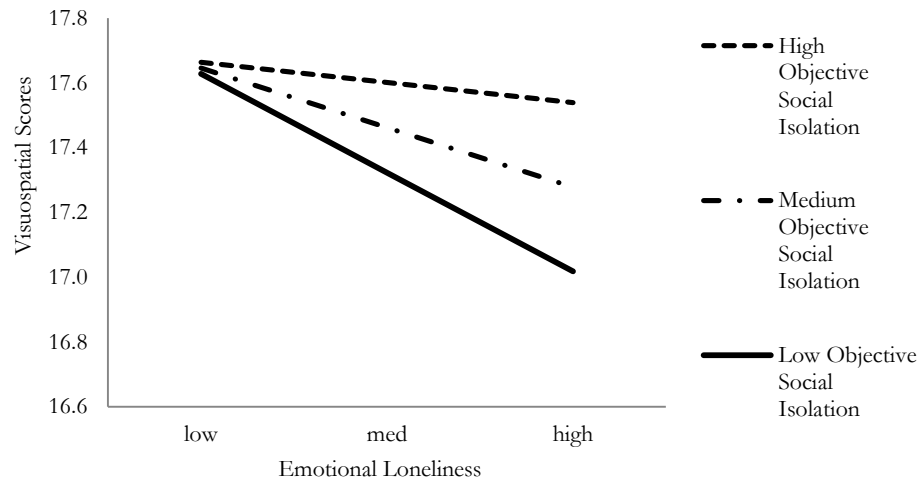


Figure 6. Effect of emotional loneliness on visuospatial scores by levels of objective social isolation. Visuospatial scores at baseline, adjusted for age, heart-disease, stroke, diabetes, physical activity, alcohol use, depression, smoking, gender and ethnicity.

Model 1, which included control variables, was statistically significant.  $F(11, 379) = 3.54, p < .001$ . The inclusion of the social isolation variables (Model 2) resulted in  $R$  being statistically different from zero,  $F(14, 376) = 3.63, p < .001$ . The interaction term was included in Step 3 and shown in Model 3a. The final model for the interaction term explained 9.70% of the variance (adjusted  $R^2$ ), in visuospatial scores,  $F(15, 375) = 3.77, p < .001$ . The  $R$  squared change, in Model 3a with the inclusion of the interaction term was significant,  $R$  squared change = .012,  $F$  change  $(1, 375) = 5.078, p < .05$ . The main effects findings were that emotional loneliness ( $\beta = -.150, p < .001$ ), was a statistically significant predictor of visuospatial scores and accounted for 1.50% unique variance after controlling for covariates. This significant main effect signified that increasing scores in emotional loneliness subscale decreases visuospatial scores. Objective social isolation had a statistically significant main effect ( $\beta = .115, p < .05$ ). This result suggested that higher levels of objective isolation were associated with higher visuospatial scores. The interaction effect was also statistically significant ( $\beta = .119, p < .01$ ).

Simple slope analysis between emotional loneliness and visuospatial scores for low levels of objective social isolation were  $-.17, p < .01$ , medium levels of objective social isolation were,  $-.10, p < .05$  and for high levels of objective social isolation,  $-.03, p = .519$ . Thereby indicating that the negative relationship between emotional loneliness and visuospatial scores is strongest for individuals who report low levels of objective social isolation, and weaker for those experiencing medium levels of objective social isolation, however the relationship between emotional loneliness and visuospatial scores does not differ for those who experiencing high levels of objective social isolation.

In summary the results find that objective social isolation moderated the relationship between emotional loneliness and three of the cognitive outcomes, MMSE, language and visuospatial scores. The most notable interpretation is that the relationship between emotional loneliness and the cognitive outcomes, though significant, is qualified by the significant interaction. In particular, the negative effect of emotional loneliness on MMSE, language and visuospatial scores appears to stronger for those older adults who indicate low levels of objective social isolation, rather than as expected for older adults who were experiencing high levels of objective social isolation.

#### **8.5.11 Hypothesis 3 - Moderating effect of education on the relationship between social isolation and cognitive performance.**

Hypothesis 3 predicted that older adults experiencing higher levels of loneliness or social isolation who had post-secondary qualifications (high level of education) would perform better on the cognitive measures than those who had secondary school qualifications or no school qualifications (low level of education). To determine whether education moderated the relationship between loneliness or objective social isolation and cognitive outcomes at baseline, a hierarchical multiple regression was used. Control variables were entered in Step 1, loneliness and social isolation variables in Step 2, and the product term being investigated in Step 3. Tables 19-24, Models 3c, 3d, and 3e display the findings from the product terms of emotional loneliness x education, social

loneliness x education, and social isolation x education, for each cognitive outcome. The results indicated that education did not moderate the relationship between the social isolation variables and cognitive outcomes, *except* for visuospatial scores ( $\beta = .182, p < .05$ ) as shown in Table 24, Model 3e.

Table 24, Model 3e demonstrates that the inclusion of the product term (social isolation x education) also resulted in the *R* squared change for Model 3e being statistically significant, *R* squared change = .010, *F* change (1, 375) = 4.336,  $p < .05$ . As with Model 1 and 2, *R* was also statistically different from zero at the end of Model 3e;  $F(15, 375) = 3.722, p < .001$ . As illustrated in Model 3e in Table 21, a significant main effect for education was found ( $\beta = .316, p < .001$ ), in that those with post-secondary education or qualifications had higher visuospatial scores than those with secondary school or no qualifications. Also objective social isolation had a significant main effect ( $\beta = .250, p < .001$ ), which demonstrated that those with higher levels of objective social isolation had higher visuospatial scores than those who were not socially isolated. This main effect was qualified by the significant interaction ( $\beta = -.182, p < .05$ ), as shown Figure 7.

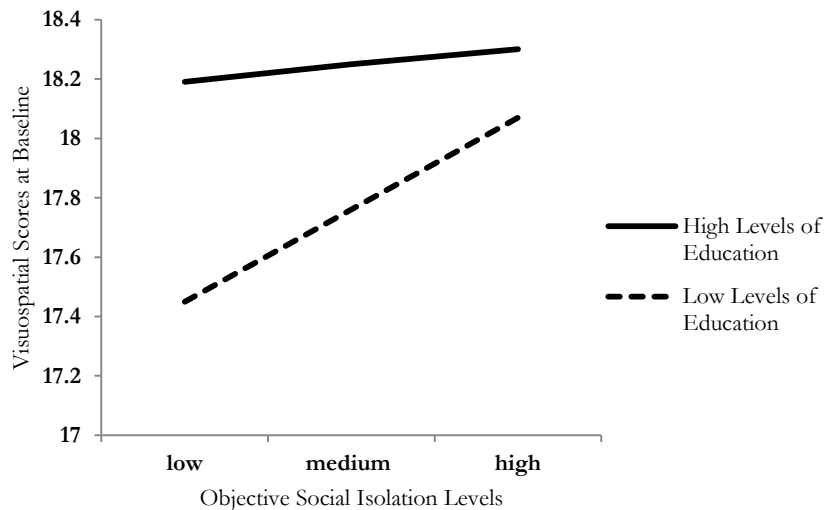


Figure 7. Effect of objective social isolation on visuospatial scores by level of education. Visuospatial scores at baseline, adjusted for age, heart disease, stroke, diabetes, physical activity, alcohol use, depression, smoking, gender and ethnicity.

Those with low education manifested a steeper slope between objective social isolation levels and visuospatial scores than those with a higher level of education. Simple slope analyses showed that older adults with low education levels manifested a significant positive slope of .27 ( $p < .001$ ), whereas their peers with high education levels had a non-significant slope of .052 ( $p = .46$ )

For older adults with low education levels, differential levels of objective social isolation was significantly related to visuospatial scores, whereas no association was noted by those with high levels of education. The results indicated that for older adults who had low levels of education, their scores on visuospatial tasks improved as there levels of social isolation increased.

Table 19

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on ACE-R scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.20(0.07)	-0.15**	-0.20(0.06)	-0.15**	-0.20(0.06)	-0.15**	-0.20(0.06)	-0.15**	-0.20(0.06)	-0.15**
	Post-secondary education	2.71(0.59)	0.22***	2.65(0.59)	0.21***	2.38(0.74)	0.19**	2.79(0.83)	0.23**	2.82(0.89)	0.23**
	Heart trouble	0.76(0.75)	0.05	0.82(0.74)	0.05	0.87(0.74)	0.06	0.80(0.74)	0.05	0.80(0.74)	0.05
	Stroke	-2.36(1.30)	-0.09	-1.94(1.29)	-0.07	-1.99(1.29)	-0.07	-1.95(1.29)	-0.07	-1.94(1.29)	-0.07
	Diabetes	-1.46(0.98)	-0.07	-0.92(0.97)	-0.04	-0.91(0.98)	-0.04	-0.92(0.98)	-0.04	-0.92(0.98)	-0.05
	Hazardous drinking	0.58(0.61)	0.05	0.45(0.60)	0.04	0.43(0.61)	0.03	0.45(0.61)	0.04	0.45(0.61)	0.04
	High physical activity level	1.46(0.69)	0.10*	1.56(0.69)	0.11*	1.55(0.69)	0.11*	1.56(0.69)	0.11*	1.56(0.69)	0.11*
	CES-Dmodified	-0.22(0.08)	-0.13**	-0.15(0.09)	-0.09	-0.15(0.09)	-0.09	-0.16(0.09)	-0.10	-0.15(0.09)	-0.09
	Smoker	-0.98(0.75)	-0.06	-1.04(0.74)	-0.07	-1.03(0.74)	-0.07	-1.03(0.74)	-0.07	-1.04(0.74)	-0.07
	Male	-1.43(0.61)	-0.12*	-1.34(0.60)	-0.11*	-1.34(0.61)	-0.11*	-1.33(0.61)	-0.11*	-1.33(0.61)	-0.11*
Step 2	Non-Māori	-0.70(0.69)	-0.05	-0.71(0.68)	-0.05	-0.69(0.68)	-0.05	-0.70(0.68)	-0.05	-0.71(0.68)	-0.05
	Emotional Loneliness			-0.75(0.20)	-0.22***	-0.85(0.26)	-0.25**	-0.75(0.20)	-0.22***	-0.76(0.20)	-0.22***
	Social Loneliness			0.37(0.21)	0.10	0.37(0.21)	0.10	0.42(0.29)	0.12	0.37(0.21)	0.10
Step 3	Objective Social Isolation Index (OSII)			0.43(0.27)	0.08	0.45(0.27)	0.08	0.43(0.27)	0.08	0.50(0.38)	0.09
	Emotional loneliness x education					0.19(0.33)	0.04				
	Social loneliness x education							-0.09(0.35)	-0.02		
	OSII x education									0.01(0.41)	0.00
R		0.403***		0.445***		0.446***		0.445***		0.445***	
Total R <sup>2</sup>		0.163***		0.198***		0.199***		0.198***		0.198***	
Adjusted R <sup>2</sup>		0.138***		0.168***		0.166***		0.166***		0.166***	
R <sup>2</sup> change				0.035**		0.001		0.000		0.000	

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Table 20

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, and Social Isolation Measures including Interaction of Social Isolation Measures and Education on MMSE scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.03(0.02)	-0.10*	-0.03(0.02)	-0.11*	-0.03(0.02)	-0.10*	-0.04(0.02)	-0.11*	-0.04(0.02)	-0.11*
	Post-secondary education	0.43(0.15)	0.15**	0.41(0.15)	0.14**	0.33(0.19)	0.11	0.61(0.21)	0.21**	0.57(0.22)	0.19*
	Heart trouble	-0.07(0.19)	-0.02	-0.06(0.19)	-0.02	-0.04(0.19)	-0.01	-0.09(0.19)	-0.02	-0.07(0.19)	-0.02
	Stroke	-0.02(0.33)	0.00	0.09(0.33)	0.01	0.08(0.33)	0.01	0.08(0.32)	0.01	0.09(0.33)	0.01
	Diabetes	-0.21(0.25)	-0.04	-0.11(0.25)	-0.02	-0.11(0.25)	-0.02	-0.11(0.25)	-0.02	-0.12(0.25)	-0.02
	Hazardous drinking	0.05(0.15)	0.02	0.02(0.15)	0.01	0.01(0.15)	0.00	0.02(0.15)	0.01	0.02(0.15)	0.01
	High physical activity level	0.40(0.17)	0.12*	0.38(0.17)	0.11*	0.37(0.17)	0.11*	0.39(0.17)	0.12*	0.38(0.17)	0.11*
	CES-Dmodified	-0.01(0.02)	-0.03	0.01(0.02)	0.02	0.01(0.02)	0.03	0.01(0.02)	0.01	0.01(0.02)	0.02
	Smoker	-0.14(0.19)	-0.04	-0.16(0.19)	-0.04	-0.15(0.19)	-0.04	-0.15(0.19)	-0.04	-0.16(0.19)	-0.04
	Male	-0.18(0.15)	-0.06	-0.15(0.15)	-0.05	-0.15(0.15)	-0.05	-0.13(0.15)	-0.05	-0.14(0.15)	-0.05
	Non-Māori	-0.25(0.17)	-0.07	-0.26(0.17)	-0.07	-0.25(0.17)	-0.07	-0.25(0.17)	-0.07	-0.25(0.17)	-0.07
Step 2	Emotional Loneliness			-0.17(0.05)	-0.21***	-0.20(0.07)	-0.25**	-0.17(0.05)	-0.21 ***	-0.17(0.05)	-0.21***
	Social Loneliness			0.07(0.05)	0.08	0.07(0.05)	0.08	0.14(0.07)	0.16	0.07(0.05)	0.08
	Objective Social Isolation Index (OSII)			0.00(0.07)	0.00	0.01(0.07)	0.01	0.00(0.07)	0.00	0.07(0.10)	0.05
Step 3a	Emotional loneliness x education					0.06(0.08)	0.05				
Step 3b	Social loneliness x education							-0.12(0.09)	-0.12		
Step 3c	OSII x education									-0.13(0.13)	-0.09
R		0.266**		0.315***		0.316***		0.322***		0.318***	
Total R <sup>2</sup>		0.071**		0.099***		0.100***		0.104***		0.101***	
Adjusted R <sup>2</sup>		0.044**		0.065***		0.064***		0.068***		0.065***	
R <sup>2</sup> change				0.028**		0.000		0.004		0.002	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 21

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle factors, and Social Isolation Measures including Interaction of Social Isolation Measures and Education on ACE-R Memory scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.06(0.03)	-0.09	-0.06(0.03)	-0.09	-0.06(0.03)	-0.09	-0.06(0.03)	-0.09	-0.06(0.03)	-0.09*
	Post-secondary education	0.76(0.28)	0.13*	0.76(0.30)	0.13*	0.39(0.37)	0.07	0.54(0.42)	0.09	0.53(0.45)	0.09
	Heart trouble	0.74(0.37)	0.10*	0.75(0.37)	0.10*	0.82(0.37)	0.11*	0.78(0.37)	0.10*	0.78(0.37)	0.10*
	Stroke	-0.62(0.65)	-0.05	-0.56(0.65)	-0.04	-0.61(0.65)	-0.05	-0.55(0.65)	-0.04	-0.56(0.65)	-0.04
	Diabetes	-1.03(0.49)	-0.10*	-0.94(0.49)	-0.09	-0.93(0.49)	-0.09	-0.94(0.49)	-0.09	-0.93(0.49)	-0.09
	Hazardous drinking	0.06(0.30)	0.01	0.04(0.30)	0.01	0.01(0.30)	0.00	0.03(0.31)	0.01	0.04(0.31)	0.01
	High physical activity level	0.78(0.34)	0.11*	0.81(0.35)	0.12*	0.80(0.35)	0.12*	0.79(0.35)	0.12*	0.80(0.35)	0.12**
	CES-Dmodified	-0.11(0.04)	-0.14**	-0.10(0.04)	-0.12*	-0.09(0.04)	-0.11*	-0.09(0.04)	-0.12*	-0.10(0.04)	-0.12*
	Smoker	-0.32(0.37)	-0.04	-0.33(0.37)	-0.04	-0.31(0.37)	-0.04	-0.33(0.37)	-0.04	-0.33(0.37)	-0.04
	Male	-0.92(0.30)	-0.16**	-0.91(0.30)	-0.15**	-0.91(0.30)	-0.15**	-0.92(0.31)	-0.15**	-0.92(0.31)	-0.15**
Step 2	Non-Māori	-0.55(0.34)	-0.08	-0.56(0.34)	-0.08	-0.53(0.34)	-0.08	-0.56(0.34)	-0.08	-0.56(0.34)	-0.08
	Emotional Loneliness			-0.12(0.10)	-0.07	-0.26(0.13)	-0.16*	-0.12(0.10)	-0.07	-0.12(0.10)	-0.087
	Social Loneliness			0.05(0.10)	0.03	0.04(0.10)	0.03	-0.03(0.15)	-0.02	0.05(0.10)	0.03
Objective Social Isolation Index (OSII)				0.11(0.14)	0.04	0.13(0.14)	0.05	0.12(0.14)	0.04	0.02(0.19)	0.01
Step 3a	Emotional loneliness x education					0.27(0.17)	.013				
Step 3b	Social loneliness x education							0.13(0.18)	0.07		
Step 3c	OSII x education									0.17(0.26)	0.06
R		0.355***		0.361***		0.370***		0.363***		0.363***	
Total R <sup>2</sup>		0.126***		0.131***		0.137***		0.132***		0.132***	
Adjusted R <sup>2</sup>		0.101***		0.098***		0.102***		0.097***		0.097***	
R <sup>2</sup> change				0.005		0.006		0.001		0.001	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 22

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle factors, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on ACE-R Fluency scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.07(0.03)	-0.12*	-0.07(0.03)	-0.13*	-0.07(0.03)	-0.13**	-0.07(0.03)	-0.13*	-0.07(0.03)	-0.12*
	Post-secondary education	0.85(0.24)	0.18***	0.81(0.24)	0.17***	1.00(0.30)	0.21***	0.99(0.33)	0.21**	0.71(0.36)	0.15*
	Heart trouble	0.31(0.30)	0.05	0.33(0.30)	0.05	0.29(0.30)	0.05	0.30(0.30)	0.05	0.34(0.30)	0.06
	Stroke	-1.37(0.52)	-0.13**	-1.24(0.52)	-0.12*	-1.21(0.52)	-0.11*	-1.24(0.52)	-0.12*	-1.24(0.52)	-0.12*
	Diabetes	-0.22(0.39)	-0.03	-0.09(0.39)	-0.01	-0.10(0.39)	-0.01	-0.09(0.40)	-0.01	-0.09(0.40)	-0.01
	Hazardous drinking	0.29(0.25)	0.06	0.25(0.24)	0.05	0.27(0.25)	0.06	0.26(0.25)	0.05	0.25(0.25)	0.05
	High physical activity level	0.41(0.28)	0.08	0.40(0.28)	0.07	0.41(0.28)	0.07	0.41(0.28)	0.08	0.40(0.28)	0.07
	CES-Dmodified	-0.06(0.03)	-0.09	-0.04(0.04)	-0.06	-0.04(0.04)	-0.07	-0.04(0.04)	-0.07	-0.04(0.04)	-0.06
	Smoker	-0.34(0.30)	-0.06	-0.37(0.30)	-0.06	-0.37(0.30)	-0.06	-0.36(0.30)	-0.06	-0.36(0.30)	-0.06
	Male	-0.59(0.25)	-0.12*	-0.57(0.24)	-0.12*	-0.57(0.24)	-0.12*	-0.56(0.25)	-0.12*	-0.57(0.25)	-0.12*
Step 2	Non-Māori	-0.30(0.28)	-0.05	-0.27(0.28)	-0.05	-0.29(0.28)	-0.05	-0.27(0.28)	-0.05	-0.28(0.28)	-0.05
	Emotional Loneliness			-0.21(0.08)	-0.16**	-0.14(0.11)	-0.10	-0.21(0.08)	-0.16**	-0.21(0.08)	-0.16**
	Social Loneliness			0.15(0.08)	0.11	0.15(0.08)	0.11	0.22(0.12)	0.15	0.15(0.08)	0.11
Objective Social Isolation Index (OSII)				-0.04(0.11)	-0.02	-0.05(0.11)	-0.02	-0.04(0.11)	-0.02	-0.08(0.15)	-0.04
Step 3a Emotional loneliness x education						0.14(0.13)	-0.08				
Step 3b Social loneliness x education								-0.11(0.14)	-0.07		
Step 3c OSII x education										0.07(0.21)	0.03
R		0.348***		0.373***		0.376***		0.375***		0.374***	
Total R <sup>2</sup>		0.121***		0.139***		0.142***		0.141***		0.140***	
Adjusted R <sup>2</sup>		0.095***		0.107***		0.107***		0.106***		0.105***	
R <sup>2</sup> change				0.018*		0.002		0.001		0.000	

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .



Table 23

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle factors, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on ACE-R Language scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.04(0.02)	-0.10*	-0.04(0.02)	-0.10*	-0.04(0.02)	-0.13*	-0.04(0.02)	-0.10*	-0.04(0.02)	-0.10*
	Post-secondary education	0.41(0.17)	0.12*	0.39(0.17)	0.12*	0.47(0.21)	0.06*	0.49(0.24)	0.15*	0.51(0.26)	0.15*
	Heart trouble	-0.07(0.22)	-0.02	-0.05(0.21)	-0.01	-0.06(0.21)	-0.05	-0.06(0.21)	-0.02	-0.06(0.21)	-0.01
	Stroke	-0.17(0.38)	-0.02	-0.03(0.37)	0.00	-0.02(0.37)	0.02	-0.03(0.37)	0.00	-0.03(0.37)	0.00
	Diabetes	-0.27(0.29)	-0.05	-0.09(0.28)	-0.02	-0.09(0.28)	0.01	-0.09(0.28)	-0.02	-0.09(0.28)	-0.02
	Hazardous drinking	0.10(0.18)	0.03	0.06(0.17)	0.02	0.07(0.17)	0.03	0.06(0.17)	0.02	0.06(0.17)	0.02
	High physical activity level	0.07(0.20)	0.02	0.10(0.20)	0.03	0.11(0.20)	0.04	0.11(0.20)	0.03	0.11(0.20)	0.03
	CES-Dmodified	-0.02(0.02)	-0.04	0.00(0.03)	0.01	0.00(0.03)	-0.02	0.00(0.03)	0.00	0.00(0.03)	0.01
	Smoker	-0.18(0.22)	-0.04	-0.19(0.21)	-0.05	-0.20(0.21)	0.01	-0.19(0.21)	-0.04	-0.19(0.21)	-0.05
	Male	0.08(0.18)	0.02	0.11(0.17)	0.03	0.11(0.17)	-0.01	0.11(0.17)	0.03	0.11(0.17)	0.03
Step 2	Non-Māori	-0.10(0.20)	-0.03	-0.10(0.20)	-0.03	-0.11(0.20)	-0.02	-0.10(0.20)	-0.03	-0.10(0.20)	-0.03
	Emotional Loneliness			-0.25(0.06)	-0.27***	-0.22(0.08)	-0.15**	-0.25(0.06)	-0.27***	-0.25(0.06)	-0.27***
	Social Loneliness			0.12(0.06)	0.12	0.12(0.06)	0.13	0.15(0.08)	0.15	0.12(0.06)	0.12
Objective Social Isolation Index (OSII)				0.15(0.08)	0.10	0.15(0.08)	-0.03	0.15(0.08)	0.10	0.20(0.11)	0.14
Step 3a Emotional loneliness x education						-0.05(0.09)	0.01				
Step 3b Social loneliness x education								-0.06(0.10)	-0.05		
Step 3c OSII x education										-0.09(0.15)	-0.06
R		0.204		0.306**		0.307**		0.307**		0.307**	
Total R <sup>2</sup>		0.042		0.093**		0.094**		0.094**		0.094**	
Adjusted R <sup>2</sup>		0.014		0.060**		0.058**		0.058**		0.058**	
R <sup>2</sup> change				0.052***		0.001		0.001		0.001	

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Table 24

*Hierarchical Multiple Regression Analyses of Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle factors, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on ACE-R Visuospatial scores Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Age	-0.04(0.01)	-0.14**	-0.04(0.01)	-0.14**	-0.04(0.01)	-0.13**	-0.04(0.01)	-0.14**	-0.04(0.01)	-0.14**
	Post-secondary education	0.48(0.12)	0.20***	0.48(0.12)	0.20***	0.34(0.15)	0.14*	0.47(0.17)	0.19**	0.77(0.18)	0.32***
	Heart trouble	-0.26(0.15)	-0.08	-0.25(0.15)	-0.08	-0.22(0.15)	-0.07	-0.25(0.15)	-0.08	-0.28(0.15)	-0.09
	Stroke	-0.02(0.27)	0.00	0.01(0.27)	0.00	-0.01(0.27)	0.00	0.01(0.27)	0.00	0.01(0.27)	0.00
	Diabetes	0.10(0.20)	0.04	0.17(0.20)	0.04	0.18(0.20)	0.04	0.17(0.20)	0.04	0.16(0.20)	0.04
	Hazardous drinking	0.05(0.13)	0.02	0.04(0.13)	0.02	0.03(0.13)	0.01	0.04(0.13)	0.02	0.04(0.12)	0.02
	High physical activity level	0.05(0.14)	0.04	0.10(0.14)	0.03	0.09(0.14)	0.03	0.10(0.14)	0.03	0.10(0.14)	0.04
	CES-Dmodified	-0.03(0.02)	-0.08	-0.02(0.02)	-0.08	-0.02(0.02)	-0.07	-0.02(0.02)	-0.08	-0.03(0.02)	-0.08
	Smoker	-0.15(0.15)	-0.05	-0.15(0.15)	-0.05	-0.14(0.15)	-0.05	-0.15(0.15)	-0.05	-0.15(0.15)	-0.05
	Male	-0.01(0.13)	-0.01	0.00(0.13)	0.00	0.00(0.13)	0.00	0.00(0.13)	0.00	0.02(0.13)	0.01
Step 2	Non-Māori	0.23(0.14)	0.08	0.22(0.14)	0.08	0.23(0.14)	0.08	0.22(0.14)	0.08	0.22(0.14)	0.08
	Emotional Loneliness			-0.09(0.04)	-0.13*	-0.14(0.05)	-0.21**	-0.09(0.04)	-0.13*	-0.09(0.04)	-0.13**
	Social Loneliness			0.03(0.04)	0.04	0.02(0.04)	0.03	0.02(0.06)	0.03	0.03(0.04)	0.04
Objective Social Isolation Index (OSII)				0.16(0.06)	0.15**	0.16(0.06)	0.15**	0.16(0.06)	0.15**	0.27(0.08)	0.25***
Step 3a Emotional loneliness x education						0.10(0.07)	0.12				
Step 3b Social loneliness x education								0.01(0.07)	0.01		
Step 3c OSII x education										-0.22(0.10)	-0.18*
R		0.305***		0.346***		0.353***		0.346***		0.360***	
Total R <sup>2</sup>		0.093***		0.120***		0.125***		0.120***		0.130***	
Adjusted R <sup>2</sup>		0.067***		0.087***		0.090***		0.084***		0.095***	
R <sup>2</sup> change				0.026*		0.005		0.000		0.010*	

Note: \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

### **8.6 Longitudinal Hypotheses – Multivariate Analyses: Hypothesis Testing of the Relationship Between Emotional Loneliness, Social Loneliness and Objective Social Isolation at Baseline (Time 1) as Predictors of Cognitive Outcomes at Follow-up (Time 2)**

Hierarchical multiple regression was employed for all longitudinal analyses (Hypotheses 4, 5, and 6). This analysis allows for the covariates to be entered in the first step, thereby producing results for Model 1 that predicts the variance in cognitive performance measures that is explained by covariates and baseline (time 1) cognitive scores. The second step was to enter emotional loneliness, social loneliness and objective social isolation measures into the same block for simultaneous analyses, creating Model 2. Model 2 was used to examine Hypotheses 4 as it enables the examination of the overall variance in the cognitive performance measures at follow-up (time 2) (ACE-R total, MMSE, memory, language, fluency and visuospatial scores) that is explained by the loneliness and social isolation indicators after controlling for all potential covariates. Step 3 involved individually entering the interaction terms to examine Hypotheses 5 and 6.

For Hypothesis 5, to examine whether objective social isolation moderated the relationship between loneliness and cognition the three predictor variables were centred to reduce multicollinearity, as previously mentioned. Step 3a is the product term of emotional loneliness x OSII and Step 3b, is the product term of social loneliness x OSII. For Hypothesis 6, to examine whether education moderated the relationship between social isolation variables and cognition the following Steps were undertaken. Step 3c is the product term emotional loneliness x education, Step 3d is the interaction of social loneliness x education, and Step 3e is the OSII x education interaction. There were 12 hierarchical multiple regressions that were performed for follow-up data and all regressions followed the process as outlined above. For ease of reading, a summary of the results for the longitudinal data is presented first, followed by more detailed information for each multiple regression.

#### **8.6.1 Summary of results for Hypothesis 4.**

The results for Hypothesis 4 are displayed in Tables 25 to 30 (refer Model 2). Hypothesis 4 predicted that measures of emotional loneliness, social loneliness and objective social isolation would be associated with poorer cognitive performance in the older adult at follow-up; however emotional loneliness would have the strongest association with cognitive performance at follow up.

Emotional loneliness was a statistically significant predictor of ACE-R total, MMSE, memory, language and visuospatial scores over time, and higher levels of emotional loneliness were associated with poorer cognitive performance. However, social loneliness was also found to be a statistically significant predictor of ACE-R total score, MMSE, memory and language, yet its relationship with the cognitive outcomes was opposite to that of emotional loneliness. That is, increases in social loneliness scores were associated with better performance in cognitive outcomes over a two year period. Objective social isolation was not found to be a statistically significant predictor of cognitive performance for any of the cognitive measures. Therefore the results for Hypothesis 4 were supported in that emotional loneliness was a predictor of poorer cognitive performance at follow-up.

#### **8.6.2 Summary of results for Hypothesis 5.**

The results for Hypothesis 5 are displayed in Tables 25 – 30, Models 3a and 3b. Hypothesis 5 prediction that older adults who experienced high levels of loneliness (emotional or social) and high levels of social isolation would have lower cognitive performance scores than their peers who were not experiencing both high levels of loneliness and objective social isolation. This hypothesis was not supported, with no statistically significant findings for the interaction terms.

### 8.6.3 Summary of results for Hypothesis 6.

Hypothesis 6 prediction that education would moderate the effect of loneliness or social isolation on cognitive performance at two year follow-up was not supported. There were no significant interactions for education and loneliness (emotional or social), or education and objective social isolation on cognitive outcomes. Therefore, this hypothesis was not supported. The results for Hypothesis 6 are displayed in Tables 31 – 36, Models 3c, 3d, 3e.

More detailed information of the results is now presented.

### 8.6.4 Hypothesis 4 Longitudinal Data - Predicting global cognition performance at follow up from emotional loneliness, social loneliness and objective social isolation at baseline.

The results of the analysis of loneliness and social isolation measures to predict ACE-R total cognitive performance over time after controlling for covariates and ACE-R total scores at baseline are provided in Table 25. The results indicated that  $R$  was significantly different from zero for each Model. For Model One, the covariates (ACE-R total scores cognitive performance Time 1, socio-demographics, mental and physical health, and lifestyle variables at baseline) explained 61.6% of variance (*adjusted*  $R^2$ ) in ACE-R total scores,  $F(12, 376) = 52.781, p < .001$ .

The  $R$  squared change between Model 1 and Model 2 was significant after the addition of the social isolation measures,  $R$  squared change = .011,  $F(3,373) = 3.775, p < .05$ . Emotional loneliness scores ( $\beta = -.100, p < .05$ ) and social loneliness scores ( $\beta = .108, p < .01$ ) were statistically significant predictors of ACE-R total scores over a two year period after controlling for known covariates and baseline ACE-R total scores. Although, both measures of loneliness were statistically significant, they differed in direction. Lower emotional loneliness scores were associated with better performance in global cognition. However, higher scores in social loneliness were associated with better global cognition performance. Further exploration was undertaken to explain the results

for social loneliness and global cognition for a suppressor effect, which is discussed below (see 8.6.12).

Covariates and loneliness and social isolation measures (Model 2) explained 62.4% of the variance (adjusted  $R^2$ ) in ACE-R total scores,  $F(15, 373) = 43.915, p < .001$ . Covariates that were statistically significant in Model 2 were ACE-R total cognition scores at baseline ( $\beta = .710, p < .001$ ), (Age ( $\beta = -.082, p < .05$ ), heart trouble ( $\beta = -.104, p < .01$ ), and smoker ( $\beta = .065, p < .05$ ).

#### **8.6.5 Hypothesis 4 Longitudinal Data - Predicting MMSE performance at follow up from emotional loneliness, social loneliness and objective social isolation at baseline.**

To determine whether social isolation measures predict MMSE scores over time after controlling for covariates and MMSE scores at baseline, a hierarchical linear regression was employed. The results of the analysis are provided in Table 26. The results indicated that  $R$  was significantly different from zero for each model. For Model 1, MMSE scores Time 1, socio-demographics, mental and physical health, and lifestyle variables at baseline explained 22.7% of variance (*adjusted  $R^2$* ) in MMSE scores,  $F(12, 378) = 10.541, p < .001$ . The  $R$  squared change between Model 1 and Model 2 was statistically significant after the addition of the social isolation measures,  $R$  squared change = .016,  $F(3, 375) = 2.742, p < .05$ . Including all social isolation variables in Step 2, resulted in both emotional loneliness ( $\beta = -.125, p < .05$ ), and social loneliness ( $\beta = .128, p < .05$ ) being statistically significant predictors of MMSE scores in Model 2. This model explained 23.8% of the variance (*adjusted  $R^2$* ) in MMSE scores,  $F(15, 375) = 9.098, p < .001$ . However, further exploration was undertaken to explain the results for social loneliness and MMSE for a suppressor effect, which is discussed below (see 8.6.12). Covariates that were statistically significant in the final model were MMSE scores ( $\beta = .364, p < .001$ ), (age ( $\beta = -.138, p < .01$ ), higher education ( $\beta = .101, p < .05$ ), hazardous drinking ( $\beta = .095, p < .05$ ) and male ( $\beta = -.102, p < .05$ ).

Table 25

*Hierarchical Multiple Regression Analyses of ACE-R total scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, Social Isolation Measures and Interaction of Loneliness measures and Social Isolation on ACE-R total scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=388).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	ACE-R total score Time 1	0.88(0.04)	0.73***	0.86(0.04)	0.71***	0.86(0.04)	0.71***	0.86(0.04)	0.71***
	Age	-0.13(0.05)	-0.08*	-0.13(0.05)	-0.08*	-0.13(0.05)	-0.08*	-0.13(0.05)	-0.08*
	Post-secondary education	0.77(0.49)	0.05	0.65(0.49)	0.04	0.64(0.61)	0.04	0.66(0.68)	0.04
	Heart trouble	-1.98(0.61)	-0.11**	-1.93(0.60)	-0.10**	-1.91(0.61)	-0.10**	-1.94(0.61)	-0.10**
	Stroke	-2.07(1.06)	-0.06	-1.87(1.05)	-0.06	-1.89(1.05)	-0.06	-1.86(1.05)	-0.06
	Diabetes	0.14(0.80)	0.01	0.38(0.79)	0.02	0.38(0.80)	0.02	0.36(0.80)	0.01
	Hazardous drinking	0.83(0.50)	0.06	0.76(0.49)	0.05	0.75(0.49)	0.05	0.77(0.49)	0.05
	High physical activity level	0.88(0.56)	0.05	0.91(0.56)	0.05	0.90(0.57)	0.05	0.89(0.57)	0.05
	CES-Dmodified	0.01(0.07)	0.01	0.02(0.07)	0.01	0.02(0.07)	0.01	0.02(0.07)	0.01
	Smoker	1.29(0.61)	0.07*	1.23(0.60)	0.07*	1.24(0.60)	0.07*	1.26(0.61)	0.07*
	Male	-0.61(0.50)	-0.04	-0.64(0.50)	-0.04	-0.63(0.50)	-0.04	-0.65(0.50)	-0.04
	Non-Māori	-0.28(0.56)	-0.02	-0.16(0.56)	-0.01	-0.15(0.56)	-0.01	-0.20(0.56)	-0.01
	Emotional Loneliness			-0.40(0.16)	-0.10*	-0.39(0.17)	-0.10*	-0.40(0.16)	-0.10*
Step 2	Social Loneliness			0.47(0.17)	0.11**	0.47(0.17)	0.11**	0.46(0.17)	0.11**
	Objective Social Isolation Index (OSII)			-0.29(0.22)	-0.04	-0.28(0.23a)	-0.04	-0.34(0.23)	-0.06
Step 3	Emotional loneliness x OSII					-0.03(.10)	-0.01		
	Social loneliness x OSII							0.08(0.12)	0.02
R		0.792***		0.799***		0.799***		0.799***	
Total R <sup>2</sup>		0.627***		0.639***		0.639***		0.639***	
Adjusted R <sup>2</sup>		0.616***		0.624***		0.623***		0.623***	
R <sup>2</sup> change				0.011*		0.000		0.000	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 26

*Hierarchical Multiple Regression Analyses of MMSE scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, Social Isolation Measures and Interaction of Loneliness measures and Social Isolation on MMSE scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	$\beta$	B(SE)	$\beta$	B(SE)	$\beta$	B(SE)	$\beta$
Step 1	MMSE Time 1	0.42(0.05)	0.38***	0.40(0.05)	0.36***	0.40(0.05)	0.37***	0.40(0.05)	0.36***
	Age	-0.05(0.02)	-0.14**	-0.05(0.02)	-0.14**	-0.05(0.02)	-0.14**	-0.05(0.02)	-0.14**
	Post-secondary education	0.35(0.15)	0.11*	0.33(0.15)	0.10*	0.32(0.15)	0.10	0.33(0.15)	0.10*
	Heart trouble	-0.22(0.19)	-0.05	-0.21(0.19)	-0.05	-0.20(0.19)	-0.05	-0.21(0.19)	-0.05
	Stroke	-0.04(0.32)	0.00	0.01(0.32)	0.00	0.01(0.33)	0.00	0.01(0.32)	0.00
	Diabetes	0.25(0.24)	0.05	0.34(0.25)	0.06	0.34(0.25)	0.06	0.34(0.25)	0.06
	Hazardous drinking	0.33(0.15)	0.10*	0.31(0.15)	0.10*	0.31(0.15)	0.09*	0.31(0.15)	0.10*
	High physical activity level	0.25(0.17)	0.07	0.30(0.17)	0.08	0.30(0.17)	0.08	0.30(0.17)	0.08
	CES-Dmodified	-0.02(0.02)	-0.03	-0.01(0.02)	-0.03	-0.01(0.02)	-0.03	-0.01(0.02)	-0.03
	Smoker	0.09(0.19)	0.02	0.08(0.19)	0.02	0.08(0.19)	0.02	0.08(0.19)	0.02
	Male	-0.32(0.15)	-0.10*	-0.33(0.15)	-0.10*	-0.33(0.17)	-0.10*	-0.33(0.15)	-0.10*
	Non-Māori	-0.29(0.17)	-0.08	-0.26(0.17)	-0.07	-0.26(0.17)	-0.07	-0.26(0.17)	-0.07
Step 2	Emotional Loneliness			-0.11(0.05)	-0.13*	-0.11(0.05)	-0.12*	-0.11(0.05)	-0.13*
	Social Loneliness			0.12(0.05)	0.13*	0.12(0.05)	0.13*	0.12(0.05)	0.13*
	Objective Social Isolation Index (OSII)			0.04(0.07)	0.03	0.05(0.07)	0.03	0.05(0.07)	0.03
Step 3	Emotional loneliness x OSII					-0.01(0.03)	-0.01		
	Social loneliness x OSII							-0.01(0.04)	-0.01
R		0.501***		0.517***		0.517***		0.517***	
Total R <sup>2</sup>		0.251***		0.267***		0.267***		0.267***	
Adjusted R <sup>2</sup>		0.227***		0.238***		0.236***		0.235***	
R <sup>2</sup> change				0.016*		0.000		0.000	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.



#### **8.6.6 Hypothesis 4 Longitudinal Data - Predicting memory performance at follow up from emotional loneliness, social loneliness and objective social isolation at baseline.**

For the memory score regression analysis,  $R$  was significantly different from zero at the end of each step. The results of this analysis are provided in Table 27. The covariates entered into for Model 1, explained 41.1% of variance (adjusted  $R^2$ ) in memory scores,  $F(12, 378) = 23.705, p < .001$ . After entrance of the social isolation measures the total variance explained in memory scores increased to 41.7 (adjusted  $R^2$ ),  $F(15, 375) = 19.583, p < .001$ . The  $R$  squared change after the inclusion of social isolation measures was not significant,  $F$  change  $(3, 375) = .010, p = .088$ . Emotional and social loneliness scores at baseline were statistically significant predictor of memory scores at Time 2, after controlling for socio-demographics, mental and physical health and lifestyle variables, with higher emotional loneliness scores predicting poorer memory scores ( $\beta = -.101, p < .05$ ), and reversely, higher social loneliness scores predicting greater memory scores ( $\beta = .104, p < .05$ ). Further exploration was undertaken to explain the results for social loneliness and memory for a suppressor effect, which is discussed below (see 8.6.12).

In Model 2, the significant variables that accounted for the variation in memory scores after social isolation measures had been entered were; baseline memory scores ( $\beta = .568, p < .001$ ), age ( $\beta = -.101, p < .05$ ), higher education ( $\beta = .089, p < .05$ ), higher physical activity level ( $\beta = .120, p < .01$ ), social loneliness ( $\beta = .104, p < .05$ ), emotional loneliness ( $\beta = -.101, p < .05$ ), smoking ( $\beta = .090, p < .05$ ), and hazardous drinking ( $\beta = .088, p < .05$ ).

#### **8.6.7 Hypothesis 4 Longitudinal Data - Predicting fluency performance at follow up from emotional loneliness, social loneliness and objective social isolation at baseline.**

For the fluency score regression analysis,  $R$  was significantly different from zero at the end of each model. The results of this analysis are provided in Table 28. The covariates

entered into for Model 1, explained 46.8% of variance (adjusted  $R^2$ ) in fluency scores,  $F(12, 378) = 29.556, p < .001$ . After entrance of the social isolation measures the total variance explained in fluency scores increased to 47.1% (adjusted  $R^2$ ),  $F(15, 375) = 24.160, p < .001$ . The  $R$  squared change after the inclusion of social isolation measures was not significant,  $F$  change  $(3, 375) = 1.813, p = .144$ . Nor did any of the social isolation variables reach the threshold for statistical significance when entered in Step 2, though marginal for both emotional loneliness ( $\beta = -.088, p = .057$ ), and social loneliness ( $\beta = .089, p = .052$ ). There were three statistically significant predictors in the final model that accounted for the variation in fluency scores at follow-up being baseline fluency scores ( $\beta = .5997, p < .001$ ), and male ( $\beta = -.117, p < .01$ ). Diabetes was also marginally statistically significant ( $\beta = -.075, p = .049$ ).

Table 27

*Hierarchical Multiple Regression Analyses of ACE-R Memory Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, Social Isolation Measures and Interaction of Loneliness measures and Social Isolation on ACE-R Memory Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Memory Time 1	0.68(0.05)	0.57***	0.67(0.05)	0.57***	0.68(0.05)	0.57***	0.67(0.05)	0.57***
	Age	-0.08(0.03)	-0.10**	-0.08(0.03)	-0.10**	-0.08(0.03)	-0.10*	-0.08(0.03)	-0.10*
	Post-secondary education	0.69(0.28)	0.10*	0.64(0.28)	0.09*	0.61(0.36)	0.09*	0.63(0.28)	0.09*
	Heart trouble	-0.43(0.36)	-0.05	-0.40(0.36)	-0.05	-0.35(0.36)	-0.04	-0.39(0.36)	-0.04
	Stroke	-0.86(0.62)	-0.06	-0.76(0.62)	-0.05	-0.79(0.62)	-0.05	-0.77(0.62)	-0.05
	Diabetes	0.55(0.47)	0.05	0.69(0.47)	0.06	0.70(0.47)	0.06	0.72(0.47)	0.06
	Hazardous drinking	0.69(0.29)	0.10*	0.65(0.29)	0.09*	0.63(0.29)	0.09*	0.63(0.29)	0.09*
	High physical activity level	0.93(0.33)	0.12**	0.97(0.33)	0.12**	0.96(0.33)	0.12**	0.99(0.33)	0.12**
	CES-Dmodified	0.02(0.04)	0.02	0.02(0.04)	0.02	0.03(0.04)	0.03	0.02(0.04)	0.03
	Smoker	0.82(0.36)	0.09*	0.81(0.36)	0.09*	0.82(0.36)	0.09*	0.77(0.36)	0.09*
	Male	-0.30(0.29)	-0.04	-0.31(0.29)	-0.04	-0.29(0.29)	-0.04	-0.29(0.29)	-0.04
	Non-Māori	-0.10(0.33)	-0.01	-0.05(0.33)	-0.01	-0.03(0.33)	-0.00	-0.01(0.33)	0.00
Step 2	Emotional Loneliness			-0.20(0.09)	-0.10*	-0.18(0.10)	-0.09	-0.20(0.09)	-0.10*
	Social Loneliness			0.22(0.10)	0.10*	0.21(0.10)	0.10*	0.24(0.10)	0.11*
	Objective Social Isolation Index (OSII)			-0.03(0.13)	-0.01	0.03(0.13)	0.01	0.03(0.14)	0.01
Step 3	Emotional loneliness x OSII					-0.09(0.06)	-0.06		
	Social loneliness x OSII							-0.09(0.07)	-0.06
R		0.655***		0.663***		0.665***		0.665***	
Total R <sup>2</sup>		0.429***		0.439***		0.442***		0.442***	
Adjusted R <sup>2</sup>		0.411***		0.417***		0.418***		0.418***	
R <sup>2</sup> change				0.010		0.003		0.003	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 28

*Hierarchical Multiple Regression Analyses of ACE-R Fluency Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, Social Isolation Measures and Interaction of Loneliness measures and Social Isolation on ACE-R Fluency Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Fluency Time 1	0.63(0.04)	0.61***	0.62(0.04)	0.60***	0.62(0.04)	0.60***	0.62(0.04)	0.60***
	Age	-0.03(0.02)	-0.06	-0.03(0.02)	-0.06	-0.03(0.02)	-0.05	-0.03(0.02)	-0.06
	Post-secondary education	0.18(0.19)	0.04	0.15(0.19)	0.03	0.17(0.19)	0.03	0.16(0.19)	0.03
	Heart trouble	-0.44(0.24)	-0.07	-0.42(0.24)	-0.07	-0.45(0.24)	-0.07	-0.43(0.24)	-0.07
	Stroke	-0.85(0.42)	-0.08*	-0.81(0.42)	-0.07	-0.78(0.42)	-0.07	-0.80(0.42)	-0.07
	Diabetes	-0.71(0.31)	-0.09*	-0.62(0.32)	-0.07*	-0.62(0.31)	-0.07	-0.64(0.31)	-0.08*
	Hazardous drinking	0.11(0.20)	0.02	0.09(0.20)	0.02	0.10(0.20)	0.02	0.10(0.20)	0.02
	High physical activity level	-0.28(0.22)	-0.05	-0.24(0.22)	-0.04	-0.23(0.22)	-0.04	-0.25(0.22)	-0.04
	CES-Dmodified	-0.05(0.03)	-0.08	-0.05(0.03)	-0.07	-0.05(0.03)	-0.08	-0.05(0.03)	-0.08
	Smoker	0.01(0.24)	0.00	0.00(0.24)	0.00	-0.01(0.24)	0.00	0.03(0.24)	0.00
	Male	-0.57(0.20)	-0.11**	-0.58(0.20)	-0.12**	-0.59(0.20)	-0.12**	-0.60(0.20)	-0.12**
	Non-Māori	-0.06(0.22)	-0.01	-0.03(0.22)	-0.01	-0.04(0.22)	0.01	-0.07(0.22)	0.01
Step 2	Emotional Loneliness			-0.12(0.06)	-0.09	-0.14(0.07)	-0.10*	-0.12(0.06)	-0.09
	Social Loneliness			0.13(0.07)	0.09	0.14(0.07)	0.09*	0.12(0.07)	0.08
	Objective Social Isolation Index (OSII)			0.01(0.07)	0.09	-0.02(0.09)	-0.01	-0.04(0.09)	-0.02
Step 3	Emotional loneliness x OSII					0.05(0.04)	0.05		
	Social loneliness x OSII							0.08(0.05)	0.07
R		0.696***		0.701***		0.703***		0.704***	
Total R <sup>2</sup>		0.484***		0.491***		0.494***		0.495***	
Adjusted R <sup>2</sup>		0.468***		0.471***		0.472***		0.473***	
R <sup>2</sup> change				0.007		0.002		0.004	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

#### **8.6.8 Hypothesis 4 Longitudinal Data - Predicting language performance at follow up from emotional loneliness, social loneliness and objective social isolation at baseline.**

A hierarchical multiple regression was used to determine the ability of social isolation measures to predict language scores after controlling for covariates. The results of the analysis are provided in Table 29. The results indicated that  $R$  was statistically significantly from zero for Model 1 and 2. The socio-demographics, mental and physical health, and lifestyle variables explained 24.4% of variance (*adjusted R<sup>2</sup>*) in ACE-R language scores Time 2,  $F(12, 378) = 11.500, p < .001$ . In Model 1, baseline ACE-R language scores ( $\beta = .457, p < .001$ ) and age ( $\beta = -.123, p < .01$ ), were the only two statistically significant variables that predicted cognitive scores. Step 2 saw the entrance of the social isolation variables. The inclusion of social isolation variables resulted in  $R$  being significantly different from zero at the end of Model 2. The total variance explained in scores for the language domain by Model 2 as a whole was 25.6% (*adjusted R<sup>2</sup>*),  $F(15, 375) = 9.939, p < .001$ . The  $R$  squared change between Model 1 and Model 2 was statistically significant after the addition of the social isolation measures,  $R$  squared change = .017,  $F$  change (3,375) = 2.975,  $p < .032$ . In Model 2, emotional loneliness was a statistically significant predictor of cognitive scores. Emotional loneliness recorded a beta value ( $\beta = -.143, p < .05$ ), and social loneliness reached statistical significance with a beta value of ( $\beta = .126, p < .05$ ) after controlling for socio-demographics, mental and physical health and lifestyle variables. Objective social isolation was not statistically significant. The direction of the beta coefficients suggests that decreased levels of emotional loneliness are associated with better performance in language over time, whereas the reverse is suggested by the results for social loneliness. That is higher scores in social loneliness predicted better language scores over a period of two years. Further exploration was undertaken to explain the results for social loneliness and memory for a suppressor effect, which is discussed below (8.6.12). Covariates that were statistically significant in the final model were baseline language scores ( $\beta = .432, p < .001$ ), and age ( $\beta = -.126, p < .01$ ).

Table 29

*Hierarchical Multiple Regression Analyses of ACE-R Language Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, Social Isolation Measures, and Interaction of Loneliness measures and Social Isolation on ACE-R Language Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Language Time 1	0.55(0.05)	0.46***	0.52(0.05)	0.43***	0.51(0.06)	0.43***	0.52(0.05)	0.43***
	Age	-0.05(0.02)	-0.12**	-0.06(0.02)	-0.13**	-0.05(0.02)	-0.12**	-0.06(0.02)	-0.13*
	Post-secondary education	0.30(0.18)	0.07	0.26(0.18)	0.07	0.27(0.18)	0.07	0.26(0.18)	0.07
	Heart trouble	-0.24(0.23)	-0.05	-0.23(0.23)	-0.05	-0.25(0.23)	-0.05	-0.23(0.23)	-0.05
	Stroke	0.07(0.40)	0.01	0.16(0.39)	0.02	0.17(0.40)	0.02	0.16(0.40)	0.02
	Diabetes	-0.04(0.30)	-0.01	0.06(0.30)	0.01	0.06(0.30)	0.01	0.06(0.30)	0.01
	Hazardous drinking	0.15(0.19)	0.04	0.12(0.19)	0.03	0.13(0.19)	0.03	0.12(0.19)	0.03
	High physical activity level	0.19(0.21)	0.04	0.20(0.21)	0.04	0.20(0.21)	0.05	0.20(0.21)	0.04
	CES-Dmodified	-0.02(0.02)	-0.04	-0.01(0.03)	-0.02	-0.01(0.03)	-0.02	-0.01(0.03)	-0.02
	Smoker	0.06(0.23)	0.01	0.04(0.23)	0.01	0.04(0.23)	0.01	0.04(0.23)	0.01
	Male	-0.05(0.19)	-0.01	-0.04(0.19)	-0.01	-0.05(0.19)	-0.01	-0.04(0.19)	-0.01
	Non-Māori	-0.11(0.21)	-0.02	-0.08(0.21)	-0.02	-0.08(0.21)	-0.02	-0.08(0.21)	-0.02
Step 2	Emotional Loneliness			-0.16(0.06)	-0.14*	-0.17(0.06)	-0.15**	-0.16(0.06)	-0.14*
	Social Loneliness			0.15(0.06)	0.13*	0.15(0.06)	0.13*	0.15(0.07)	0.13*
	Objective Social Isolation Index (OSII)			0.01(0.07)	0.09	-0.06(0.09)	-0.04	-0.05(0.09)	-0.03
Step 3	Emotional loneliness x OSII					0.03(0.04)	0.04		
	Social loneliness x OSII							0.01(0.04)	0.01
R		0.517***		0.533***		0.534***		0.533***	
Total R <sup>2</sup>		0.267***		0.284***		0.285***		0.285***	
Adjusted R <sup>2</sup>		0.244***		0.256***		0.255***		0.254***	
R <sup>2</sup> change				0.017*		0.001		0.000	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

#### **8.6.9 Hypothesis 4 Longitudinal Data - Predicting visuospatial performance at follow up from emotional loneliness, social loneliness and objective social isolation at baseline.**

For the visuospatial score regression analysis,  $R$  was significantly different from zero at the end of each model. The results of this analysis are provided in Table 30. The covariates entered into for Model 1, explained 29.4% of variance (adjusted  $R^2$ ) in visuospatial scores,  $F(12, 378) = 14.554, p < .001$ . After entrance of the social isolation measures the total variance explained in visuospatial scores increased to 30.8% (adjusted  $R^2$ ),  $F(15, 375) = 12.575, p < .001$ . The  $R$  squared change after the inclusion of social isolation measures was statistically significant;  $R$  squared change = .019,  $F$  change (3, 375) = 3.502,  $p < .05$ .

Emotional loneliness was the only social isolation variables to be a statistically significant predictor of visuospatial scores after controlling for previous visuospatial scores, socio-demographics, mental and physical health and lifestyle variables. Emotional loneliness recorded a beta value ( $\beta = -.154, p < .01$ ). In Model 2 other statistically significant predictors were the following covariates, baseline visuospatial scores ( $\beta = .465, p < .001$ ), heart trouble ( $\beta = -.114, p < .01$ ) and stroke ( $\beta = -.157, p < .001$ ).

Table 30

*Hierarchical Multiple Regression Analyses of Visuospatial Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, Social Isolation Measures and Interaction of Loneliness measures and Social Isolation on Visuospatial Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390).*

		Model 1		Model 2		Model 3a		Model 3b	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Visuospatial Time 1	0.54(0.05)	0.47***	0.54(0.05)	0.47***	0.53(0.05)	0.46***	0.54(0.05)	0.47***
	Age	0.01(0.01)	0.03	0.01(0.01)	0.02	0.01(0.01)	0.03	0.01(0.01)	0.02
	Post-secondary education	0.10(0.13)	0.04	0.08(0.12)	0.03	0.09(0.12)	0.03	0.08(0.12)	0.03
	Heart trouble	-0.40(0.16)	-0.11**	-0.40(0.15)	-0.11*	-0.43(0.15)	-0.12**	-0.40(0.15)	-0.11**
	Stroke	-1.05(0.27)	-0.17***	-0.97(0.27)	-0.16***	-0.94(0.27)	-0.15***	-0.96(0.27)	-0.16***
	Diabetes	-0.04(0.20)	-0.01	0.02(0.20)	0.00	0.03(0.20)	0.01	0.01(0.20)	0.00
	Hazardous drinking	0.05(0.13)	0.02	0.03(0.13)	0.01	0.04(0.13)	0.01	0.04(0.13)	0.01
	High physical activity level	0.22(0.14)	0.07	0.18(0.14)	0.06	0.19(0.14)	0.06	0.17(0.14)	0.05
	CES-Dmodified	-0.01(0.02)	-0.02	0.01(0.02)	0.02	0.00(0.02)	0.01	0.00(0.02)	0.01
	Smoker	0.06(0.16)	0.02	0.04(0.15)	0.01	0.03(0.15)	0.01	0.06(0.15)	0.02
	Male	0.23(0.13)	0.08	0.25(0.13)	0.09	0.24(0.13)	0.08	0.24(0.13)	0.08
	Non-Māori	-0.20(0.14)	-0.06	-0.20(0.14)	-0.06	-0.21(0.14)	-0.06	-0.22(0.14)	-0.07
Step 2	Emotional Loneliness			-0.12(0.04)	-0.15**	-0.13(0.04)	-0.17**	-0.12(0.04)	-0.15**
	Social Loneliness			0.07(0.04)	0.08	0.07(0.04)	0.09	0.06(0.04)	0.07
	Objective Social Isolation Index			-0.06(0.06)	-0.05	-0.09(0.06)	-0.07	-0.08(0.06)	-0.07
Step 3	Emotional loneliness x OSII					0.05(0.03)	0.09		
	Social loneliness x OSII							0.05(0.03)	0.08
R		0.562***		0.579***		0.584***		0.582***	
Total R <sup>2</sup>		0.316***		0.335***		0.341***		0.339***	
Adjusted R <sup>2</sup>		0.294***		0.308***		0.313***		0.311***	
R <sup>2</sup> change				0.019*		0.007		0.004	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.



#### **8.6.10 Hypothesis 5 Longitudinal data results -Objective social isolation moderates the relationship between loneliness (emotional and/or social) and cognitive performance.**

It was predicted that differing levels of objective social isolation at baseline would moderate the relationships between loneliness (emotional and social) at baseline and cognitive performance scores at follow-up. Specifically those with both higher levels of loneliness and objective social isolation at baseline would have poorer cognitive performance at follow-up than their peers due to the potential negative additive effect of being both objectively isolated and lonely (emotionally or socially). Hierarchical multiple regression analysis was performed to test the hypothesis on follow-up data. Emotional loneliness, social loneliness and objective social isolation variables were centred and then emotional loneliness and objective social isolation was multiplied to produce the interaction term as was social loneliness and objective social isolation. The main effects and interaction term were used in a hierarchical multiple regression to predict cognitive outcomes, after controlling for known covariates being (age, heart disease, diabetes, stroke, alcohol use, physical activity levels, depression, smoking, gender and ethnicity). The interactions terms were added in Step 3 of the final models.

Tables 26-30, Models 3a and 3b display the findings of the centred product terms emotional loneliness x OSII, and social loneliness x OSII, on cognitive outcomes at follow-up. Unlike the cross sectional data the interaction effect of emotional loneliness x OSII did not result in any statistically significant findings and therefore was not a predictor of cognitive performance over a two year period. As was found with the cross-sectional data, there were also no statistically significant findings for the interaction term social loneliness x OSII for any of the cognitive measures.

#### **8.6.11 Hypothesis 6 Longitudinal data results - Moderating effect of education on the relationship of social isolation variables and cognitive outcomes.**

To investigate whether education moderated the potential effects of social isolation on cognitive outcomes, a hierarchical multiple regression was employed. Tables 31-36, Models 3c, 3d, and 3e display the findings from the interaction terms being emotional loneliness x education, social loneliness x education and OSII x education at baseline, for each cognitive outcome at follow-up. There were no statistically significant findings that differing levels of education moderated the effect of social isolation variables on cognitive performance. The inclusion of the interaction variables at Step 3a, Step 3b, and Step 3c, for each cognitive outcome did not result in the *R* squared change being statistically significant, nor did the interaction terms add any statistically significant unique variances to the final models for any of the cognitive outcomes.

Table 31

*Hierarchical Multiple Regression Analyses of ACE-R total scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on ACE-R Total Scores Time 2 Showing Standardised Regression Coefficients, R, total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=388)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Global Cognition Time 1	0.88(0.04)	0.73***	0.86(0.04)	0.71***	0.86(0.04)	0.71***	0.86(0.04)	0.71***	0.86(0.04)	0.71***
	Age	-0.13(0.05)	-0.08*	-0.13(0.05)	-0.08*	-0.14(0.05)	-0.08*	-0.13(0.05)	-0.08*	-0.13(0.05)	-0.08*
	Post-secondary education	0.77(0.49)	0.05	0.65(0.49)	0.04	0.88(0.61)	0.06	0.63(0.68)	0.04	0.64(0.73)	0.04
	Heart trouble	-1.98(0.61)	-0.11**	-1.93(0.60)	-0.10**	-1.97(0.61)	-0.11**	-1.92(0.61)	-0.10**	-1.93(0.61)	-0.10**
	Stroke	-2.07(1.06)	-0.06	-1.87(1.05)	-0.06	-1.84(1.06)	-0.06	-1.87(1.05)	-0.06	-1.87(1.05)	-0.06
	Diabetes	0.14(0.80)	0.01	0.38(0.79)	0.02	0.37(0.80)	0.02	0.38(0.80)	0.02	0.38(0.80)	0.02
	Hazardous drinking	0.83(0.50)	0.06	0.76(0.49)	0.05	0.77(0.49)	0.05	0.76(0.49)	0.05	0.76(0.49)	0.05
	High physical activity level	0.88(0.56)	0.05	0.91(0.56)	0.05	0.91(0.57)	0.05	0.90(0.57)	0.05	0.90(0.57)	0.05
	CES-Dmodified	0.01(0.07)	0.01	0.02(0.07)	0.01	0.02(0.07)	0.01	0.02(0.07)	0.01	0.02(0.07)	0.01
	Smoker	1.29(0.61)	0.07*	1.23(0.60)	0.06*	1.22(0.60)	0.06*	1.23(0.60)	0.06*	1.23(0.60)	0.06*
	Male	-0.61(0.50)	-0.04	-0.64(0.50)	-0.04	-0.64(0.50)	-0.04	-0.64(0.50)	-0.04	-0.64(0.50)	-0.04
	Non-Māori	-0.28(0.56)	-0.02	-0.16(0.56)	-0.01	-0.18(0.56)	-0.01	-0.16(0.56)	-0.01	-0.16(0.56)	-0.01
Step 2	Emotional Loneliness			-0.40(0.16)	-0.10*	-0.31(0.22)	-0.08	-0.40(0.16)	-0.10*	-0.40(0.16)	-0.10*
	Social Loneliness			0.47(0.17)	0.11**	0.48(0.17)	0.11**	0.46(0.24)	0.11*	0.47(0.17)	0.11**
	Objective Social Isolation Index (OSII)			-0.29(0.22)	-0.04	-0.30(0.22)	-0.05	-0.29(0.22)	-0.04	-0.30(0.31)	-0.05
Step 3	Emotional loneliness x education					-0.17(0.27)	-0.03				
	Social loneliness x education							0.01(0.28)	0.00		
	OSII x education									0.01(0.41)	0.00
R		0.792***		0.799***		0.799***		0.799***		0.799***	
Total R2		0.627***		0.638***		0.639***		0.638***		0.638***	
Adjusted R2		0.616***		0.624***		0.623***		0.623***		0.623***	
R2 change				0.011*		0.000		0.000		0.000	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 32

*Hierarchical Multiple Regression Analyses of MMSE Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on MMSE Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	MMSE Time 1	0.42(0.05)	0.38***	0.40(0.05)	0.36 ***	0.40(0.05)	0.36 ***	0.40(0.05)	0.36 ***	0.40(0.05)	0.36 ***
	Age	-0.05(0.02)	-0.14**	-0.05(0.02)	-0.14 **	-0.05(0.02)	-0.14 **	-0.05(0.02)	-0.14 **	-0.05(0.02)	-0.14 **
	Post-secondary education	0.35(0.15)	0.11*	0.33(0.15)	0.10 *	0.36(0.19)	0.11	0.44(0.21)	0.13 *	0.54(0.22)	0.17 *
	Heart trouble	-0.22(0.19)	-0.05	-0.21(0.19)	-0.05	-0.21(0.19)	-0.05	-0.23(0.19)	-0.06	-0.23(0.19)	-0.06
	Stroke	-0.04(0.32)	0.00	0.01(0.32)	0.00	0.02(0.33)	0.00	0.01(0.32)	0.00	0.02(0.32)	0.00
	Diabetes	0.25(0.24)	0.05	0.34(0.25)	0.06	0.34(0.25)	0.06	0.35(0.25)	0.06	0.34(0.25)	0.06
	Hazardous drinking	0.33(0.15)	0.10*	0.31(0.15)	0.10 *	0.31(0.15)	0.10 *	0.31(0.15)	0.10 *	0.31(0.15)	0.09 *
	High physical activity level	0.25(0.17)	0.07	0.30(0.17)	0.08	0.30(0.17)	0.08	0.31(0.17)	0.08	0.31(0.17)	0.08
	CES-Dmodified	-0.02(0.02)	-0.03	-0.01(0.02)	-0.03	-0.02(0.02)	-0.04	-0.02(0.02)	-0.04	-0.02(0.02)	-0.04
	Smoker	0.09(0.19)	0.02	0.08(0.19)	0.02	0.08(0.19)	0.02	0.08(0.19)	0.02	0.08(0.19)	0.02
	Male	-0.32(0.15)	-0.10*	-0.33(0.15)	-0.10 *	-0.33(0.15)	-0.10 *	-0.32(0.15)	-0.10 *	-0.32(0.15)	-0.10 *
	Non-Māori	-0.29(0.17)	-0.08	-0.26(0.17)	-0.07	-0.27(0.17)	-0.07	-0.26(0.17)	-0.07	-0.26(0.17)	-0.07
Step 2	Emotional Loneliness			-0.11(0.05)	-0.13 *	-0.10(0.07)	-0.11	-0.11(0.05)	-0.13 *	-0.12(0.05)	-0.13 *
	Social Loneliness			0.12(0.05)	0.13 *	0.12(0.05)	0.13 *	0.16(0.07)	0.17 *	0.12(0.05)	0.13 *
	Objective Social Isolation Index (OSII)			0.04(0.07)	0.03	0.04(0.07)	0.03	0.04(0.07)	0.03	0.13(0.09)	0.09
Step 3	Emotional loneliness x education					-0.02(0.08)	-0.02				
	Social loneliness x education							-0.06(0.09)	-0.06		
	OSII x education									-0.16(0.13)	-0.10
R		0.501***		0.517***		0.517***		0.518***		0.520***	
Total R <sup>2</sup>		0.251***		0.267***		0.267***		0.268***		0.270***	
Adjusted R <sup>2</sup>		0.227***		0.237***		0.236***		0.237***		0.239***	
R <sup>2</sup> change				0.016*		0.000		0.001		0.003	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 33

*Hierarchical Multiple Regression Analyses of Memory Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on Memory Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Memory Time 1	0.68(0.05)	0.57***	0.67(0.05)	0.57***	0.68(0.05)	0.57***	0.67(0.05)	0.57***	0.67(0.05)	0.57***
	Age	-0.08(0.03)	-0.10**	-0.08(0.03)	-0.10**	-0.08(0.03)	-0.10*	-0.08(0.03)	-0.10*	-0.08(0.03)	-0.10*
	Post-secondary education	0.69(0.28)	0.10*	0.64(0.28)	0.09*	0.77(0.36)	0.11*	0.61(0.40)	0.09	0.73(0.43)	0.10
	Heart trouble	-0.43(0.36)	-0.05	-0.40(0.36)	-0.05	-0.43(0.36)	-0.05	-0.40(0.36)	-0.04	-0.41(0.36)	-0.05
	Stroke	-0.86(0.62)	-0.06	-0.76(0.62)	-0.05	-0.73(0.62)	-0.05	-0.76(0.62)	-0.05	-0.76(0.62)	-0.05
	Diabetes	0.55(0.47)	0.05	0.69(0.47)	0.06	0.69(0.47)	0.06	0.69(0.47)	0.06	0.69(0.47)	0.06
	Hazardous drinking	0.69(0.29)	0.10*	0.65(0.29)	0.09*	0.66(0.29)	0.09*	0.65(0.29)	0.09*	0.65(0.29)	0.09*
	High physical activity level	0.93(0.33)	0.12**	0.97(0.33)	0.12**	0.97(0.33)	0.12**	0.97(0.33)	0.12**	0.97(0.33)	0.12**
	CES-Dmodified	0.02(0.04)	0.02	0.02(0.04)	0.02	0.02(0.04)	0.02	0.02(0.04)	0.02	0.02(0.04)	0.02
	Smoker	0.82(0.36)	0.09*	0.81(0.36)	0.09*	0.80(0.36)	0.09*	0.81(0.36)	0.09*	0.81(0.36)	0.09*
	Male	-0.30(0.29)	-0.04	-0.31(0.29)	-0.04	-0.30(0.29)	-0.04	-0.31(0.29)	-0.04	-0.30(0.29)	-0.04
	Non-Māori	-0.10(0.33)	-0.01	-0.05(0.33)	-0.01	-0.06(0.33)	-0.01	-0.05(0.33)	-0.01	-0.05(0.33)	-0.01
Step 2	Emotional Loneliness			-0.20(0.09)	-0.10*	-0.15(0.13)	-0.07	-0.20(0.09)	-0.10*	-0.20(0.09)	-0.10*
	Social Loneliness			0.22(0.10)	0.10*	0.22(0.10)	0.11*	0.21(0.14)	0.10	0.22(0.10)	0.10*
	Objective Social Isolation Index (OSII)			-0.03(0.13)	-0.01	-0.03(0.13)	-0.01	-0.03(0.13)	-0.01	0.01(0.18)	0.00
Step 3	Emotional loneliness x education					-0.10(0.16)	-0.04				
	Social loneliness x education							0.02(0.17)	0.01		
	OSII x education									-0.07(0.24)	-0.02
R		0.655***		0.663***		0.663***		0.663***		0.663***	
Total R <sup>2</sup>		0.429***		0.439***		0.440***		0.439***		0.439***	
Adjusted R <sup>2</sup>		0.411***		0.417***		0.416***		0.415***		0.415***	
R <sup>2</sup> change				0.010		0.000		0.000		0.000	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 34

*Hierarchical Multiple Regression Analyses of Fluency Cognition Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on Fluency Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Fluency Time 1	0.63(0.04)	0.61***	0.62(0.04)	0.60***	0.62(0.04)	0.60***	0.62(0.04)	0.60***	0.62(0.04)	0.60***
	Age	-0.03(0.02)	-0.06	-0.03(0.02)	-0.06	-0.03(0.02)	-0.06	-0.03(0.02)	-0.06	-0.03(0.02)	-0.05
	Post-secondary education	0.18(0.19)	0.04	0.15(0.19)	0.03	0.15(0.24)	0.03	0.20(0.27)	0.04	-0.15(0.29)	-0.03
	Heart trouble	-0.44(0.24)	-0.07	-0.42(0.24)	-0.07	-0.42(0.24)	-0.07	-0.42(0.24)	-0.07	-0.38(0.24)	-0.06
	Stroke	-0.85(0.42)	-0.08*	-0.81(0.42)	-0.07	-0.81(0.42)	-0.07	-0.81(0.42)	-0.07	-0.81(0.42)	-0.07
	Diabetes	-0.71(0.31)	-0.09*	-0.62(0.32)	-0.07	-0.62(0.32)	-0.07	-0.62(0.32)	-0.07	-0.61(0.31)	-0.07
	Hazardous drinking	0.11(0.20)	0.02	0.09(0.20)	0.02	0.09(0.20)	0.02	0.09(0.20)	0.02	0.09(0.20)	0.02
	High physical activity level	-0.28(0.22)	-0.05	-0.24(0.22)	-0.04	-0.24(0.22)	-0.04	-0.23(0.22)	-0.04	-0.24(0.22)	-0.04
	CES-Dmodified	-0.05(0.03)	-0.08	-0.05(0.03)	-0.07	-0.05(0.03)	-0.07	-0.05(0.03)	-0.07	-0.05(0.03)	-0.07
	Smoker	0.01(0.24)	0.00	0.00(0.24)	0.00	0.00(0.24)	0.00	0.00(0.24)	0.00	0.00(0.24)	0.00
	Male	-0.57(0.20)	-0.11**	-0.58(0.20)	-0.12**	-0.58(0.20)	-0.12**	-0.58(0.20)	-0.12**	-0.60(0.20)	-0.12**
Step 2	Non-Māori	-0.06(0.22)	-0.01	-0.03(0.22)	-0.01	-0.03(0.22)	0.00	-0.03(0.22)	0.00	-0.03(0.22)	-0.01
	Emotional Loneliness			-0.12(0.06)	-0.09	-0.12(0.08)	-0.09	-0.12(0.06)	-0.09	-0.12(0.06)	-0.08
	Social Loneliness			0.13(0.07)	0.09	0.13(0.07)	0.09	0.15(0.09)	0.10	0.13(0.07)	0.09
	Objective Social Isolation Index (OSII)			0.01(0.07)	0.09	0.01(0.09)	0.01	0.01(0.09)	0.01	-0.11(0.12)	-0.05
Step 3	Emotional loneliness x education					0.00(0.11)	0.00				
	Social loneliness x education							-0.03(0.11)	-0.02		
	OSII x education									0.24(0.16)	0.10
	R	0.696***		0.701***		0.701***		0.701***		0.703***	
	Total R <sup>2</sup>	0.484***		0.491***		0.491***		0.491***		0.494***	
	Adjusted R <sup>2</sup>	0.468***		0.471***		0.470***		0.470***		0.473***	
	R <sup>2</sup> change			0.007		0.002		0.000		0.003	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 35

*Hierarchical Multiple Regression Analyses of ACE-R Language Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on ACE-R Language Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Language Time 1	0.55(0.05)	0.46***	0.52(0.05)	0.43***	0.52(0.05)	0.43***	0.52(0.05)	0.43***	0.51(0.05)	0.43***
	Age	-0.05(0.02)	-0.12**	-0.06(0.02)	-0.13**	-0.06(0.02)	-0.13**	-0.06(0.02)	-0.13*	-0.06(0.02)	-0.13*
	Post-secondary education	0.30(0.18)	0.07	0.26(0.18)	0.07	0.24(0.23)	0.06	0.20(0.25)	0.05	0.47(0.27)	0.12
	Heart trouble	-0.24(0.23)	-0.05	-0.23(0.23)	-0.05	-0.23(0.23)	-0.05	-0.22(0.23)	-0.04	-0.26(0.23)	-0.05
	Stroke	0.07(0.40)	0.01	0.16(0.39)	0.02	0.15(0.40)	0.02	0.16(0.40)	0.02	0.16(0.39)	0.02
	Diabetes	-0.04(0.30)	-0.01	0.06(0.30)	0.01	0.06(0.30)	0.01	0.06(0.30)	0.01	0.05(0.30)	0.01
	Hazardous drinking	0.15(0.19)	0.04	0.12(0.19)	0.03	0.12(0.19)	0.03	0.12(0.19)	0.03	0.12(0.19)	0.03
	High physical activity level	0.19(0.21)	0.04	0.20(0.21)	0.04	0.20(0.21)	0.04	0.20(0.21)	0.04	0.21(0.21)	0.05
	CES-Dmodified	-0.02(0.02)	-0.04	-0.01(0.03)	-0.02	-0.01(0.03)	-0.02	-0.01(0.03)	-0.02	-0.01(0.03)	-0.02
	Smoker	0.06(0.23)	0.01	0.04(0.23)	0.01	0.04(0.23)	0.01	0.04(0.23)	0.01	0.04(0.23)	0.01
	Male	-0.05(0.19)	-0.01	-0.04(0.19)	-0.01	-0.04(0.19)	-0.01	-0.04(0.19)	-0.01	-0.03(0.19)	-0.01
	Non-Māori	-0.11(0.21)	-0.02	-0.08(0.21)	-0.02	-0.07(0.21)	-0.02	-0.08(0.21)	-0.02	-0.08(0.21)	-0.02
Step 2	Emotional Loneliness			-0.16(0.06)	-0.14*	-0.17(0.08)	-0.15*	-0.16(0.06)	-0.14*	-0.16(0.06)	-0.15**
	Social Loneliness			0.15(0.06)	0.13*	0.15(0.06)	0.13*	0.13(0.09)	0.11	0.15(0.06)	0.13*
	Objective Social Isolation Index (OSII)			0.01(0.07)	0.09	-0.05(0.08)	-0.03	-0.05(0.08)	-0.03	0.04(0.12)	0.02
Step 3	Emotional loneliness x education					0.01(0.10)	0.01				
	Social loneliness x education							0.04(0.11)	0.03		
	OSII x education									-0.16(0.16)	-0.08
R		0.517***		0.533***		0.533***		0.533***		0.535***	
Total R <sup>2</sup>		0.267***		0.284***		0.285***		0.285***		0.287***	
Adjusted R <sup>2</sup>		0.244***		0.256***		0.256***		0.254***		0.256***	
R <sup>2</sup> change				0.017*		0.000		0.000		0.002	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.

Table 36

*Hierarchical Multiple Regression Analyses of ACE-R Visuospatial Scores Time 1, Socio-Demographics, Depressive Symptomology, Medical Factors, Lifestyle, and Social Isolation Measures Including Interaction of Social Isolation Measures and Education on ACE-R Visuospatial Scores Time 2 Showing Standardised Regression Coefficients, R, Total R<sup>2</sup>, Adjusted R<sup>2</sup> and R<sup>2</sup> Change (N=390)*

		Model 1		Model 2		Model 3c		Model 3d		Model 3e	
		B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β	B(SE)	β
Step 1	Visuospatial Time 1	0.54(0.05)	0.47***	0.54(0.05)	0.47***	0.54(0.05)	0.46***	0.54(0.05)	0.47***	0.53(0.05)	0.46***
	Age	0.01(0.01)	0.03	0.01(0.01)	0.02	0.01(0.01)	0.02	0.01(0.01)	0.02	0.01(0.01)	0.02
	Post-secondary education	0.10(0.13)	0.04	0.08(0.12)	0.03	0.05(0.16)	0.02	0.02(0.17)	0.01	0.19(0.19)	0.07
	Heart trouble	-0.40(0.16)	-0.11**	-0.40(0.15)	-0.11*	-0.40(0.16)	-0.11*	-0.39(0.16)	-0.11*	-0.41(0.16)	-0.12**
	Stroke	-1.05(0.27)	-0.17***	-0.97(0.27)	-0.16***	-0.97(0.27)	-0.16***	-0.97(0.27)	-0.16***	-0.97(0.27)	-0.16***
	Diabetes	-0.04(0.20)	-0.01	0.02(0.20)	0.00	0.02(0.20)	0.00	0.02(0.20)	0.00	0.02(0.20)	0.00
	Hazardous drinking	0.05(0.13)	0.02	0.03(0.13)	0.01	0.03(0.13)	0.01	0.03(0.13)	0.01	0.03(0.13)	0.01
	High physical activity level	0.22(0.14)	0.07	0.18(0.14)	0.06	0.18(0.14)	0.06	0.18(0.14)	0.06	0.19(0.14)	0.06
	CES-Dmodified	-0.01(0.02)	-0.02	0.01(0.02)	0.02	0.01(0.02)	0.02	0.01(0.02)	0.02	0.01(0.02)	0.02
	Smoker	0.06(0.16)	0.02	0.04(0.15)	0.01	0.05(0.15)	0.01	0.04(0.15)	0.01	0.04(0.15)	0.01
	Male	0.23(0.13)	0.08	0.25(0.13)	0.09	0.25(0.13)	0.09	0.24(0.13)	0.09	0.25(0.13)	0.09*
	Non-Māori	-0.20(0.14)	-0.06	-0.20(0.14)	-0.06	-0.19(0.14)	-0.06	-0.20(0.14)	-0.06	-0.19(0.14)	-0.06
Step 2	Emotional Loneliness			-0.12(0.04)	-0.15**	-0.13(0.05)	-0.16*	-0.12(0.04)	-0.15*	-0.12(0.04)	-0.16**
	Social Loneliness			0.07(0.04)	0.08	0.07(0.04)	0.08	0.05(0.06)	0.06	0.07(0.04)	0.09
	Objective Social Isolation Index (OSII)			-0.06(0.06)	-0.05	-0.06(0.06)	-0.05	-0.06(0.06)	-0.05	-0.01(0.08)	-0.01
Step 3	Emotional loneliness x education					0.02(0.07)	0.02				
	Social loneliness x education							0.03(0.07)	0.04		
	OSII x education									-0.08(0.11)	-0.06
R		0.562***		0.579***		0.579***		0.579***		0.579***	
Total R <sup>2</sup>		0.316***		0.335***		0.335***		0.335***		0.336***	
Adjusted R <sup>2</sup>		0.294***		0.308***		0.306***		0.307***		0.307***	
R <sup>2</sup> change				0.019*		0.000		0.000		0.001	

Note: \*p < .05. \*\*p < .01. \*\*\*p < .001.



#### **8.6.12 Exploration of the suppressor effect.**

The unanticipated result of social loneliness being positively related to ACE-R total, MMSE, memory and language resulted in further exploration. Two statistics provided evidence for a suppressor effect; the zero order correlation and beta weights. Social loneliness was suspected as being a suppressor variable due to a review of those statistics. Firstly, in the bivariate analyses (zero-order correlation) social loneliness was not found to have a significant statistical association with any of the cognitive domains (social loneliness's correlation with the cognitive domains was near zero or negligible (ACE-R (.001), MMSE (.042) memory (.005), and language (.045). Secondly, after controlling for covariates and analysing together emotional loneliness, social loneliness, and objective social isolation in the final model, social loneliness results became significant for ACE-R, MMSE, memory and language. This change from a near zero correlation with the dependent variables (ACE-R, MMSE, memory and language) to a larger and statistically significant beta weight suggests that social loneliness is a suppressor variable, as it shared little to no variance directly with the cognitive outcomes, and contributes to the regression equation through suppressing irrelevant variance from other independent variables (Nathans, Oswald, & Nimon, 2012; Pandey & Elliot, 2010). This potential suppressor effect merited investigation.

All regressions were rerun for each cognitive domain, which involved sequentially excluding one of the covariates or predictors each rerun). This analysis revealed that adding social loneliness to the tested model increased the  $\beta$  coefficients of emotional loneliness and led to an overall increase for the final model in the explanation of cognitive performance. The findings are typical of a classic suppressor variable (Pandey & Elliot, 2010). Where a suppressor variable correlates with other independent variables (such as the relationship between emotional loneliness and social loneliness), the suppressor variable in the multivariate analyses accounts for or suppresses some outcome-irrelevant variation or 'noise in one or more other independent variables, and

as a consequences improves the overall predictive power of the model (Pandey & Elliot, 2010; Tzelgov & Henik, 1991).

Further analysis involved the use of product measure which can also identify suppressor variables (Thomas, Hughes and Zumbo, 1998). Product measure is the multiplication of an independent variable's beta weight by the zero order correlation of the independent variable and the dependent variable. The resultant equation thereby reflects the total of both the direct and indirect effects (LeBreton, Ployart, & Ladd, 2004). Thomas et al. (1998) stated that using product measures for a suspected suppressor will demonstrate whether a variable did or did not directly contribute to the regression effect, as the product measure formula should yield a small or negligible value for a suspected suppressor variable. This was performed for social loneliness as a suspected suppressor and the following cognitive domains (ACE-R, MMSE, memory and language). Table 37 demonstrates the values for both emotional loneliness and social loneliness using the product measure formula. As shown in Table 37 social loneliness makes a limited contribution compared to emotional loneliness though it had a similar beta weight as emotional loneliness.

Table 37

*Comparison of Product Measure for Emotional Loneliness and Social Loneliness*

Product Measure <sup>1</sup>	ACE-R	MMSE	Memory	Language
Emotional Loneliness	2.48%	2.08%	1.62%	2.63%
Social Loneliness	.08%	.52%	.04%	.61%

<sup>1</sup>Values for product measure sum were from Table 12 and Tables 25, 26, 27, and 28.

## **Chapter Nine: Discussion**

### **9.1 Introduction**

The aim of this thesis was to develop an understanding of the relationship between loneliness and objective social isolation, and cognitive performance of older adults from Aotearoa/New Zealand, and whether loneliness (emotional or social) or objective social isolation best predicted poorer cognitive performance over time. A number of studies in the last decade have focused on whether an older person's social relationships may influence their cognitive performance. The literature review identified areas for further consideration, as highlighted in Chapter 2. These areas were a) studies which consider the multidimensional aspects of loneliness (emotional and social) and cognitive performance, b) studies investigating loneliness and objective social isolation simultaneously on cognitive performance, c) whether the relationship between loneliness and cognition was influenced by different levels of social isolation and d) if education moderated the relationship between loneliness (emotional and social) or objective social isolation and cognitive performance.

This study aimed to address those gaps through the utilisation of data from the New Zealand Longitudinal Study of Ageing (Chapter 7). The relationship between social isolation variables at baseline and, cognitive tasks at baseline and follow-up were analysed; thereby providing cross-sectional and longitudinal findings (Chapter 8).

This final chapter discusses and interprets the findings with reference to previously published studies (see 9.2 and 9.3). Section 9.4 offers two explanations on why emotional loneliness may have a negative association with cognitive performance. Limitations of the study and future research requirements are discussed (9.5), and then the chapter closes with a discussion of contributions this study has made (9.6).

## 9.2 Discussion of Cross-sectional Analyses

This section will discuss the cross-sectional findings. The format for the discussion of each hypothesis investigated includes a brief overview of the hypothesis, the study findings, followed by comparisons with the literature.

### 9.2.1 Hypothesis 1. Emotional loneliness, social loneliness, and objective social isolation will differ in their association with cognitive performance, with emotional loneliness having the strongest association with cognition

The hypothesis predicted loneliness (emotional and social) and objective social isolation would differ in their association with cognitive performance, and that emotional loneliness would explain more of the variation in the cognitive outcomes than objective social isolation or social loneliness when analysed together. Emotional loneliness explained more of the variance in cognitive performance than social loneliness or objective social isolation. That is, older adults who reported symptoms of emotional loneliness, such as feelings of rejection and/or emptiness, and absence of a confidant were more likely to have poorer cognitive performance in ACE-R total cognition, MMSE, fluency, language, and visuospatial measures, independent of their objective social isolation status and perception of their wider social network (social loneliness). Therefore, supporting Hypothesis 1. Social loneliness, the older adult's perception of their social integration and wider relationships, was not associated with cognitive performance. There was no statistically significant relationship at a bivariate or multivariate level between social loneliness and any of the cognitive outcomes. Indicating that perception of one's broader social network whether supportive or deficient in some form is not related to cognitive performance. However there was an unusual (and possibly anomalous) finding in that older adults who were socially isolated had *better* visuospatial scores than their peers who were socially integrated.

### **9.2.2 Comparison with the literature for emotional loneliness, social loneliness and objective social isolation and their association with cognitive performance.**

#### ***Emotional loneliness has the strongest association with cognitive performance.***

The finding in the current study that emotional loneliness has a greater association with cognitive performance than objective social isolation is consistent with previous findings from cross-sectional studies that have assessed loneliness or perceived social isolation and measures of objective social isolation (DiNapoli et al., 2013; Gow et al., 2013; Hughes et al., 2008; O’Launaigh et al., 2012). These studies however differed from that of Shankar et al. (2013) who reported that older adults who were socially isolated or lonely had poorer verbal fluency and poorer immediate and delayed recall scores than their peers who were not socially isolated or experiencing loneliness.

The study by Gow et al. shares similarities with the current one in placing all social isolation variables simultaneously into the final model to determine the *relative* effect of social isolation variables on cognitive performance. Gow et al. (2013) reported loneliness as a significant predictor of overall cognitive ability, while controlling for age, gender, and intelligence at 11 years old, whereas, social isolation measures (such as living arrangements and social contact) were not predictors of cognitive performance. Gow et al. (2013), in the final model included depression which resulted in loneliness no longer being significant. This differed from the present findings and that of others where a measure of perceived social isolation and loneliness, respectively were reported as statistically significant predictors of overall cognitive ability independent of depression (DiNapoli et al., 2013; O’Launaigh et al., 2012; Shankar et al., 2013).

Research has indicated that loneliness increases feelings of low mood (Cacioppo et al., 2010), though not all lonely people are depressed. In a study on loneliness, depression and cognitive decline it was reported that of older adults who were lonely at baseline half of them had no endorsement of depressive symptomatology or endorsed subthreshold depressive symptoms (Donovan et al., 2017). Also, in the study by

Donovan et al. older adults who were lonely had a greater risk of cognitive decline independent of baseline depression rates, however depression was also linked with cognitive decline. The relationship between loneliness and depression has been reported and although distinct concepts they are correlated (Cacioppo et al., 2010; Donovan et al., 2017).

It was suggested by Cacioppo and Cacioppo (2013) that if loneliness influences cognitive health through the effect it has on depression, controlling for depression in the initial analysis will mask the true effect of loneliness on cognitive functioning. Controlling for depression will also obscure the effect of loneliness on cognitive functioning if loneliness and depression have different but correlated mechanisms that influence cognitive functioning. This was evident in a study by Wilson et al. (2007) that analysed depression and loneliness on cognitive decline and found that controlling for depression reduced the effect of loneliness on global cognition (<20%). However, controlling for loneliness reduced the effect of depression on global cognition substantially (>50%). This suggests that loneliness has an effect on cognitive decline that is, in part, independent of depression as found in the current study, but also that loneliness partially accounts for the relationship between depression and cognitive decline. The correlation between emotional loneliness and depression was moderate ( $r = 0.41, p < .001$ ), in the current study, similar to that found by Wilson et al. (2007) of ( $r = .47, p < .001$ ).

In regard to the findings for the current study, it is worth bearing in mind that although the effect sizes were small, this may in part be due to the use of depression as a controlling variable.

***Emotional loneliness and social loneliness differ in the strength of their association with cognitive performance.***

Emotional loneliness and social loneliness were moderately correlated in the current study ( $r = .51, p < .001$ ). Feelings ascribed to emotional loneliness were related to poorer cognitive performance whereas the experience of social loneliness was not.

Similar findings have been reported (van Baarsen et al., 2001) indicating that they are different phenomena.

An Irish study investigating which factors (including cognitive ability) had an association with emotional or social loneliness in community dwelling older adults 60 years and older reported social loneliness had a stronger association with cognition than emotional loneliness (Schnittger et al., 2012). The study differed from the current thesis in that cognitive measures were used as a predictor of emotional loneliness and social loneliness not as an outcome of loneliness. It was found by Schnittger et al. that emotional loneliness was correlated with poorer executive functioning, attentiveness, and self-reported memory issues; however, in the multivariate analysis this was accounted for by depression, perceived stress, neuroticism, living alone, and accommodation type. Verbal fluency was correlated with social loneliness, and in the multiple regression analyses remained a risk factor for social loneliness. The findings from the study by Schnittger et al. differed from the current study in that they did not report an association between emotional loneliness and the cognitive measures in the multivariate analysis, which the current study did. This is more than likely due to the use of cognitive measures as a risk factor of loneliness rather than as an outcome of loneliness.

It is acknowledged that there are no other studies that have specifically looked at emotional and social loneliness as separate phenomena and as predictors of cognitive performance. To provide some form of comparison, studies that have assessed emotional and social loneliness and mortality will now be discussed. A five year longitudinal study that assessed the relationship between emotional loneliness and social loneliness and mortality in older adults, with and without cancer, who were not cognitively impaired, reported very similar findings to the current study. Emotional loneliness (measured using the Social Provisions Scale subscale *attachment*) (SPS; Cutrona, 1986; Cutrona & Russell, 1987) was found to be associated with mortality for older adults (Drageset, Eide, Kirkevold, & Ranhoff, 2013). Social loneliness (measured

using the SPS subscale *social integration*) did not have any association with mortality. As with the current study, depression did not account for the association between emotional loneliness and the outcome of interest (mortality) (Drageset et al., 2013). In a 25 year longitudinal study of loneliness and mortality in older men, social loneliness was not associated with mortality (Julsing, Kromhout, Geleijnse, & Giltay, 2016). However, emotional loneliness was a risk factor for mortality. This was attenuated by mood and cardiovascular risk factors. As a result emotional loneliness was no longer a statistically significant risk factor for mortality.

The studies mentioned above, and the findings from the current study, are signalling that nurturing supportive intimate relationships are more important for health (physical and cognitive) and survival, than satisfaction with one's broader social network.

### ***The relationship between emotional loneliness and cognitive domains.***

The present study's finding that emotional loneliness has an association with global cognition adds to the growing evidence that loneliness is detrimental to cognitive performance in the older adult. Importantly this study looked not just at the influence of social isolation variables and global cognition, but also the relationship between social isolation variables and specific cognitive domains. The following discussion focuses on the cognitive domains.

#### *Language.*

The current findings for emotional loneliness are consistent with some previously published studies about the relationship between loneliness and cognitive domains but not others. One of the notable findings in the current study is the identification of a relationship between language and emotional loneliness. The relationship between language and perceived or objective social isolation has garnered little attention in comparison to other cognitive domains such as memory. This may be because language abilities are often the most resistant to aging (Schwartzman, Gold, Andres, Arbuckle, & Chaikelson, 1987). Yet in the current study language was the cognitive domain that had



the strongest relationship with emotional loneliness after control variables had been entered. This contrasts with the findings of DiNapoli et al. (2013) who reported perceived social isolation no longer explained the variance of language ability after socio-demographic, medical, and mental health variables were taken into account. The different findings between Di Napoli et al. and the current study, may be attributed to the tasks used to assess language ability. The ACE-R language subscale includes a variety of tasks that involve comprehension, repetition, naming, writing, and reading. These tasks highlight word finding difficulties, and semantic problems. The breadth of cognitive abilities assessed by the ACE-R language tasks in comparison to using just one task may account for the differences in results.

#### *Memory.*

In the current study verbal memory was found to be negatively correlated with emotional loneliness, though it no longer remained significant in the multivariate analyses after entry of control variables. The current study's results are consistent with that of Schnittger et al. (2012), who reported no association between memory and emotional loneliness in multivariate analyses. This contrasts that of Gilmour (2011) who reported that immediate recall was negatively correlated with loneliness, which remained in the multivariate analyses. O'Launigh et al (2012) reported delayed recall was poorer for those who were lonely. It is worth noting tasks that require naming of objects, such as that used in the ACE-R language have also been used as a measure of semantic memory. Semantic memory was influenced by emotional loneliness in a group of older adults (Wilson et al., 2007).

#### *Visuospatial performance.*

The ACE-R visuospatial domain assesses nonverbal skills, and older adults who were emotionally lonely scored lower in this domain than those who were not experiencing emotional loneliness. The visuospatial measure assesses executive functioning, visual perception, and visual fields. The tasks also assess constructional praxis. Few studies

have used tasks that assess visuospatial ability. For example some of the tasks used in the ACE-R for assessing visual-spatial ability are comparable to those used by O'Launaigh et al. (2012) to assess visual memory, which was found to have an association with loneliness.

#### *Verbal fluency.*

Emotionally lonely people also scored lower in the verbal fluency tasks. Verbal fluency tasks test verbal ability, semantic memory, and executive control. The current findings support the work of DiNapoli et al. (2013), who reported that those who perceived themselves as having few supportive friends or close confidantes performed more poorly in executive functioning (measured with a verbal fluency test and a trail making test). The findings of the current study differ from Schnittger et al. (2012) who reported verbal fluency was associated with social loneliness but not emotional loneliness, and O'Launaigh et al., (2012) who reported no association between verbal fluency and loneliness after controlling for socio-demographics, depression, and social networks.

#### ***Summary of emotional loneliness and association with cognition.***

It needs to be recognised that the inconsistent findings on the association between loneliness and objective social isolation, and cognition as mentioned in Chapter Two relates to not only how loneliness and objective social isolation is operationalised or measured, but also how cognition is measured or categorised in the studies. For example, verbal fluency as a measure has been included in the category executive function, and in another study as a form of semantic memory. When comparing cognitive domains, rather than focusing just on domain comparison, tasks utilised in studies need to also be compared to ensure consistency. Emotional loneliness appears to impact cognitive ability across the majority of domains, although some domains appear to be more sensitive to the influence of emotional loneliness, or loneliness in general, than others. The results of the current study are comparable to some previous studies and differ from those of others.

***Objective social isolation influences visuospatial performance only.***

Objective social isolation (using a composite measure that included marital status, cohabitation status, and frequency of contact with children, family and friends, and engagement in religious or social activities), appeared to have minimal association with overall cognitive performance. It was found that older adults who were experiencing higher levels of social isolation were more likely to have better performance in visuospatial ability compared to those with lower levels of social isolation or who were not socially isolated, independent of their loneliness status.

The finding that objective social isolation was largely unrelated to cognitive performance in the current study is not completely unexpected, and in line with the findings of others (Gow et al., 2013; O’Launaigh et al., 2012). However, they differed from those of Shankar and colleagues (2013) who reported that social isolation was associated with verbal fluency and memory, in a fully covariate-adjusted model, which included loneliness.

In comparing the different findings between the current study and Shankar and colleagues the following was noted. The study by Shankar and colleagues had a large sample size of 6,034 participants with an average age of 65.6 years in comparison to the 418 participants in the current study whose average age is 70.9 years. The large sample in the study by Shankar and colleagues does reduce opportunity for finding a statistically significant result by chance. It is worth noting the effect sizes reported by Shankar and colleagues were small. For example, social isolation accounted for 0.07% of the unique variance in verbal fluency scores, and 0.06% for delayed recall. Although the current study’s finding for visuospatial ability is a small effect size and the sample population is within the guidelines for the amount of predictors used, there is a possibility it may be a chance finding.

The current study did not control for wealth whilst the study by Shankar and colleagues did and it was reported that level of wealth is a statistically significant predictor of cognitive functioning independent of socio-demographics, physical and mental health,

lifestyle factors, and social isolation and loneliness. Wealth enables a person to better access primary health care, and other sources of support and preventative measures. Research has indicated that social integration for those with lower income or lower socioeconomic status has a strong relationship with health than for those who have high levels of wealth (Heritage, Wilkinson, Grimaud, & Pickett, 2008). The link between wealth and social integration is also reflected in the behavioural pathways discussed in Uchino's (2006) model of how social relationships may influence health. That is, for individuals with limited financial resources, being socially integrated and the benefits of that social integration such as advice or support appears to be a buffer against financial constraints, whereas those with wealth can purchase services or interventions that benefit health.

Wealth also enables a person to choose whether to engage in intellectual pursuits, or hobbies that may provide cognitive stimulation. By not controlling for wealth, the relationship between social isolation and cognition may have been underestimated. However, this study did control for education, and education attainment has been utilised as a proxy for socioeconomic status as discussed previously (Section 6.7.5)

The study by Shankar and colleagues controlled for working status, which the current study did not. Working offers opportunity to be involved in a mentally stimulating environment. There is the mental stimulation from the work itself, which, depending on the role, may offer opportunity for frequent novel experiences and/or complex decision making. Research has indicated that the level of cognitive complexity of the job is associated with better cognitive functioning in later life (Andel, Kåreholt, Parker, Thorslund, & Gatz, 2007). Another consideration is that employment offers opportunity for social interaction that may provide cognitive stimulation. The STAC-R (5.2.2) and the cognitive reserve theory (4.2.1) both suggest that cognitively challenging environments are a source of neural resource enrichment which helps increase the older adults' resilience to neuronal insults. Controlling for working status, would exclude the

potential benefits that employment may confer such as cognitive stimulation, and support from work colleagues. Future studies would benefit from including working status as a control variable.

### **9.2.3 Summary of the findings for Hypothesis 1.**

The current study showed that different aspects of social relationships may be differentially important for cognitive ability. Emotional loneliness influenced cognition in a fairly consistent pattern across the domains, with one noted difference found in the memory domain. The study of the social relationship variables simultaneously is a vital step in understanding what aspects of social relationships are detrimental to cognitive functioning in the older adult. Also, the current study's use of a variety of cognitive measures indicates that, if aspects of social relationships influence cognition, the social relationship variable is more likely to have a generalised effect on the cognitive ability of the older adult, as was shown with emotional loneliness. This brings us to Hypothesis 2, which provides further insight into the relationship between loneliness, social isolation, and cognitive performance.

### **9.2.4 Hypothesis 2: Do different levels of social isolation moderate the relationship between loneliness and cognitive performance.**

The second hypothesis was that the potential negative effects of emotional loneliness or social loneliness on cognitive outcomes would be greater for those who experienced high levels of objective social isolation, than those who experienced low levels of objective social isolation. This hypothesis was investigated because of the lack of research that has investigated the interaction between these two variables on cognitive performance. It is important because loneliness and social isolation have both been found to be related to cognitive performance and also share similarities in how they influence health. For example, loneliness and social isolation have been linked with poorer immune functioning, poor lifestyle habits such as inactivity, and smoking. Differences have also been demonstrated with objective social isolation found to be a

better predictor of physical health, including cognition, with subjective loneliness found to be a better predictor of mental health (Beller & Wagner, 2018a). Beller & Wagner, (2018b) found that mortality rates were highest in older adults who were both lonely and socially isolated. Loneliness and social isolation was reported as having a synergistic effect on poorer delayed recall, and dementia (McHugh et al., 2016; Shankar et al., 2013). Thus, further studies investigating the relationship between social isolation and loneliness on other outcomes such as cognition, are warranted.

#### **9.2.5 Summary of results for Hypothesis 2: Do different levels of objective social isolation moderate the relationship between loneliness (emotional and social) and cognitive performance.**

The prediction that experiencing high levels of both loneliness (either emotional or social) and objective social isolation would result in poorer performance on the cognitive tasks, was not supported. There was an unpredicted moderation effect, in which emotionally lonely people who reported themselves as *not* socially isolated performed *more* poorly on the MMSE, language, and visuospatial measures than emotionally lonely people who reported medium and high levels of objective social isolation. There was no moderation effect between social loneliness and levels of objective social isolation.

#### **9.2.6 Comparison with the literature for Hypothesis 2.**

Few cross-sectional studies have investigated this question making it difficult to compare. The findings do differ from the longitudinal studies that have been mentioned such as those by Shankar et al. (2013) and McHugh et al. (2016). In a four year follow-up it was found that as loneliness increased recall worsened for older adults who reported high levels of isolation, compared to their peers who reported low or medium levels of isolation (Shankar et al., 2013). In an eight year longitudinal study, on loneliness, social isolation, and incident dementia a super additive effect was noted

(McHugh et al., 2016). Loneliness was predictive of a diagnosis of dementia, but social isolation was not. However high levels of social isolation and loneliness was predictive of dementia. This suggests that social isolation is not a risk for dementia, unless an individual is also lonely.

Although these studies are longitudinal they are at odds with the current study's cross-sectional findings. One study that provides partial support for the current study's findings is a cross-sectional study that created a discordance measure between loneliness and social isolation (if propensity for loneliness could be explained by relating it to susceptibility to social isolation), and utilised that to investigate cognitive outcomes (McHugh et al, 2017). The findings of McHugh and colleagues were similar to the current study's findings that individuals who experienced high levels of loneliness but did not self-report as socially isolated performed poorer on cognitive tasks than those who are both lonely and socially isolated. These findings are suggesting that feeling 'emotionally lonely in a crowd' is more detrimental to cognitive outcomes than 'feeling lonely when alone' for those in this study.

### **9.2.7 Hypothesis 3. The role of education in moderating the relationship between emotional loneliness, social loneliness, and objective social isolation, and cognitive performance.**

The final research question for the cross-sectional data was whether education moderated the relationship between the measures of loneliness or objective social isolation and cognitive performance. Higher levels of education have an association with better cognitive performance, as well as self-esteem and mastery (Borenstein-Graves, Small, Mortimer, Haley, & Jang, 2003; Orth, Trzesniewski, & Robins, 2010; Wilson et al., 2009). This may see those with higher education attainment have more awareness of options available to them, or a stronger belief that they have the coping skills to manage their loneliness or social isolation, or the stressors they may encounter on a daily basis.

### **9.2.8 Summary of results for Hypothesis 3.**

Contrary to the hypothesis, higher levels of education did not moderate the association between perceived or objective social isolation and the cognitive outcomes. It was found that education moderated the relationship between objective social isolation and visuospatial ability only for those with low levels of education. Visuospatial scores differed depending on levels of objective social isolation for older adults with low levels of education. Those who were socially isolated performed better on visuospatial tasks than those who were not socially isolated. The effect size was very small ( $\beta = .180, p < .05$ ). For older adults who had post-secondary school qualifications (high level), there was no significant differences in visuospatial scores between those who were socially isolated and those that were not.

### **9.2.9 Comparison with the previous research.**

The findings that education did not moderate the relationship between loneliness and social isolation for global cognition, memory, fluency, and language is consistent with the findings of DiNapoli et al. (2013) (although the study by DiNapoli and colleagues did not assess visuospatial ability).

There is no obvious explanation of why there exists a positive correlation between high levels of social isolation and visuospatial ability scores for those with low education. As already mentioned (see section 9.2.6), a lack of controlling for employment status might account for the results. Another, explanation is the role of digital technology including internet use. Internet use has been reported as beneficial for psychological wellbeing through reducing social isolation for those that live alone (Cotten, Anderson, & McCullough, 2013; Cotten, Ford, Ford, & Hale, 2014). Digital technology use has been associated with cognitive performance. One study found that older adults who had a greater frequency of computer activity performed significantly better on an executive functioning task than those with lower computer activity use (Tun & Lachman, 2010). The association was strongest for those with lower cognitive ability than those with



higher cognitive ability. It is plausible that for socially isolated adults in Aotearoa/New Zealand the use of computers/internet or digital technology is a way to combat social isolation. Those who are regarded as highly isolated may be more inclined to use the internet, than those with a partner, family or friends, or involved in the community. This increased internet use may have cognitive benefits on specific domains such as visuospatial ability and it may be more beneficial for those with lower education than those with higher education. This is an area that would benefit from future research and will be discussed in the section on future research (9.5).

In summary the key message from the cross-sectional analyses is that the way the older adult perceives their relationships and the interactions with significant or close others has a greater influence on their cognitive ability, than the structural aspects of their social network such as marital status, frequency of social contact, and engagement with community groups. Emotional loneliness's effect on cognitive ability is independent of depression, lifestyle behaviours, medical conditions, social loneliness, and social isolation. The effect of emotional loneliness on cognitive performance was found to be greater for those who are surrounded by others, than those who are isolated. This is an important finding and following the longitudinal results below a discussion will occur on the overall results of the study, with an aim to offer an explanation on why emotional loneliness is detrimental to cognitive performance.

### **9.3 Discussion of Longitudinal Analyses**

#### **9.3.1 Hypothesis 4: Investigating the differential relationship between loneliness (emotional and social), social isolation and cognitive performance over a two year period.**

It was predicted that older adults who experienced high levels of loneliness (emotional or social) or objective social isolation at baseline would have poorer cognitive performance at follow-up (2 years later) than their peers who were not lonely or socially isolated at baseline. It was also hypothesized that emotional loneliness at baseline would

explain more of the variance in cognitive scores at follow-up than social loneliness or objective social isolation.

### **9.3.2 Summary of results for Hypothesis 1: Emotional loneliness, social loneliness and objective social isolation, as predictors of cognitive performance over time.**

The results of the multivariate analyses indicated that it is the experience of emotional loneliness at baseline that was predictive of poorer performance in later global cognition, (Total ACE-R and MMSE) memory, language and visuospatial scores, independent of socio-demographics, medical conditions, lifestyle and physical and mental health variables. Fluency was the only cognitive domain not significantly predicted by emotional loneliness after a two year period. Objective social isolation at baseline was not associated with cognitive performance after two years. An interesting finding was that the older adults experiencing *social* loneliness had better cognitive performance over time for global cognition, memory, and language, than those who were not socially lonely. As mentioned in the results section chapter 7, social loneliness was identified as a suppressor variable. Further discussion on this will occur later in the chapter.

This study found partial support for hypothesis 4 that emotional loneliness would be predictive of poorer cognitive performance and explain a greater amount of the variance than objective social isolation or social loneliness. The prediction that social loneliness and objective social isolation would also be predictive of poorer cognitive performance after two years was not supported. As with the cross-sectional findings emotional loneliness independently explains the variance in cognitive scores over time for majority of cognitive domains after controlling for covariates that have been linked with both cognitive decline and loneliness.

### **9.3.3 Comparison with the literature for emotional loneliness, social loneliness and objective social isolation and their association with cognitive performance.**

The current findings are in line with previously published studies that have reported loneliness has a detrimental influence on cognitive performance over time, after controlling for covariates such as socio-demographics, health, and depression (Donovan et al., 2017; Ellwardt et al., 2013; Tilvis et al., 2004; Wilson et al., 2007; Zhong, Chen, Tu, & Conwell, 2017). However, some studies have found loneliness does not influence cognitive performance over a six year period (Deary & Okely, 2018) and a seven year period (Stessman, Rottenberg, Shimshilashvili, Ein-Mor, & Jacobs, 2014). When reviewing the differences between the current study and those that found a relationship between loneliness and cognition and those that did not, one possible explanation is that of measurement. The use of a single item global measurement of loneliness was used by Deary and Okely (2018) and Stessman et al. (2014), whereas in the current study and that by Ellwardt et al. (2013) and Wilson et al. (2007), the De Jong Gierveld Loneliness scale a comprehensive measure of loneliness was utilised (a measure of loneliness that does not mention the word 'lonely'). One of the factors identified with using a single item measure of loneliness is the large variability in responses to options provided such as 'sometimes' or 'often'. In a study 'sometimes' has resulted in respondents assuming it means 20% of the time in comparison to half of the time (Pepper, 1981). Furthermore, a study comparing both direct and indirect measures of loneliness, found that 32% of those who responded to a direct measure of loneliness reported not being lonely, whereas their responses on an indirect measure placed them in the moderately lonely category (Victor et al., 2005b). Measure differences and response options may explain the inconsistency found between the studies.

Another explanation relates to the use of control variables. For example, the study by Deary and Okely (2018) controlled for depression and anxiety, psychological states that have associated positively with loneliness and found to have a negative association with

cognitive functioning (Barg et al., 2006; Donovan et al., 2017; Wang, Shu, Dong, Luo, & Hao, 2013), which may have attenuated the relationship between loneliness and cognition.

Comparing studies that have analysed together loneliness and objective social isolation to determine their relative effect on cognition over time, the current study's findings are consistent with previously published results. That is, loneliness at baseline is a predictor of cognitive performance over time but social isolation is not (Holwerda et al., 2014; McHugh et al., 2016; Rafnsson, Orrell, d'Orsi, Hogervorst, & Steptoe, 2017). Yet the current study differed from that of Shankar et al. (2013) who reported objective social isolation was a predictor of poorer cognitive performance over time. The current study, and that of McHugh et al. (2016), Rafnsson et al. (2017) and Shankar et al. (2013), all used a social isolation index, which originated from the work of Shankar and colleagues, though with variations, as did the one in the current study. The differences between studies though is not uncommon and as previously mentioned in Chapter Two is one of the ongoing issues in determining what aspects of social relationships are protective or risk factors for cognitive decline. In the study by Rafnsson et al. (2017) marital status was removed from the social isolation index, and found to be a predictor of cognitive decline. In the current study marital status was included in the social isolation index. Yet, as previously mentioned the current study did not control for working status, nor did that of Holwerda et al. (2014) and Rafnsson et al. (2017), and may account for the lack of findings between social isolation and cognition, that was reported by Shankar et al. (2013). For example in the current study approximately 30% of older adults were working either part-time or full time. The demographics of the working older adult were not investigated in the current study. However studies have reported that being single and female is a predictor of continue to work in older age (Di Gessa et al., 2017; Templer, Armstrong-Stassen, & Cattaneo, 2010). It is plausible that by not including working status in the current study as a component of the Objective Social Isolation Index, there are older adults who could be living alone, with little contact with family

and friends but working. Therefore, not all those who may have been categorised as socially isolated may in fact be isolated from other people. As a result the current study may not have effectively captured social isolation in the older adult. Having said that, the current study's results reflect those of a 15 year longitudinal study that reported it was the qualitative and functional aspects of social relationships such as perception of relationships that were associated with significant declines in cognitive functioning, not the structural aspects such as being objectively isolated (Amieva et al., 2010).

As hypothesised, emotional loneliness was a better predictor of poorer cognitive performance over time than social loneliness after controlling for covariates. However, social loneliness was found to predict better cognitive performance for some domains at a later date rather than poorer cognitive performance as predicted. This finding must be treated with caution. Based on the current theory and research there is very little evidence that indicates being socially lonely should enhance cognition. As mentioned earlier (8.9.7) social loneliness at baseline was not found to be correlated with any of the cognitive outcomes at baseline or follow-up. Yet unexpectedly the multivariate analysis indicated that social loneliness was a positive predictor of cognitive outcomes. Further analyses determined that social loneliness increased the overall model predictability for the cognitive outcomes and the regression weight of other predictors by removing irrelevant predictive variance from them. The possible and most likely explanation is that social loneliness is a suppressor variable. It was suggested by Pandey and Elliot (2010) that a conceptual interpretation of the results for a suppressor variable, such as social loneliness is deemed not warranted. Though it was determined that social loneliness is a suppressor variable in the current study, a discussion has been included that provides a possible explanation of how the experience of social loneliness could be associated with better cognitive performance at a later date.

### ***Could social loneliness enhance cognitive performance?***

In an examination of Weiss's typology of loneliness, social loneliness is associated with not feeling "in tune" with others, not feeling part of a group and not having a lot in

common with others (Russell, 1984). For the older adult social loneliness may have come about due to retirement, or shifting communities to either be closer to family, to move into a retirement community, or for financial reasons. These are all factors which may disrupt ability to stay connected with previous social networks. For older adults residing in the community, a sense of social loneliness for any reason may result in an attempt to combat those feelings through potentially cognitive stimulating tasks. In a study regarding social loneliness and the older person, it was reported that as people aged they did not attach less importance to the quantity or quality of social contacts (Heylen, 2010). These findings contradict the thesis of disengagement theory which states that as one gets closer to death they are more inclined to disengage from society and therefore decrease social interactions (Fung, Carstensen, & Lang, 2001; Heylen, 2010). In the current study the sample was a group of relatively healthy older people. For those experiencing social loneliness, attempts may have been made to engage in social activities or to pursue other avenues to alleviate their social loneliness. One such way could be through the use of the internet. A study on internet use reported that social loneliness was a predictor of internet use, whereas emotional loneliness was not (Sum, Mathews, Hughes, & Campbell, 2008) and, internet use in the older adult has been suggested as a tool that may provide cognitive stimulation (Myhre, Mehl, & Glisky, 2017). Myhre and colleagues investigated whether internet use, specifically using Facebook could enhance cognition due to benefits from online social engagement, and found that processing speed, executive functioning and working memory improved with internet use, though there were no significant changes in scores on loneliness and social support for their participants. The results appear to indicate that these activities may not have reduced the older adult's feelings of loneliness but provided a form of cognitive stimulation. This may also be the same for other activities. That is older adults who are feeling socially lonely may attempt to engage in activities with others (such as volunteer work or hobbies) or engage in solitary activities (such as crosswords, reading, or gardening) with the aim of reducing their social loneliness. However, these activities

may not reduce their sense of social loneliness but it may provide a form of cognitive stimulation. There is also support for this explanation, in that lower levels of mastery as measured by the Perlin Mastery Scale have not been associated with social loneliness, but they are associated with emotional loneliness. This may indicate that socially lonely people are more inclined to attempt to reduce their loneliness in part due to their sense of mastery (Peerenboom et al., 2015)

Further research on the relationship between different forms of loneliness and cognitive functioning is required before any speculative explanations can be ruled out.

#### **9.3.4 Hypothesis 5 and summary of results of whether different levels of social isolation (at baseline) moderate the relationship between loneliness (at baseline) and cognitive performance over time.**

Hypothesis 5 is important for understanding how different levels of social isolation may interact with the relationship between loneliness and cognitive functioning over time. Unlike the cross-sectional findings, the results did not provide any indication that objective social isolation at baseline moderated the relationship between loneliness (emotional or social) at baseline and cognitive performance at two year follow-up.

#### **9.3.5 Comparison with the literature for Hypothesis 5.**

The current study's results align with some of the reported findings by Shankar et al. (2013) though not all. Both the current study and that of Shankar and colleagues found that objective social isolation did not moderate the relationship between loneliness and executive functioning (verbal fluency test). However Shankar and colleagues reported that older adults who were lonely and socially isolated, had poorer recall four years later than those who were lonely but not isolated. This indicated that social isolation strengthened the relationship between loneliness and poorer recall. Another study that has looked at the interaction between loneliness and social isolation reported social isolation did not have an association with dementia other than for those who were lonely in a six year follow-up study (McHugh et al., 2016).

One difference between the current study and those mentioned above is the length of time between baseline and follow-up; in the current study there was a two year follow-up which is a shorter observation period than that of Shankar et al. and McHugh et al. Another consideration between the current study and that of Shankar et al. is differences in key measures and the participants' demographics. In the current study only 1% of older adults received the top score in Objective Social Isolation Index compared to the 4.8% of older adults in the study by Shankar and colleagues. This was reflected in a lower mean score for the Objective Social Isolation Index ( $M = 1.3$ ) in the current study compared to that reported by Shankar and colleagues of ( $M = 1.5$ ). The sample investigated by Shankar et al. (2013) also was younger ( $M = 65.6$  years) and in poorer health, with 53.6% stating that they had heart disease, compared to those in the current study ( $M = 70.91$  years) and 20% with heart disease. The larger percentage of older adults diagnosed with cardiovascular disease in the sample population may indicate that there are other lifestyle factors that are not being accounted for such as diet, or alcohol use, which have been associated with social isolation, loneliness, and cognitive functioning.

Though the current study's results did not indicate that social isolation moderates the relationship between loneliness and cognition, other studies as mentioned above. This is an area that would continue to benefit from further work.

#### **9.3.6 Hypothesis 6: The role of education in moderating the relationship between emotional loneliness, social loneliness, and objective social isolation, and cognitive performance over time.**

The final hypothesis predicted that, for older adults experiencing high levels of loneliness or social isolation, and lower levels of education would be associated with poorer cognitive performance after two years. There was no evidence that levels of education buffered or exacerbated the relationship between loneliness or social isolation and cognitive functioning over time.



### **9.3.7 Comparison with the literature for Hypothesis 6.**

There are very few studies that have looked at whether variables such as education moderate the relationship between social relationships and cognition. One such study (Shankar et al., 2013) assessed whether education moderated the relationship between loneliness, social isolation, and cognitive performance at four year follow-up. Similar to the current study it was reported that there was no interaction effect between education, loneliness, and social isolation for verbal fluency performance or immediate recall. However Shankar and colleagues did find that older adults with low levels of education had poorer delayed recall as levels of either loneliness or social isolation increased.

The current study's results are consistent with the idea that education is strongly associated with base cognitive ability but not the change in performance over 2 years associated with loneliness and/or loneliness

### **9.3.8 Summary of findings from longitudinal hypothesis.**

In summary, the key message from the longitudinal findings was that, like the cross-sectional findings, the experience of emotional loneliness is one that has negative consequences for cognitive performance, and therefore a potential to influence quality of life for the older adult. Cognitive ability at baseline accounted for the majority of the variance in the cognitive scores at follow-up and emotional loneliness was a better and more consistent predictor of cognitive outcomes than age, education, heart trouble, alcohol use, smoking, depression, and physical activity – all known factors that may influence cognitive decline in the older adults. The next section will discuss proposed explanations of the ways in which emotional loneliness may influence cognition.

## **9.4 Explanation of the Finding that Emotional Loneliness Influences Cognitive Performance**

This section will offer two plausible explanations on why emotional loneliness's relationship with cognitive performance at baseline and follow-up was negative. Different kinds of behavioural, psychological and physiological mechanisms have been

suggested as explanations of why loneliness may be associated with cognitive performance (Chapter 4). Bivariate associations were found between the social relationship variables (emotional loneliness, social loneliness and social isolation) and physical activity and depression, though not for medical conditions such as heart disease, stroke, or diabetes. As shown in the multivariate analyses, when confounding variables (depression, and physical activity) are controlled for, emotional loneliness continues to account for the variance in cognitive performance for the majority of the cognitive domains, yet social loneliness and social isolation do not. Although a consequence of emotional loneliness may be reduced mood and decreased physical activity, which may influence cognitive performance as suggested by Cacioppo and colleagues, it also appears that there is something else about emotional loneliness that is associated with poorer cognition, which differs from social loneliness and social isolation.

#### **9.4.1 Emotionally lonely people, emotion regulation and cognitive processes.**

One possibility is that older adults who are emotionally lonely tax their cognitive resources by trying to regulate their negative emotions. This explanation derives from socioemotional selectivity theory, and the belongingness hypothesis.

Socioemotional selective theory's (SST; Carstensen et al., 1999; Charles & Carstensen, 2010) tenet is that as one ages and time horizons shrink, consciously or subconsciously a motivational shift occurs that directs an individual's attention to emotionally meaningful goals rather than knowledge based goals (Carstensen et al., 1999; Charles & Carstensen, 2010). This shift of increased attention to goals that emphasise emotion and meaning is present-focused rather than future-focused. This reappraisal of goals can result in greater awareness of one's current emotions, more contentment with current status, and an aim to better regulate emotion experienced in daily life (Charles, 2010; Charles & Carstensen, 2010). Charles and Carstensen postulate that the reappraisal of goals to one

of emotional security results in the individual actively constructing their social networks to meet those goals. That is relationships with family and friends and the deepening of those existing relationships becomes the priority over retaining or increasing peripheral social contacts.

The importance of meaningful relationships is also at the heart of a belonging hypothesis. Baumeister and Leary (1995) proposed the 'need to belong' hypothesis that individuals "have a pervasive drive to form and maintain at least a minimum quantity of lasting, positive, and significant interpersonal relationships" (p. 497). To have ones *needs for belongingness* met the bonds between individuals require "stability, affective concerns, and continuation into the foreseeable future" (p. 500). They suggest that if an individual's belongingness needs are not met this may lead to loneliness, withdrawal and social isolation. A key element of belongingness is the perception that one is cared for and one's welfare is of concern to another. The loss of one relationship can be substituted by another to some extent although the substitution of relationships takes time, and requires ongoing shared experiences that build intimacy and affective concern.

Mellor, Stokes, Firth, Hayashi, and Cummins (2008) assessed loneliness and the need to belong, and reported that older adults who were lonely were more than likely to have an unmet need to belong regardless of whether they lived alone or with others. Like loneliness, belongingness is based on how one evaluates those significant interpersonal relationships. More than likely belongingness, change in goal perspectives and time are motivating factors for the older adult to have relationships that are supportive, emotionally meaningful, and satisfying. Therefore for older adults who do not have relationships (due to loss such as passing of a partner or intimate friend) that fulfil one's emotional/belongingness needs, or as postulated under SST, allow one to achieve the goal of emotional regulation may lead to emotional distress and negative affect. However, it may even be more emotionally distressing to be surrounded by others while continuing to feel that one does not have relationships that meet ones needs of

belongingness or one's goals to have meaningful relationships than to be socially isolated.

Evidence indicates that older adults who focus on emotional goal attainment engage in cognitive strategies such as thoughts and actions that minimise exposure to negative events or increase exposure to positive events (Birditt & Fingerman, 2005; Charles, Piazza, Luong, & Almeida, 2009; Knight et al., 2007). Positive emotion increases when valued goals are achieved whereas failure to achieve those goals results in negative affect and thus (importantly) a need to engage in emotion-regulation strategies (Charles & Carstensen, 2010). If older adults are self-regulating emotion to avoid negative experiences or reduce emotional arousal this may (in part) explain why emotionally lonely people perform more poorly on cognitive tasks than those who are not emotionally lonely.

Self-regulation of emotional distress is hypothesised by Baumeister, Twenge, and Nuss (2002) to explain why a lack of belongingness resulted in poorer performance in complex cognitive tasks and controlled responses though not in tasks that involve automatic processes such as encoding of information. Baumeister and colleagues performed a series of studies on a lack of belongingness and cognitive processes, and reported that manipulation of a future lack of belongingness was regarded as a threatening and unwanted event and that this motivated individuals to suppress and attend to the emotional distress, which required the cognitive process of executive control. It was suggested by Baumeister et al. (2002) that attending to emotion taxes executive function and as a consequence impairs controlled processes required for the cognitive tasks being undertaken. Impaired processes were only for those logical and cognitively challenging tasks and not for tasks requiring basic formation processing such as easy rote memory tasks.

Other studies that have manipulated loneliness (by for example, asking participants to recall times when they felt isolated, lacked a confidante, companionship or a sense of

belongingness) have shown increases in anxiety levels, fears of negative evaluation, and behaviour change such as acting more cordially towards others (Cacioppo et al., 2006). The current study's results can be understood if older adults who are emotionally lonely have to suppress or self-regulate behaviours and thereby are taxing their cognitive processing. Emotional loneliness was associated with poorer performance in global cognition, verbal fluency, language, and visuospatial ability at Time 1, though not memory. All of the cognitive domains examined in the current study however involve some aspects of executive functioning. In the ACE-R executive functioning is measured by the fluency subtest. Completing visuospatial ability tasks also places a heavy demand on executive functioning (Baddeley, 1996; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001). Visuospatial ability tasks includes the clock drawing test which draws one executive functioning processes such as planning and abstract thinking. The ACE-R language tasks are also associated with executive functioning processes such as semantic knowledge retrieval. Finally the memory tasks in the ACE-R draw on executive processes such as attention regulation and inhibiting irrelevant information in episodic memory.

In the longitudinal analysis, emotional loneliness predicted poorer cognitive performance for all cognitive domains *except* verbal fluency, the measure of executive functioning. The lack of a relationship between emotional loneliness and verbal fluency in the longitudinal analyses in part may be explained by the scoring system for the fluency tasks. The ACE-R fluency measures uses two tasks, semantic fluency and phonemic fluency. Semantic (category) fluency involves the generation of the names of members of categories such (e.g., fruit, animals) within a 60 second time frame. Phonemic (letter) fluency involves the generation of words that begin with a particular letter within a 60 second time frame. Scoring for category fluency and letter fluency is number of non-repeated correct words produced based on the specific category animal or letter, respectively. The ACE-R fluency scoring system differs from the standardised fluency tests in the following way. In ACE-R fluency tests, scores are grouped and then

points are given in ranked order (for example in semantic fluency 6 – 7 words = 3, 8 – 10 words = 4, 11 - 13 words = 5, 14 – 17 words = 6 and 18 words or more a 7, being the top score). A similar scoring system occurs for phonemic fluency. This scoring system creates a ceiling effect with all scores above a certain number given the top available mark.

The points allocated for semantic fluency and phonemic fluency are then added together to create a total verbal fluency score. If an individual produced 17 words at Time 1 for semantic and 14 words at follow-up, they would receive the same score of 6, indicating no changes over time. This could occur for both subtests. This suggests that the combining of the two fluency tasks and the scoring system with a ceiling effect may reduce the sensitivity to changes in the ACE-R fluency measure.

Furthermore, semantic verbal fluency has been suggested as having greater clinical utility for detecting changes in cognitive performance and diagnosing Alzheimer's disease and mild impairment compared to phonemic fluency (Cerhan et al., 2002; Steenhuis & Østbye, 1995; Zec, 1993). In a meta-analysis of 153 papers, involving 15,990 participants semantic fluency was significantly more impaired relative to phonemic fluency in cognitive impaired older adults (Henry, Crawford, & Phillips, 2004). Longitudinal studies with cognitively intact older adults and cognitively impaired older adults have reported that semantic fluency declines faster than phonemic fluency for both populations (Clark et al., 2009). Semantic verbal fluency has also been established as far superior than phonemic verbal fluency in distinguishing between cognitively intact and cognitively impaired older adults (Taler & Phillips, 2008)

In sum, in the current sample of non-clinical older adults, the verbal fluency test's scoring system and the combining of the semantic verbal fluency and phonemic fluency, tasks may result in reduced sensitivity to changes and therefore explain the lack of relationship between emotional loneliness and fluency at follow-up in this current study

#### **9.4.2 Emotional regulation and biological vulnerabilities, explaining the poorer cognitive performance of those who are 'lonely in a crowd'.**

The finding that in the current study the 'lonely in a crowd' subgroup had poorer cognitive performance than others, may also be explained by Socioemotional Selectivity Theory that as one ages, emotional goals become of the utmost importance (Carstensen et al., 1999). Research has indicated that the majority of older adults experience higher levels of well-being than younger adults. It is postulated by Charles and Piazza (2009) that older adults with low levels of distress are able to regulate their emotion to reduce or avoid negative experiences, thereby increasing levels of well-being. However, it is suggested by Charles (2010) that when an older adult experiences high levels of distress which are unavoidable (such as loss of significant others who provide emotional support, caregiving for a partner, ongoing negative interactions with significant others, functional limitations that may cause pain or hassles as well as ongoing daily hassles), age-related advantages in emotional regulation and well-being that has been evidence between young and older adults, no longer remain and in many instances reverse in direction. Charles postulated that the decrease in wellbeing seen in some older adults is due to a reduction in flexibility in biological systems that comes with age. For example, studies have reported that older adults have a prolonged physiological response to activation of the hypothalamic pituitary adrenal axis (HPA) (Bakke et al., 2004). Increased heartrate in response to emotional stressors is attenuated by the ageing process as is blood pressure reactivity to emotional stressors (Labouvie-Vief, Lumley, Jain, & Heinze, 2003; Smith, Hillman, & Duley, 2005; Uchino, Holt-Lunstad, Bloor, & Campo, 2005).

It is plausible that older adults who are emotionally lonely but surrounded by others, are in an unavoidable ongoing negative situation (such as caregiving for a partner, in an unsatisfactory relationship, having ongoing negative interactions with family or friends). This daily affective distress that arises from emotional loneliness may have negative consequences such as increased blood pressure and ongoing activation of the HPA axis

which have all been linked with poorer cognitive performance in older adults. Though the current study controlled for heart disease, which can be influenced by blood pressure and stress, it may also be that levels of stress and or blood pressure may also need to have been taken into account as control variables. Loneliness and stress, particularly that caused by interpersonal stressors, are associated. Interpersonal stressors caused by conflict elicit, not only the highest daily stress, but make up the majority of daily stressors (Almeida, 2005). A consequence of loneliness and stressors, such as interpersonal conflict, is poor sleep quality (Aanes, Hetland, Pallesen, & Mittelmark, 2011; Cacioppo et al., 2002; Fortunato & Harsh, 2006; Weiss, 1973).

#### **9.4.3 Loneliness, sleep quality, and cognitive performance.**

The relationship between loneliness, stress, sleep quality and cognitive performance will now be discussed as the final explanation in explaining how emotional loneliness may influence cognition as found in the current study.

Poor sleep quality is characterised by unwanted intruding wakeful experiences (Nebes, Buysse, Halligan, Houck, & Monk, 2009). Limited unwanted nocturnal disturbances that have been identified as a precipitator to sleep development issues and also perpetuating sleep difficulties include intrusive thoughts, rumination and feelings of emotional isolation prior to sleeping (Åkerstedt, Kecklund, & Axelsson, 2007; Harvey, Tang, & Browning, 2005; Tang & Harvey, 2004). Lonely older adults may engage in the act of rumination, which has been found to impact sleep quality and sleep duration (Guastella & Moulds, 2007; Hansson, Jones, Carpenter, & Remondet, 1987). Loneliness has been associated with hypervigilance (such as increased attention to social threats, rejections and exclusion,) and it is suggested that this hypervigilance may manifest itself into sleep disturbances through the night, therefore reducing quality of sleep (Cacioppo & Hawkey, 2003; Kurina et al., 2011; Sadeh, Keinan, & Daon, 2004).



Restricted and disrupted sleep has been shown to increase the activity of the autonomic sympatho-adrenal system and the HPA axis, which with chronic activation can impair brain function such as affecting hippocampal neurogenesis (Lucassen et al., 2010; Lupien et al., 2009; Meerlo, Sgoifo, & Suchecki, 2008; Miller & O'Callaghan, 2005).

Though sleep disturbances have been reported as being a consequence of loneliness there appears to be few studies that have investigated the relationship between loneliness, sleep and cognitive functioning. Thus, the following explanation is speculative: Measures of global loneliness have been associated with decreases in subjective sleep quality, as well as in objective sleep efficiency measures (increased micro-awakenings) (Cacioppo et al., 2002; Hawkey, Preacher, & Cacioppo, 2010; Jacobs, Cohen, Hammerman-Rozenberg, & Stessman, 2006). The relationship is bidirectional with poorer sleep also having been associated with increased levels of loneliness and social withdrawal (Simon & Walker, 2018). A study that utilised the de Jong Gierveld Emotional and Social Loneliness subscales reported that older adults who were emotional lonely had poorer sleep quality as measured by the Pittsburg Sleep Quality Index, whereas those who were experiencing symptoms of social loneliness or living alone (social isolation) did not (McHugh & Lawlor, 2011). This suggests that emotional loneliness or the perceived lack of having supportive, caring relationships is more important to sleep quality than the physical presence or absence of others, or lack of a broader social network. Poor sleep has also been associated with less than satisfactory marital quality (Yang et al., 2013).

McHugh and Lawlor (2013) hypothesised that stress may explain the association between emotional loneliness and sleep quality, and performed a further study. It was found that emotional loneliness impacted sleep quality. However, the experience of emotional loneliness is also stressful, and may increase levels of perceived stress, which consequently over time affected sleep quality.

Poorer sleep quality has also been associated with increases in heart disease, obesity, inflammation and also poorer cognitive performance and increased rates of cognitive decline (Blackwell et al., 2014; Irwin, Olmstead, & Carroll, 2016; Nebes et al., 2009; Spira, Chen-Edinboro, Wu, & Yaffe, 2014; Tobaldini et al., 2017). In a meta-analysis of 35 studies, short duration and long duration of sleep were both associated with poorer cognitive functioning across multiple domains, including overall cognitive ability (Lo, Groeger, Cheng, Dijk, & Chee, 2016). Subjective sleep complaints have also been associated with increased rates of cognitive decline over a three year period (Jelicic et al., 2002). Poor sleep quality impacted cognitive performance in a group of older adults in fluid intelligence through abstract solving and executive functioning, but not in memory, attention or processing speed (Nebes et al., 2009). As discussed in Chapter Five, The STAC-R demonstrates that stress, depression and neuroticism are potential neural resource depletion variables, which can lead to poorer cognitive performance. Based on the current study's findings, and that of others, loneliness, and in particular emotional loneliness, may influence cognitive health in similar ways as stress and depression. If emotional loneliness influences sleep quality directly and indirectly through higher levels of perceived stress, then interventions that focus on stress management and or sleep strategies, may offer a form of intervention that may buffer against the detrimental influence of emotional loneliness.

## **9.5 Limitations and Future Research**

There are several limitations of the current study. The observation period of two years was relatively short to examine change in cognition. A longer observation period would be recommended in a sample of relatively healthy community based old adults. The ACE-R has been widely used for both clinical and research work including measuring cognitive changes (Mioshi et al., 2006). It is primarily a dementia screening tool, and may not be as sensitive to capture normal ageing change within a short observation period in comparison to other neuropsychological tests.

Although the current study utilised cross-sectional data and longitudinal data, it did not allow for any analysis of causation. The current study examined the influence of different aspects of social relationships on cognition in the older adult, yet loneliness and social isolation may be a behavioural reaction to diminishing cognitive performance due to the pathology associated with dementia. In the prodromal stages of dementia impairments in social cognition and socio-cognitive skills have been found (Bediou et al., 2009; Elamin, Pender, Hardiman, & Abraham, 2012). Studies that have a longer follow-up period, enabling the exclusion of participants with dementia that assess both loneliness and social isolation would help determine if loneliness and social isolation influence cognitive decline independent of dementia status. If loneliness and cognitive functioning have a bi-directional relationship, it is still important to understand the role loneliness has on cognitive functioning and rate of cognitive decline.

The current study did not assess the stability of loneliness or social isolation. Loneliness and social isolation may have been a recent occurrence or part of an enduring personality trait or ongoing condition. For example, it has been suggested that some individuals enter older adulthood with a '*continuity of loneliness*', which is chronic loneliness influenced by personality factors and a lifelong pattern of behaviours and accumulation of experiences with interpersonal relationships (Fry & Debats, 2002; Victor et al., 2005a). The relationship between loneliness and cognition may differ for those who experience chronic loneliness in comparison to older adults who experience loneliness as a response to grief and loss, in older age. Future research would benefit from determining the chronicity of loneliness and social isolation on cognitive functioning. This could also help inform interventions on loneliness.

Few studies that examine social relationships and cognitive functioning in the older adult have included an analysis of the role of personality traits. Personality factors have been associated with loneliness and cognitive ability. Loneliness was found to be associated with higher levels of neuroticism and lower levels of extraversion (Cacioppo

et al., 2006). In the Seattle Longitudinal study of Ageing, personality trait measures were associated with cognitive ability and accounted for up to 20% of shared variance (Schaie et al., 2004). Many studies on social relationships and cognitive functioning have utilised pre-existing data sets, as was the case with the current one. Therefore, consideration to include personality measures in future phases of longitudinal studies would be warranted to understand if the relationship between loneliness and cognition is accounted for wholly or partially by personality traits.

Another limitation pertains to the Objective Social Isolation Index (OSII). The OSII used in the current study is a composite measure, and is based on self-report items. The validity of answers on frequency of contact and social engagement were unable to be verified through diaries or interview observations. The reliability of the OSII was not checked due to their only being one collection of data in each wave (2010 and 2012). Also, due to the length of time between data collection (2 years) reliability of the OSII was not assessed. In general the validity and reliability of the OSII is unknown in the current study as well as other studies that the index was based on (Shankar et al., 2011; Steptoe et al., 2013).

As mentioned the level of contact with family and others reported by the participants, may not accurately reflect the actual contact. In part this might be due to the available responses. For example, the question of how often one attends social activities offered three choices, “yes, regularly”, “yes, occasionally” or ‘no’, responses regarded as vague quantifiers. The use of vague quantifiers are not a reflection of the absolute frequency (such as attending social activities) but a reflection of the frequency relative to the older adult’s expectations (Schwarz & Oyserman, 2001). Expectations may influence interpretation of response options. It has been suggested that using an absolute frequency scale (such as once a week, or 3 times per week), reduces issues associated with interpretation of response options (Schaeffer, 1991). There is also a possibility that

individuals may report greater frequency of contact, or more social contact and/or more supportive and closer relationships than they have, which cannot be ignored (Victor et al., 2005a). Future research may benefit from having participants use a daily diary to determine actual contact.

The OSII did not specifically allow for the role technology may have in reducing social isolation. In Aotearoa/New Zealand internet access for those aged 65 -74 in 2009 was 54% access, and increased to 61% by 2012 (Statistics New Zealand, 2012). It is possible that those who are socially isolated utilise the internet for social contact or for leisure or cognitive stimulation. The Objective social isolation index questions did not orientate the respondents to incorporate technology as a means of contact or social engagement. Therefore, it is not known whether social contact through technology was informally included in frequency of contact with family and friends. For example, those who are geographically distanced from family members or who are homebound due to physical disabilities or illness may utilise the internet for social contact. Future studies would benefit from incorporating measures that include communication through the use of technology. Also is the need to consider digital technologies as an intervention tool to reduce social isolation.

The representativeness of the current study's sample limits the generalisability of the findings. The current study's analyses utilised a sample of participants who were willing, and able (physically, mentally and cognitively) to engage in face to face interviews. The sample was more likely to be married and have a higher education than the general population and represented a cohort of high functioning and healthy older adults. Also the current sample consisted only of community dwellers, in the age band 65-84. This excluded all other older adults who may be institutionalised or in residential care for the ageing, or unable to participate in face-to-face interviews due to ill health (physical or mental) or a disability, therefore limiting the findings.

A strength of the current study was that many covariates were accounted for however it is more than likely that there are other possible confounding variables that may have obscured effects. For example, as mentioned there was no control for working status, and working may confer a benefit to an individual through cognitive stimulation or support. There are many other variables that were not included such as prescribed medication that may influence cognitive performance, mood and energy levels which may reduce ability to engage in social interactions. Other possible confounds include levels of stress, and sleep quality, factors that have been associated with cognitive performance as discussed (9.4). Do lonely and socially isolated people have higher levels of stress and poorer sleep that may have an influence on their cognitive performance?

## **9.6 Conclusion**

The study of the relationships between social relationship factors and cognition has aptly been described as an area that is poorly defined and has ongoing problems with the differing definitions of key constructs and phenomena (McHugh et al., 2017). The current study used a measure of loneliness that is bi-dimensional, reliable and has been reported as an appropriate measure to use in the study of older adults (Penning, Liu, & Chou, 2014; van Baarsen et al., 2001). Social isolation was assessed through utilising an index based on previous studies. This intended to minimise the ongoing issues of variation in measures and allow comparisons to other studies. It also allowed the exploration of the relative and synergistic relationship between loneliness (emotional and social), social isolation and cognitive performance and revealed some novel findings.

Firstly, examining loneliness as a bi-dimensional construct provided information that emotional and social loneliness differ in their association with cognition. Secondly, analysing together emotional loneliness, social loneliness and objective social isolation in the same sample provided information that the effect of emotional loneliness on cognitive performance is independent of social loneliness and objective social isolation.

Thirdly, exploration of social isolation levels revealed the novel finding that those who were emotionally lonely but not deemed as socially isolated performed poorer on some cognitive tasks than those who were emotionally lonely and socially isolated.

The above findings highlight the need for those working with older adults to assess the type of loneliness or social isolation an individual is experiencing, and to determine the cause. It was suggested by Masi, Chen, Hawkley, and Cacioppo (2011) that due to the high correlation between emotional and social types of loneliness that it can be operationalised as a unidimensional construct. Yet the current study shows that different aspects of being lonely are differentially related to cognitive outcomes. Also, understanding that loneliness has different causes and consequences may be helpful to inform interventions in a way that increases their effectiveness. To date the research has indicated that interventions to reduce loneliness have had limited effect. Interventions such as working on maladaptive cognitions and stress reduction appear to be more successful than those that focus on increasing social interactions, developing greater social skills and increasing social support (Masi et al., 2011). In light of the current study's findings, increasing opportunity for social connections for the individual who is emotionally lonely but not alone more than likely will not reduce their experiences of loneliness. However, interventions such as those used in Cognitive Behavioural Therapy like self-assessment of maladaptive cognitions, emotions and behaviours, reframing of belongingness and loneliness, and identification of potential meaning in their experience of loneliness may be more beneficial.

Another area highlighted by the current study was that there is a unique variance associated with emotional loneliness after the variance of other related demographic, health and lifestyle factors is partialled out. This led to the speculative suggestion that emotional loneliness may result in the individual using emotional regulation strategies that are cognitively demanding, or emotionally lonely people are more prone to increased stress levels and/or reduce sleep. It is plausible that interventions that focus

on strategies to reduce the burden of emotional regulation, stress levels and increase sleep quality (such as mindfulness, psychoeducation on sleep hygiene, or stress reduction programmes) may be beneficial for cognition.

The findings that older adults who are emotionally lonely but not alone have poorer cognition is concerning as this subgroup of people may be vulnerable but overlooked. This group of participants may experience high levels of interpersonal conflict, or in the role of caregiving for a partner due to Alzheimer's disease. Those who are lonely but not alone may have personality traits that predispose them to feelings of loneliness or lack of belongingness. Importantly as this lonely group are not deemed socially isolated, those around them, as well as those who work with the older population may be unaware of the emotionally lonely person's distress, or may overlook this subgroup of older adults for interventions that may reduce feelings of loneliness. Wenger et al. (1996) noted that loneliness but not social isolation is related to experiencing a general sense of loss. Therefore, the lonely in a crowd in the current study may be experiencing the loss of a certain relationship. In another study it was suggested that those who were lonely but had a large social network, may have invested in quantity of social network members rather than quality of relationships with social network members, and strengthening of already established ties may be warranted (Lee & Ko, 2017). The 'lonely in a crowd' subgroup require further attention, as the current study showed that they are at risk for poorer cognitive decline than those experiencing loneliness and high levels of social isolation. Understanding who the lonely but not isolated adults are is important to ensure that resources and interventions target those who are most vulnerable to the detrimental effects of loneliness on cognition.

In conclusion, humans are motivated to belong and be socially connected with others (Baumeister & Leary, 1995; Cacioppo et al., 2006; MacDonald & Leary, 2005). However, the connection that may be most valued is that of being attached to other human beings who provides warmth, genuine concern and a sense of emotional



closeness and security. For the older adult the lack or perceived lack of relationship that provided a sense of emotional closeness and support in this study was shown to have a negative impact on cognitive performance as well as predicting poorer cognitive performance in the older adult two years later. Emotional loneliness in older people may be hard to ameliorate as well as being more persistent than social loneliness. The lack of an intimate other may not be remedied by having company from others who provide a different form of connectedness. The most important finding in this study could be that those who were emotionally lonely but not socially isolated had poorer scores at baseline in global cognition, language and visuospatial tasks, than those who were emotionally lonely and socially isolated. Though these associations were not extended to the longitudinal analysis, there is benefit for the literature on social relationships and cognition from the current study's contribution, in particular, the way it can inform practice of those working with older people whether it through assessment of needs or development of intervention programmes. It is hoped that the current research may assist those working with the older adult, the older adult themselves and their families to understand the importance of social connections at a meaningful level.

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## Appendices

# YOUR HEALTH, WELL-BEING, & QUALITY OF LIFE

- 1) In general, would you say your health is: (Please tick ONE circle)

Excellent	Very good	Good	Fair	Poor
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- 2) The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so how much?

(Tick ONE circle on each line)

	Yes, limited a lot	Yes, limited a little	No, not limited at all
<u>Moderate activities</u> , such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
Climbing <u>several</u> flights of stairs	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3

- 3) During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

(Tick ONE circle on each line)

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
<u>Accomplished less</u> than you would like	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
Were limited in the <u>kind</u> of work or other activities	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- 4) During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

(Tick ONE circle on each line)

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
<u>Accomplished less</u> than you would like	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
Did work or activities <u>less carefully than usual</u>	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- 5) These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much time during the past 4 weeks...

(Tick ONE circle on each line)

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
Have you felt calm and peaceful?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
Did you have a lot of energy?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
Have you felt downhearted and depressed?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- 6) During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)? (Please tick ONE circle)

Not at all	A little bit	Moderately	Quite a bit	Extremely
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- 7) During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)? (Please tick ONE circle)

All of the time	Most of the time	Some of the time	A little of the time	None of the time
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- 8) Below is a list of some of the ways you may have felt or behaved. Please indicate how often you have felt this way during the past week.

(Tick ONE circle on each line)

	Rarely or none of the time	Some or a little of the time	Occasionally or a moderate amount of time	All of the time
I was bothered by things that usually don't bother me	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I had trouble keeping my mind on what I was doing	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I felt depressed	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I felt that everything I did was an effort	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I felt hopeful about the future	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I felt fearful	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
My sleep was restless	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I was happy	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I felt lonely	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I could not "get going"	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

- 9) (a) How often do you have a drink containing alcohol? (Please tick ONE circle)

Never	Monthly or less	Two to four times per month	Two to three times per week	Four or more times a week
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- (b) Have you ever drunk alcohol in the past? (Please tick ONE circle)

Yes	No
<input type="radio"/> 1	<input checked="" type="radio"/> 2

(If you ticked 'No' please go to Q.10)

- (c) How many drinks containing alcohol do you have on a typical day when drinking? (Please tick ONE circle)

1 or 2	3 or 4	5 or 6	7 to 9	10 or more
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

- (d) How often do you have six or more drinks on one occasion? (Please tick ONE circle)

Never	Less than monthly	Monthly	Weekly	Daily or almost daily
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

**10) We would like to know the type and amount of physical activity involved in your daily life.**

**How often do you take part in sports or activities that are...**

(Tick ONE circle on each line)

	More than once a week	Once a week	One to three times a month	Hardly ever or never
...vigorous (e.g., running or jogging, swimming, aerobics)	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
...moderately energetic (e.g., gardening, brisk walking)	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
...mildly energetic (e.g., vacuuming, laundry/washing)	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

**11) Please tick 'Yes' to indicate if a health professional has told you that you have any of the following conditions. If possible, please also indicate your age when this condition was diagnosed or recognised.**

	Yes <input type="radio"/>	Approximate age
Anaemia (low iron)?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Arthritis or rheumatism?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Asthma?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Bowel disorders (e.g., colitis or polyps)?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Cancer? Please specify type (e.g. lung, leukaemia, melanoma): _____	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Chronic kidney or urinary tract conditions?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Chronic liver trouble (e.g., cirrhosis)?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Chronic skin conditions (e.g., dermatitis or psoriasis)?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Diabetes?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Epilepsy?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Hearing impairment?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Heart trouble (e.g., angina or heart attack)?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Hepatitis?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Hernia or rupture?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
High blood pressure or hypertension?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Intellectual disability/handicap?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Leg ulcers?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Mental illness?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Other respiratory conditions (e.g., bronchitis)?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Physical disability/handicap?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Sight impairment (that cannot be corrected by glasses)?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Sleep disorder?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Stomach ulcer or duodenal ulcer?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Stroke?	<input type="radio"/> 1	<input type="text"/> <input type="text"/>
Other? Please specify below: _____	<input type="radio"/> 1	<input type="text"/> <input type="text"/>

12) (a) Have you, at any stage of your life, ever been a regular smoker?

Yes	No	
<input type="radio"/> 1	<input checked="" type="radio"/> 2	→ (If you ticked 'No' please go to Q.13)

(b) If you currently consider yourself a regular smoker, how many do you think you would smoke on an average day? (Please tick ONE circle)

1 to 10 a day	11 to 20 a day	21 to 30 a day	31 or more a day	<b>OR</b>	Not a regular smoker
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4		<input type="radio"/> 5

13) Here is a list of statements that people have used to describe their lives or how they feel. We would like to know how often, if at all, you think this applies to you.

(Tick ONE circle on each line)

	Often ▼	Some- times ▼	Not often ▼	Never ▼
My age prevents me from doing the things I would like to	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I feel that what happens to me is out of my control	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I feel left out of things	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I can do the things that I want to do	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I feel that I can please myself what I do	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
Shortage of money stops me from doing things I want to do	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I look forward to each day	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I feel that my life has meaning	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I enjoy the things that I do	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I feel full of energy these days	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I feel that life is full of opportunities	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
I feel that the future looks good for me	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

14) The following questions are about your quality of life and health. Please think about your life in the last four weeks.

(Tick ONE circle on each line)

	Very poor ▼	Poor ▼	Neither good nor poor ▼	Good ▼	Very good ▼
How would you rate your quality of life?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

	Very dissatisfied ▼	Dissatisfied ▼	Neither satisfied nor dissatisfied ▼	Satisfied ▼	Very satisfied ▼
How satisfied are you with your health?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
How satisfied are you with your ability to perform your daily living activities?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
How satisfied are you with yourself?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
How satisfied are you with your personal relationships?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
How satisfied are you with the conditions of your living place?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

	Not at all ▼	A little ▼	Moderately ▼	Mostly ▼	Completely ▼
Do you have enough energy for everyday life?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5
Have you enough money to meet your needs?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5



## ***Family & Friends***



This section is about your relationships with your family members, neighbours and friends.

**15) Think about your current relationships with friends, family members, co-workers, community members and so on. To what extent do you agree that each statement describes your current relationships with other people?**

(Tick ONE circle on each line)

	Strongly Disagree ▼	Disagree ▼	Agree ▼	Strongly agree ▼
There are people I can depend on to help me if I really need it	1	2	3	4
I feel that I <u>do not</u> have close personal relationships with other people	1	2	3	4
There is no one I can turn to for guidance in times of stress	1	2	3	4
There are people who depend on me for help	1	2	3	4
There are people who enjoy the same social activities I do	1	2	3	4
Other people do not view me as competent	1	2	3	4
I feel personally responsible for the well-being of another person	1	2	3	4
I feel part of a group of people who share my attitudes and beliefs	1	2	3	4
I do not think other people respect my skills and abilities	1	2	3	4
If something went wrong, no one would come to my assistance	1	2	3	4
I have close relationships that provide me with a sense of emotional security and well-being	1	2	3	4
There is someone I could talk to about important decisions in my life	1	2	3	4
I have relationships where my competence and skills are recognized	1	2	3	4
There is no one who shares my interests and concerns	1	2	3	4
There is no one who really relies on me for their well-being	1	2	3	4
There is a trustworthy person I could turn to for advice if I were having problems	1	2	3	4
I feel a strong emotional bond with another person	1	2	3	4
There is no one I can depend on for aid if I really need it	1	2	3	4
There is no one I feel comfortable talking about problems with	1	2	3	4
There are people who admire my talents and abilities	1	2	3	4
I lack a feeling of intimacy with another person	1	2	3	4
There is no one who likes to do the things I do	1	2	3	4
There are people I can count on in an emergency	1	2	3	4
No one needs me to care for them	1	2	3	4

**16) How far away, in distance, does your nearest:**

(Tick ONE circle on each line)

	Same house/ within 1 kilometre ▼	1-5 kilometres ▼	6-15 kilometres ▼	16-50 kilometres ▼	50+ kilometres/ overseas ▼	Not applicable or none living ▼
child live?	1	2	3	4	5	6
brother or sister live?	1	2	3	4	5	6
relative live ( <u>not</u> including your spouse/child/siblings)?	1	2	3	4	5	6

**17) Do you attend any of the following:**

(Tick ONE circle on each line)

	Yes, regularly ▼	Yes, on occasion ▼	No ▼
Religious meetings	1	2	3
Meetings of any community/neighbourhood or social groups	1	2	3

**18) How often do you speak or do something with:**

(Tick ONE circle on each line)

	Daily ▼	2-3 times a week ▼	At least weekly ▼	At least monthly ▼	Less often ▼	Never / I have none ▼
any of your children or other relatives?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
any friends in your community/neighbourhood?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
any of your neighbours?	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6

**19) These questions are about your feelings of being supported. Please tell us who provides different types of support for you by ticking the appropriate circle below. You can tick more than one circle if more than one person provides this support. Tick the circle labelled 'No-one' if no-one offers this support to you.**

	Sources of social support									
	Partner ▼	Child or Grandchild ▼	Parent or Grandparent ▼	Extended Family ▼	Close Friends ▼	Colleagues ▼	Acquaintances ▼	Doctor/ Psychologist ▼	Other (s) ▼	No-one ▼
Who can you call on when you need to talk or discuss something?	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1
Who would you be able to rely on for help if you were sick?	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1
Who would you be able to rely on if you had financial problems?	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1
Suppose that you would like to go out for the day tomorrow and you don't want to go alone. Who do you think is very likely to want to go with you?	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1
Suppose that someone very close to you passes away. Who could you call on immediately – without making any sort of arrangement - for comfort?	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 1

**20) Please indicate for each of the statements below the extent to which they apply to the way you feel now. (Tick ONE circle on each line)**

	Yes ▼	More or less ▼	No ▼
There is always someone I can talk to about my day-to-day problems	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
I miss having a really close friend	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
I experience a general sense of emptiness	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
There are plenty of people I can lean on when I have problems	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
I miss the pleasure of the company of others	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
I find my circle of friends and acquaintances too limited	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
There are many people I can trust completely	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
There are enough people I feel close to	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
I miss having people around	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
I often feel rejected	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3
I can call on my friends whenever I need them	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3

21) The following questions are about getting along with people and how you feel you are treated in your own home. These people may be family members or others who come to visit you. (Tick ONE circle on each line)

	Yes ▼ (1)	No ▼ (2)
Are you afraid of anyone in your family?	(1)	(2)
Has anyone close to you tried to hurt you or harm you recently?	(1)	(2)
Has anyone close to you called you names or put you down or made you feel bad recently?	(1)	(2)
Do you have enough privacy at home?	(1)	(2)
Do you trust most of the people in your family?	(1)	(2)
Can you take your own medication and get around by yourself?	(1)	(2)
Are you sad or lonely often?	(1)	(2)
Do you feel that nobody wants you around?	(1)	(2)
Do you feel uncomfortable with anyone in your family?	(1)	(2)
Does someone in your family make you stay in bed or tell you you're sick when you know you're not?	(1)	(2)
Has anyone forced you to do things you didn't want to do?	(1)	(2)
Has anyone taken things that belong to you without your OK?	(1)	(2)

22) The following questions concern your feelings of being discriminated against by others. How often in your day to day life has any of the following happened to you?

(Tick ONE circle on each line).

	Almost daily ▼ (1)	At least once a week ▼ (2)	A few times a month ▼ (3)	A few times a year ▼ (4)	Less than once a year ▼ (5)	Never ▼ (6)
You are treated with less courtesy and respect than other people	(1)	(2)	(3)	(4)	(5)	(6)
You receive poorer service than other people at restaurants and stores	(1)	(2)	(3)	(4)	(5)	(6)
People act as if they think you are not smart	(1)	(2)	(3)	(4)	(5)	(6)
People act as though they are afraid of you	(1)	(2)	(3)	(4)	(5)	(6)
You are called names or insulted	(1)	(2)	(3)	(4)	(5)	(6)
You are threatened or harassed	(1)	(2)	(3)	(4)	(5)	(6)

23) What would you say is the single most important reason for any of these things above happening to you? Was it your: (Please tick ONE circle)

Race or ethnicity? (1) (2) Sexual orientation?

Gender? (3) (4) Disability?

Age? (5) (6) Religion?

Weight? (7) (8) Health?

Not applicable: I am not discriminated against (9) (10) Other (Please specify):

24) What is your religion? (Please tick ONE circle)

Christianity (1)	Islam (2)	Hinduism (3)	Sikh (4)	Judaism (5)
Buddhism (6)	Taoism (7)	Ratana (8)	Other (9)	No religion (10)

25) Is faith important to you?

Yes ☐ 1 No ☒ 2 → (If you ticked 'No' please go to Q.26)

If you ticked 'Yes' above, how important is your faith to you? (Please tick ONE circle)

A little important ☐ 1 Reasonably important ☐ 2 Very important ☐ 3

26) How often do you practice religion, attend services or otherwise participate in religious activities? (Please tick ONE circle)

Daily ☐ 1 Several times a week ☐ 2 Once a week ☐ 3 Once a month ☐ 4 Seldom or never ☐ 5 *Not practicing* ☐ 6

27) The next three questions concern personal matters and they are important from a research point of view to understand people's sense of happiness and experience. We hope you don't mind us asking them. Remember that you are not obliged to answer, so if there is a question that you cannot answer then please feel free to move straight on.

(a) Are you interested in sex? (Please tick ONE circle)

Not at all ☐ 1 A little ☐ 2 Quite a bit ☐ 3 Very much ☐ 4

(b) How often do you have sexual contact? (Please tick ONE circle)

Never ☐ 1 Occasionally ☐ 2 Often ☐ 3 Very often ☐ 4

(c) How would you describe your sexual orientation? (Please tick ONE circle)

Opposite sex attraction ☐ 1 Same sex attraction ☐ 2

Great effort! You've done well. Take a break if you like, get a cup of tea, and get ready for the next part.

## ***Your Caring Commitments***



The next section asks about caring roles you may perform for others (e.g., looking after sick relatives, caring for children).

Please answer the first question even if you do not undertake these sorts of roles.

**28) The following questions ask about childcare.**

**(a) Do you provide unpaid care for your grandchildren?** (Please tick ONE circle)

Yes, daily	Yes, weekly	Yes, occasionally	No, never	No, don't have grandchildren
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

**(b) Do you provide unpaid childcare for other people's children?** (Please tick ONE circle)

Yes, daily	Yes, weekly	Yes, occasionally	No, never
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

**29) Please indicate if you personally receive any home-based care and/or support for the following jobs or chores. If possible, please also indicate who pays for this care or support.**

	Yes, I receive support for this	Who pays for this support?			
		You or your family	A government agency (e.g., ACC, DHB)	Other	Don't know
Preparing your meals	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
Shopping for groceries and other things	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
Normal everyday housework (e.g., laundry)	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
Heavy household work (e.g., gardening)	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
Looking after your personal finances (e.g., paying bills)	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
Your personal care (e.g., bathing)	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4
Communicating with other people (e.g., at the doctor)	<input type="radio"/> 1	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

**30) These questions are about providing care for someone with a long-term illness, disability or frailty. By 'providing care' we mean practical assistance for at least 3 hours a week. Which of the following statements best applies to you?** (Please tick ONE)

I currently provide care for someone with a long-term illness, disability or frailty	<input type="radio"/> 1	If you ticked one of these please go to <b>question 31</b> below
I have been caring for someone with a long-term illness, disability or frailty who has passed away or moved into a nursing home or hospital in the last 12 months	<input type="radio"/> 2	
I used to provide care for someone with a long-term illness, disability or frailty more than 12 months ago but do not actively care for them now	<input type="radio"/> 3	If you ticked one of these please go to <b>question 33</b> on <b>page 14</b>
I have not provided cared for someone with a long-term illness, disability or frailty	<input type="radio"/> 4	
I currently provide care for someone with a long-term illness, disability or frailty as part of my paid work	<input type="radio"/> 5	

**31) If you ticked '1' or '2' above, how many people with a long-term illness, disability or frailty do/did you regularly provide care for?** (Please tick ONE circle)

One person	Two people	More than two people
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3

**32) Please select the person you have cared for the longest. Tell us about that person and their circumstances at the time of care.**

**(a) Approximately how old is/was the person you care(d) for?** Years

**(b) How long have/had you been caring for this person?** Years   Months

**(c) How often on average do (did) you provide this care or assistance?**  
(Please tick ONE circle)

Every day ☐ 1      Several times per week ☐ 2      Once a week ☐ 3      Once every few weeks ☐ 4      Less often ☐ 5

**(d) How much time on average do (did) you usually spend providing such care or assistance on each occasion?** (Please tick ONE circle)

All day and night ☐ 1      All day ☐ 2      All night ☐ 3      Several hours ☐ 4      About an hour ☐ 5

**(e) Is the person you care(d) for your:** (Please tick ONE circle)

Spouse or partner? ☐ 1      ☐ 2 Mother-in-law or father-in-law?  
Mother or father? ☐ 3      ☐ 4 Other relative?  
Son or daughter? ☐ 5      ☐ 6 Friend?  
Brother or sister? ☐ 7      ☐ 8 Other? (Please specify)

**(f) Does/did the person you care(d) for:** (Please tick ONE circle)

Live with you? ☐ 1      ☐ 2 Live alone?  
Live with their family? ☐ 3      ☐ 4 Live in a nursing home or care facility?  
Live with their friends? ☐ 5      ☐ 6 Other? (Please specify)

**(g) Does/did the person you care(d) for have any of the following major medical conditions or disabilities?** (Please tick ALL that apply)

Frailty in old age <input type="checkbox"/> 1	<input type="checkbox"/> 1 Cancer
Stroke <input type="checkbox"/> 1	<input type="checkbox"/> 1 Infectious disease
Alzheimer's disease / dementia <input type="checkbox"/> 1	<input type="checkbox"/> 1 Major injury (e.g., head or spinal)
Autoimmune disorder <input type="checkbox"/> 1	<input type="checkbox"/> 1 Respiratory condition (e.g., asthma, emphysema)
Intellectual disability or handicap <input type="checkbox"/> 1	<input type="checkbox"/> 1 Paralysis
Cerebral palsy <input type="checkbox"/> 1	<input type="checkbox"/> 1 Musculoskeletal condition (e.g., break / fracture)
Developmental disorder (e.g., Autism) <input type="checkbox"/> 1	<input type="checkbox"/> 1 Severe arthritis / rheumatism
Mental health problem (e.g., depression) <input type="checkbox"/> 1	<input type="checkbox"/> 1 Visual impairment
Substance abuse / addiction <input type="checkbox"/> 1	<input type="checkbox"/> 1 Other? (please specify)
Other neurological disorder (e.g., multiple sclerosis, motor neuron disease) <input type="checkbox"/> 1	



## ***Your Work or Retirement Status***



Nearly half-way there now.

The next section asks about whether you are working, retired or doing other things. You will be able to skip some of these questions.

**33) Please indicate your CURRENT employment status:**

Full-time paid employment, including self employment (35 or more hours per week)	(1)
Part-time paid work, including self employment (less than 35 hours per week)	(2)
Retired, no paid work	(3)
Full-time homemaker	(4)
Full-time student	(5)
Unable to work due to health or disability issue	(6)
Unemployed and seeking work	(7)
Other: (Please specify)	(8)

---

**34) Is your spouse/partner:**

Employed Full-time	Employed Part-time	Not employed	Not applicable
(1)	(2)	(3)	(4)

**35) Which of the following best describes:**

	(A) Your current occupation	(B) Your main occupation between 30-65
(a) Your current occupation?		
(b) Your main occupation between the ages of 30-65?		
Not in Paid Employment <u>OR</u> Retired	(1)	(1)
Labourer (e.g., Cleaner, food packer, farm worker)	(2)	(2)
Machinery Operator / Driver (e.g., Machine operator, store person)	(3)	(3)
Sales worker (e.g., Insurance agent, sales assistant, cashier)	(4)	(4)
Clerical / Administrative Worker (e.g., Administrator, personal assistant)	(5)	(5)
Community or Personal Service Worker (e.g., Teacher aide, armed forces, hospitality worker, carer)	(6)	(6)
Technician / Trades Worker (e.g., Engineer, carpenter, hairdresser)	(7)	(7)
Professional (e.g., Accountant, doctor, nurse, teacher)	(8)	(8)
Manager (e.g., General manager, farm manager)	(9)	(9)

If you are **CURRENTLY EMPLOYED** in either part-time or full-time work (including self-employment) please go to question 36 on the next page

If you are **NOT** currently employed please go straight to question 42 on page 17.

## For Those People Currently in Paid Work

36) How many hours do you currently work in paid employment per week?

Hours per week

--	--	--

37) Please indicate how much you agree or disagree with the following statements.

(Tick ONE circle on each line)

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
My job is usually interesting enough to stop me getting bored	1	2	3	4	5
It seems that my friends are more interested in their jobs	1	2	3	4	5
I consider my job rather unpleasant	1	2	3	4	5
I am often bored with my job	1	2	3	4	5
I feel fairly well satisfied with my present job	1	2	3	4	5
Most of the time I have to force myself to go to work	1	2	3	4	5
I feel that my job is just as interesting as any others I could get	1	2	3	4	5
I definitely dislike my work	1	2	3	4	5
I feel like I am happier in my work than most people	1	2	3	4	5
Most days I am enthusiastic about work	1	2	3	4	5
Each day of work feels like it will never end	1	2	3	4	5
I like my job better than the average worker does	1	2	3	4	5
My job is pretty uninteresting	1	2	3	4	5
I find real enjoyment in my work	1	2	3	4	5
I am disappointed that I ever took this job	1	2	3	4	5

38) Please indicate how much you agree or disagree with the following statements.

(Tick ONE circle on each line)

	Strongly disagree	Somewhat disagree	Moderately disagree	Neither agree nor disagree	Moderately agree	Somewhat agree	Strongly agree
I can financially afford to retire now	1	2	3	4	5	6	7
One reason I continue to work is because I cannot afford to retire	1	2	3	4	5	6	7
I worry about the standard of living I will have in retirement	1	2	3	4	5	6	7
I worry about having enough income in retirement	1	2	3	4	5	6	7
I am satisfied with what my family income will be in retirement	1	2	3	4	5	6	7
I feel secure that the government will financially support me in retirement	1	2	3	4	5	6	7
I feel pressure to retire	1	2	3	4	5	6	7

**39) The following statements refer to your current occupation. Please indicate the extent to which you disagree or agree with each statement.**

(Tick ONE circle on each line)

	Strongly Disagree	Disagree	Agree	Strongly agree
I have constant time pressure due to a heavy work load	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have many interruptions and disturbances while performing my job	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Over the past few years, my job has become more and more demanding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I receive the respect I deserve from my superior or a respective relevant person	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My job promotion prospects are poor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have experienced or I expect to experience an undesirable change in my work situation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My job security is poor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Considering all my efforts and achievements, I receive the respect and prestige I deserve at work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Considering all my efforts and achievements, my job promotion prospects are adequate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Considering all my efforts and achievements, my salary/income is adequate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I get easily overwhelmed by time pressures at work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
As soon as I get up in the morning I start thinking about work problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When I get home, I can easily relax and 'switch off' work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
People close to me say I sacrifice too much for my job	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Work rarely lets me go, it is still on my mind when I go to bed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If I postpone something that I was supposed to do today I'll have trouble sleeping at night	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**40) At what age do you think you will retire completely?**

I think I will retire at age

--	--	--

**41) Do you expect your spouse/partner to retire at about the same time as you?**

(Please tick ONE circle)

Yes	No	Spouse/partner not working	Not applicable
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## For Those People Who Are Currently Retired

Please answer the next questions if you are **CURRENTLY RETIRED** (either partly or completely). If you are **NOT** currently retired then please go to page 18.

42) What was your MAIN reason for stopping or reducing work? (Please tick ONE circle)

- |  |      |      |                                  |
|--|------|------|----------------------------------|
| Forced due to poor health                      | (1)  | (2)  | Wanted to do other things        |
| Forced due to disability or injury             | (3)  | (4)  | Don't need to work               |
| Forced by employer                             | (5)  | (6)  | Felt it was time to retire       |
| Made redundant                                 | (7)  | (8)  | Had care-giving responsibilities |
| Lacked skills to continue                      | (9)  | (10) | I relocated                      |
| Was unhappy at work                            | (11) | (12) | Business was sold                |
| Became eligible for New Zealand Superannuation | (13) | (14) | Other? (please specify)          |
- 

43) If you consider yourself **completely** retired:

(a) How long have you been retired?

<input type="text"/>	<input type="text"/>	Years	<input type="text"/>	<input type="text"/>	Months	OR	Tick if 'Not completely retired yet' <input type="radio"/>
----------------------	----------------------	-------	----------------------	----------------------	--------	----	--

(b) How satisfying did you find your previous work? (Please tick ONE circle)

Extremely unsatisfying	Unsatisfying	Somewhat unsatisfying	Neither satisfying nor unsatisfying	Somewhat satisfying	Satisfying	Extremely satisfying
(1)	(2)	(3)	(4)	(5)	(6)	(7)

(c) How long did it take you to get used to retirement? (Please tick ONE circle)

Less than one month	Six months	Nine months	One year	Two years	I'm not used to retirement yet
(1)	(2)	(3)	(4)	(5)	(6)

(d) How difficult has it been for you to adjust to retirement? (Please tick ONE circle)

Very difficult	←————→			Not difficult at all
(1)	(2)	(3)	(4)	(5)

(e) All in all, would you say that your retirement has turned out to be: (Please tick ONE circle)

Very satisfying	Somewhat satisfying	Not at all satisfying
(1)	(2)	(3)

**You are now over half-way through the questionnaire. Time for a cuppa or a break?**



## ***Your Financial Wellbeing***

The next section asks about your financial circumstances and living costs. We know that a lot of people don't like to answer questions about their income, and that is very understandable. But having this information about New Zealanders in general is very important for the success of this study. So we would really appreciate it if you would agree to answer these questions.

Please be assured that your answers to these questions are completely confidential.

If you have any concerns about answering these questions then please feel free to contact us:

**Phone:** 0800-100-134

**Email:** NZLSA@massey.ac.nz

**44) What are ALL the ways you PERSONALLY got income in the last 12 months?**

Wages, salary, commissions, bonuses...etc, paid by my employer	1
Self-employment, or business I own and work in	1
Interest, dividends, rent, other investments	1
Regular payments from ACC or a private work accident insurer	1
New Zealand Superannuation or Veterans Pension	1
Transitional Retirement Benefit	1
Other superannuation, pensions, annuities (other than NZ Superannuation, Veterans Pension or War Pension)	1
Unemployment Benefit	1
Working for Families Tax Credits	1
Accommodation supplement	1
Domestic Purposes Benefit	1
Invalids Benefit	1
Student Allowance	1
Unsupported Child Benefit	1
Other government benefits, income support payments, or war pensions	1
Other sources of income, counting support payments from people who do not live in my household	1
No source of income during that time	1

**45) What are ALL the ways your HOUSEHOLD got income in the last 12 months?**

You may not know your household's exact income or all the sources of this income, but please give us your best estimate as this will be important information for us.

Wages, salary, commissions, bonuses...etc, paid by employer	1
Self-employment	1
Interest, dividends, rent, other investments	1
Regular payments from ACC or a private work accident insurer	1
New Zealand Superannuation or Veterans Pension	1
Transitional Retirement Benefit	1
Other superannuation, pensions, annuities (other than NZ Superannuation, Veterans Pension or War Pension)	1
Unemployment Benefit	1
Working for Families Tax Credits	1
Accommodation supplement	1
Domestic Purposes Benefit	1
Invalids Benefit	1
Student Allowance	1
Unsupported Child Benefit	1
Other government benefits, income support payments, or war pensions	1
Other sources of income, counting support payments from people who do not live in my household	1
No source of income during that time	1

The next few questions refer to your estimated personal and household income, and your current housing costs. We want to know about:

1. the range of incomes received by people in the study and how adequate they are to meet essential costs; and
2. housing costs because it is one of the biggest expenses people pay.

We would really appreciate it if you would agree to answer the next few questions. Please be assured that your answers to these questions are completely confidential.

**46) From all the sources you listed on the previous page, what is your total PERSONAL income? Complete ONE box only. Use either the before tax or after tax amount, and choose just one of the time periods (e.g., weekly or annually).**

(Complete ONE box only)

<b><u>BEFORE TAX PERSONAL INCOME</u></b>		<b>OR</b>	<b><u>AFTER TAX PERSONAL INCOME</u></b>	
Weekly	\$		Weekly	\$
Fortnightly	\$		Fortnightly	\$
Monthly	\$		Monthly	\$
Annually	\$		Annually	\$

**47) What is your total HOUSEHOLD income? Complete ONE box only. Use either the before tax or after tax amount, and choose just one of the time periods (e.g., weekly or annually).**

(Complete ONE box only)

<b><u>BEFORE TAX HOUSEHOLD INCOME</u></b>		<b>OR</b>	<b><u>AFTER TAX HOUSEHOLD INCOME</u></b>	
Weekly	\$		Weekly	\$
Fortnightly	\$		Fortnightly	\$
Monthly	\$		Monthly	\$
Annually	\$		Annually	\$

**48) Please indicate below how much your current housing costs are and how frequently you pay this amount.**

<b>HOME OWNERS</b>	If you own (freehold, leasehold, or under a "licence to occupy") your current residence, please include mortgage repayments, rates, insurance, lease costs and retirement village or body corporate fees.
<b>RENTERS or BOARDERS</b>	Please consider just your regular rental/board payments.

I pay \$\_\_\_\_\_ in housing costs.

I pay this amount every...(Please tick ONE circle below)

Week	Fortnight	Month	Quarter	Year	Other (Please specify below)
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6 _____



**49) For the following questions, please indicate whether or not you have (or have access to) the item:** (Tick ONE circle on each line)

	Yes, I have it ▼	No, because I don't want it ▼	No, because of the cost ▼	No, for some other reason ▼
Telephone	1	2	3	4
Washing machine	1	2	3	4
At least two pair of good shoes	1	2	3	4
Suitable clothes for important or special occasions	1	2	3	4
Personal computer	1	2	3	4
Home contents insurance	1	2	3	4
Enough room for family to stay the night	1	2	3	4

**50) For the following questions, please indicate whether or not you do the activity:**  
(Tick ONE circle on each line)

	Yes, I do it ▼	No, because I don't want to ▼	No, because of the cost ▼	No, for some other reason ▼
Keep the main rooms of your home adequately warm	1	2	3	4
Give presents to family or friends on birthdays, Christmas or other special occasions	1	2	3	4
Visit the hairdresser at least once every three months	1	2	3	4
Have holidays away from home for at least a week every year	1	2	3	4
Have a holiday overseas at least every three years	1	2	3	4
Have a night out for entertainment or socialising at least once a fortnight	1	2	3	4
Have family or friends over for a meal at least once every few months	1	2	3	4

**51) In the last 12 months, have you done any of these things not at all, a little, or a lot?**  
(Tick ONE circle on each line)

	Not at all ▼	A little ▼	A lot ▼
Gone without or cut back on fresh fruit and vegetables to help keep down costs	1	2	3
Continued wearing clothing that was worn out because you couldn't afford a replacement	1	2	3
Put off buying clothes for as long as possible to help keep down costs	1	2	3
Stayed in bed longer to save on heating costs	1	2	3
Postponed or put off visits to the doctor to help keep down costs	1	2	3
NOT picked up a prescription to help keep down costs	1	2	3
Spent less time on hobbies than you would like to help keep down costs	1	2	3
Done without or cut back on trips to the shops or other local places to help keep down costs	1	2	3

**52) The following questions are about your material standard of living – the things that money can buy. Your material standard of living does NOT include your capacity to enjoy life. You should NOT take your health into account.**

**(a) Generally, how would you rate your material standard of living?** (Please tick ONE circle)

High	Fairly high	Medium	Fairly low	Low
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

**(b) Generally, how satisfied are you with your current material standard of living?**

Very satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Very dissatisfied
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

**(c) How well does your total income meet your everyday needs for such things as accommodation, food, clothing and other necessities?** (Please tick ONE circle)

Not enough	Just enough	Enough	More than enough
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

**53) What assets do you and/or your partner own?** (Tick ALL that apply)

No assets	<input type="radio"/> 1	<input type="radio"/> 1	Any bank deposits or savings
Estate and trust funds	<input type="radio"/> 1	<input type="radio"/> 1	Any managed funds
A motor vehicle or vehicles	<input type="radio"/> 1	<input type="radio"/> 1	Any shares
Your own home	<input type="radio"/> 1	<input type="radio"/> 1	A rental property or properties
A holiday home	<input type="radio"/> 1	<input type="radio"/> 1	Other <u>major</u> assets (please specify below):
A business or businesses	<input type="radio"/> 1		
A farm or farms	<input type="radio"/> 1		

**54) Could you tell us the Government/Capital Valuation of your dwelling (including land), that is on your rates bill?**

Value \$ 

--	--	--	--	--	--	--	--

**55) Overall, and not counting the value of your family home, what do you think these assets would be worth after subtracting mortgages owing, loans and unpaid bills?**  
(Please tick ONE circle)

Loss	<input type="radio"/> 1	<input type="radio"/> 2	\$0
\$1 to \$5,000	<input type="radio"/> 3	<input type="radio"/> 4	\$5,001 to \$10,000
\$10,001 to \$25,000	<input type="radio"/> 5	<input type="radio"/> 6	\$25,001 to \$50,000
\$50,001 to \$100,000	<input type="radio"/> 7	<input type="radio"/> 8	\$100,001 to \$250,000
\$250,001 to \$500,000	<input type="radio"/> 9	<input type="radio"/> 10	\$500,001 to \$1,000,000
\$1,000,001 to \$1,500,000	<input type="radio"/> 11	<input type="radio"/> 12	\$1,500,001 to \$2,000,000
\$2,000,000 or more	<input type="radio"/> 13		

**56) Do you currently have a student loan?** (Please tick ONE circle)

No ☐ 1      Yes ☐ 2      → If yes, please indicate the amount of the loan below:

Value \$ 

--	--	--	--	--	--	--	--

57) How many people inside and beyond your household, excluding yourself, are dependent on you for their financial support?

Total number of people

OR 'I have no dependents' ☐

58) At what age did you, or others on your behalf, start saving for your retirement?

Age

AND/OR

'I'm not currently saving for retirement' ☐

59) Other than New Zealand Superannuation, please indicate what sources of financial support you and your partner (if applicable) currently have which will support you in your retirement years: (Tick ALL that apply)

	Yourself	Your partner (if applicable)
None	<input type="radio"/>	<input type="radio"/>
Kiwisaver	<input type="radio"/>	<input type="radio"/>
Other employer sponsored superannuation	<input type="radio"/>	<input type="radio"/>
Overseas superannuation or pension	<input type="radio"/>	<input type="radio"/>
Other pension or superannuation	<input type="radio"/>	<input type="radio"/>
Personal savings	<input type="radio"/>	<input type="radio"/>
Personal investments	<input type="radio"/>	<input type="radio"/>

## ***Living in Your Neighbourhood***



The next section asks you about living in, and getting around, your neighbourhood.

**60) Please answer the next set of questions about your feelings of safety.**

(Tick ONE circle on each line)

	Yes	No
Do you ever walk alone in your neighbourhood during the day?	<input type="radio"/> 1	<input type="radio"/> 2
Do you ever walk alone in your neighbourhood at night?	<input type="radio"/> 1	<input type="radio"/> 2
Over the last 12 months, have you been in a situation in your <u>neighbourhood</u> when your safety was threatened by someone else?	<input type="radio"/> 1	<input type="radio"/> 2
Over the last 12 months, have you been in a situation in your <u>home</u> when your safety was threatened by someone else?	<input type="radio"/> 1	<input type="radio"/> 2

**61) Is getting to the shops difficult for you? Why is this?** (Please tick ALL that apply)

**Yes** → Because

- ☐ 1 The footpaths are inadequate
- ☐ 1 I do not feel safe
- ☐ 1 There is no public transport
- ☐ 1 There is public transport but the timetable is inappropriate
- ☐ 1 My health/disability makes walking or catching public transport difficult
- ☐ 1 Other reason (please specify):

---

**No** → Because

- ☐ 1 I can walk comfortably
- ☐ 1 I have my own transport
- ☐ 1 I can use public transport
- ☐ 1 Someone else takes me
- ☐ 1 Other reason (please specify):

---

**62) Which other types of places do you have difficulty getting to:** (Tick ALL that apply)

N/A (I do not have difficulties) ☐ 1 ☐ 1 Leisure activity

Medical centres ☐ 1 ☐ 1 Friend's place

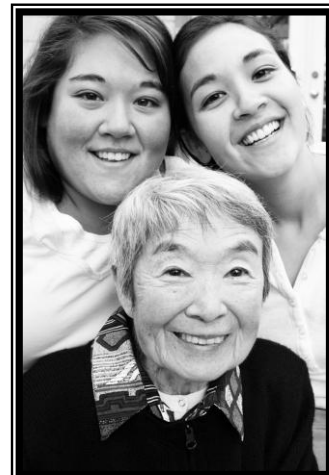
Church/Temple ☐ 1 ☐ 1 Family member's place

Library ☐ 1 ☐ 1 Other (Please specify):

---

Whew! That was the hardest part! Thanks so much for helping with this information. Give yourself another break. We are nearly at the finish. We think you will enjoy our final questions.

## ***Your Personal Situation***



This last section asks about general information on who you are, where you are from, and who is in your household.



63) When were you born?

Day		Month		19	Year	

64) Are you (Please tick ONE circle)

Male	Female
<input type="radio"/>	<input type="radio"/>

65) Which one of these statements is true about you? (Please tick ONE circle)

(Please answer for your most recent marriage or partnership)

I am legally married	<input type="radio"/>
I am in a civil union/de facto/partnered/opposite sex relationship	<input type="radio"/>
I am in a civil union/de facto/partnered/same sex relationship	<input type="radio"/>
I am divorced or permanently separated from my legal husband or wife	<input type="radio"/>
I am a widow or widower	<input type="radio"/>
I am single (but not a widow or widower)	<input type="radio"/>

66) What age is your partner?

<table border="1" style="display: inline-table;"> <tr> <td style="width: 40px; height: 30px;"></td> <td style="width: 40px; height: 30px;"></td> <td style="width: 40px; height: 30px;"></td> </tr> </table>				Years old	<u>OR</u>	Tick if question not applicable <input type="radio"/>

67) What is your highest educational qualification? (Please tick ONE circle)

No qualifications	<input type="radio"/>
Secondary school qualifications (e.g., School Certificate, University entrance, NCEA)	<input type="radio"/>
Post-secondary certificate, diploma, or trade diploma	<input type="radio"/>
University degree	<input type="radio"/>

68) (a) Which of the following best describes the type of residence that you live in?

House or townhouse – detached or ‘stand alone’	<input type="radio"/>
House, townhouse, unit or apartment joined to one or more other houses, townhouses, units or apartments	<input type="radio"/>
Unit, villa or apartment in Retirement Village (licence to occupy)	<input type="radio"/>
Moveable dwelling (e.g., caravan, motor home, boat, tent)	<input type="radio"/>
Rest home or continuing care hospital	<input type="radio"/>
Other (Please specify below):	<input type="radio"/>

(b) Please indicate whether the residence that you live in is: (Please tick ONE circle)

Owned by yourself and/or spouse/partner with a mortgage	<input type="radio"/>
Owned by yourself or spouse/partner without a mortgage	<input type="radio"/>
Owned by a family trust	<input type="radio"/>
Rented	<input type="radio"/>
None of the above – you are a boarder	<input type="radio"/>
Other (Please specify below):	<input type="radio"/>

69) (a) In what year did you move to your current location of residence?

Year

--	--	--	--

(b) Where did you move from (e.g., name of city, town or overseas country)?

\_\_\_\_\_

(c) What was your main reason for moving to your current residence? (Please tick ONE circle)

- |                             |                          |                          |   |
|-----------------------------|--------------------------|--------------------------|---|
| To be near or with children | <input type="radio"/> 1  | <input type="radio"/> 2  | To be near or with other relatives or friends |
| Change in marital status    | <input type="radio"/> 3  | <input type="radio"/> 4  | Health problems or to be closer to health     |
| Returning to family lands   | <input type="radio"/> 5  | <input type="radio"/> 6  | Work or retirement related                    |
| To free up equity           | <input type="radio"/> 7  | <input type="radio"/> 8  | Larger home                                   |
| Smaller home                | <input type="radio"/> 9  | <input type="radio"/> 10 | Easier maintenance of house and/or gardens    |
| Leisure activities          | <input type="radio"/> 11 | <input type="radio"/> 12 | Climate or weather                            |
| Other (please specify):     | <input type="radio"/> 13 |                          |   |

\_\_\_\_\_

70) Please tick as many circles as you need to show all the people who live in the same household as you. Please also put in the NUMBERS of each category that you tick.

Number

My legal husband or wife	<input type="radio"/> 1	
My partner or de facto, boyfriend or girlfriend	<input type="radio"/> 1	
My son(s) and/or daughter(s)	<input type="radio"/> 1	
My parent(s) and/or parent(s)-in-law	<input type="radio"/> 1	
My sister(s) and/or brother(s)	<input type="radio"/> 1	
My flatmate(s)	<input type="radio"/> 1	
My grandchild(ren)	<input type="radio"/> 1	
My friend(s)	<input type="radio"/> 1	
My boarder(s)	<input type="radio"/> 1	
Other(s) (please specify): _____	<input type="radio"/> 1	
None of the above – I live alone.	<input type="radio"/> 1	

71) We would like to know whether you participate in other recreational activities. Please indicate below how often you have:

(Tick ONE circle on each line)

	Never	Once a year	Twice a year	4 times a year	Monthly	Weekly
Been a spectator at a sports event	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Gone to a concert, movie, play or other cultural event	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Gone to a restaurant, café, pub or bar	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Gone to the TAB, casino, horse or dog track, or similar	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Gone to a barbeque, hangi, or similar event	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Gone to a library or museum	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6
Participated in an outdoor activity (walking, cycling, etc.)	<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6



**72) Please indicate below which ethnic group or groups you belong to:** (Tick ALL that apply)

- |  |                          |                          |         |
|--|--------------------------|--------------------------|---------|
| New Zealand European                     | <input type="checkbox"/> | <input type="checkbox"/> | Niuean  |
| Māori                                    | <input type="checkbox"/> | <input type="checkbox"/> | Chinese |
| Samoan                                   | <input type="checkbox"/> | <input type="checkbox"/> | Indian  |
| Cook Island Māori                        | <input type="checkbox"/> | <input type="checkbox"/> | Tongan  |
| Other (e.g., Dutch, Japanese, Tokelauan) | <input type="checkbox"/> |                          |         |

(Please specify): \_\_\_\_\_

**73) Please indicate below which ethnic group you feel you identify with the most:** (Please tick ONE)

- |  |                       |                       |         |
|--|-----------------------|-----------------------|---------|
| New Zealand European                     | <input type="radio"/> | <input type="radio"/> | Niuean  |
| Māori                                    | <input type="radio"/> | <input type="radio"/> | Chinese |
| Samoan                                   | <input type="radio"/> | <input type="radio"/> | Indian  |
| Cook Island Māori                        | <input type="radio"/> | <input type="radio"/> | Tongan  |
| Other (e.g., Dutch, Japanese, Tokelauan) | <input type="radio"/> |                       |         |

(Please specify): \_\_\_\_\_

**74) Please answer the following questions about the ethnic group you said you most identify with.**

(Tick ONE circle on each line)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
	▼	▼	▼	▼	▼
I have spent time trying to find out more about my ethnic group, such as its history, traditions, and customs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have a strong sense of belonging to my own ethnic group	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I understand pretty well what my ethnic group membership means to me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have often done things that will help me understand my ethnic background better	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have often talked to other people in order to learn more about my ethnic group	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel a strong attachment towards my own ethnic group	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**75) In which language(s) could you have a conversation covering everyday things?**

- |  |                          |                          |         |
|--|--------------------------|--------------------------|---------|
| New Zealand European                     | <input type="checkbox"/> | <input type="checkbox"/> | Niuean  |
| Māori                                    | <input type="checkbox"/> | <input type="checkbox"/> | Chinese |
| Samoan                                   | <input type="checkbox"/> | <input type="checkbox"/> | Indian  |
| Cook Island Māori                        | <input type="checkbox"/> | <input type="checkbox"/> | Tongan  |
| Other (e.g., Dutch, Japanese, Tokelauan) | <input type="checkbox"/> |                          |         |

(Please specify): \_\_\_\_\_

**If you have Māori ancestry, please complete question 76 below.  
If you do not have Māori ancestry, please turn to question 77 on the next page**

**76) (a) Do you identify as Māori?**

Yes	No
<input type="radio"/> 1	<input type="radio"/> 2

**(b) How many generations of your Māori ancestry can you name?** (Please tick ONE circle)

1 generation (parents)	2 generations (grandparents)	3 generations (great-grandparents)	More than 3 generations
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

**(c) Have you ever been to a marae; and if yes – how often over the past 12 months?**  
(Please tick ONE circle)

Not at all	Once	A few times	Several times	More than once a month
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5

**(d) In terms of your involvement with your whanau, would you say that your whanau plays...** (Please tick ONE circle)

A very large part in your life	A large part in your life	A small part in your life	A very small part in your life
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

**(e) Do you have a financial interest in Māori land (i.e., as an owner, part/potential owner or beneficiary)?** (Please tick ONE circle)

Yes	No	Not sure/don't know
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3

**(f) This question considers your contacts with people. In general, would you say that your contacts are with...** (Please tick ONE circle)

Mainly Māori	Some Māori	Few Māori	No Māori
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4

**(g) How would you rate your overall ability with Māori language?** (Please tick ONE circle)

Excellent	Very good	Good	Fair	Poor	Not applicable
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6

**77) These are questions about your participation in organisations and clubs. Please indicate below how often you attend each organisation or club and whether you have a leadership role in any of these organisations or clubs (e.g., serve on the Trust Board, committee, or coach or mentor others, etc.).**

	How often do you participate in the following types of organisations or groups?							Do you perform a committee or leadership role? Yes
	Never	Once a year	Twice a year	4 times a year	Monthly	Weekly		
Sports clubs	1	2	3	4	5	6	→	1
Community or service organisation that helps people	1	2	3	4	5	6	→	1
Trade union or professional associations	1	2	3	4	5	6	→	1
Political party	1	2	3	4	5	6	→	1
Religious or church organisations	1	2	3	4	5	6	→	1
Choir, drama or music society	1	2	3	4	5	6	→	1
Hobby or leisure-time association	1	2	3	4	5	6	→	1
School or Kohango Reo organisation	1	2	3	4	5	6	→	1
RSA, Workingman's Clubs	1	2	3	4	5	6	→	1
Women's organisations	1	2	3	4	5	6	→	1
An organisation of my ethnic group	1	2	3	4	5	6	→	1
Other ethnic organisations apart from my own	1	2	3	4	5	6	→	1
Any other club, lodge, group or similar organisation (Please specify): _____	1	2	3	4	5	6	→	1

**78) In general, how happy or unhappy do you usually feel?**

Extremely unhappy	Pretty unhappy	Slightly unhappy	Slightly happy	Pretty happy	Extremely happy
0	1	2	3	4	5
6	7	8	9	10	

**79) All things considered, how satisfied are you with your life as a whole these days?**

Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
1	2	3	4	5



## Request for an interview

This study is being done *by* New Zealanders *for* New Zealanders, to help us understand what factors might help New Zealanders have a better, active, and more fulfilling life. In addition to completing this questionnaire we are also very interested in interviewing you regarding your current life situation. You are under no obligation to be interviewed but if you would like to be interviewed then we would love to hear from you.

The interviews will be conducted between 1<sup>st</sup> September and 24<sup>th</sup> December 2010. If you are interested in being interviewed please tick the circle below and fill in your contact details so we will be able to contact you and arrange a time for an interview that suits you:

Please TICK here

**"Yes, I would like to be interviewed"** ☐

**Please note:** Your contact details will remain confidential and will not be used for any other purpose.

**Name:** \_\_\_\_\_

**Address:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Phone:** \_\_\_\_\_

**Email:** \_\_\_\_\_

**Please turn the page**

We have found that over the years people’s circumstance might change (e.g., they move house) and that we can lose track of people if they don’t let us know of their new address. To remedy this we would like you to nominate three people whom we can contact in the event that we do lose track of you. You do not have to do this, but it would help us. Please ensure that those you name are happy to act as contact people. We will only contact these people in the event that we cannot locate you.

Contact Person Number 1	
Name:	
<div></div> <div>Surname</div>	<div></div> <div>First Name</div>
Address:	Phone:
<div></div>	<div></div>
<div></div>	
<div></div>	Email:
<div></div>	<div></div>

Contact Person Number 2	
Name:	
<div></div> <div>Surname</div>	<div></div> <div>First Name</div>
Address:	Phone:
<div></div>	<div></div>
<div></div>	
<div></div>	Email:
<div></div>	<div></div>

Contact Person Number 3	
Name:	
<div></div> <div>Surname</div>	<div></div> <div>First Name</div>
Address:	Phone:
<div></div>	<div></div>
<div></div>	
<div></div>	Email:
<div></div>	<div></div>



**NEW ZEALAND LONGITUDINAL STUDY OF AGEING**

**Questionnaire Cover Sheet**

	<b>RESPONDENT ID</b>			
<b>NZ</b>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

<b>INTERVIEWER</b>
<input type="text"/>

<b>DATE</b>
<input type="text"/>

NO. OF SUPPLEMENTARY SHEETS USED:  
Enter "0" if none used

NOTES:

**Thank you very much for agreeing to this interview. It will be very important for our study and I hope that you will find it interesting as well.**

First we have some housekeeping questions. You will already have answered most of these in the postal survey, but we will ask these again in case anything has changed.

1. Could you tell me your date of birth, please? *Write dates in box*

dd	mm	yyyy

*(Circle ONE number)*

2. Could you tell me which of these ethnicities you identify with, please? You can identify more than one. *(Circle as many numbers as apply)*

New Zealand European	1
Māori	2
Samoan	3
Tongan	4
Niuean	5
Cook Island Māori	6
Tokelauan	7
Chinese	8
Indian	9
Other- such as Dutch, Japanese, Tokelauan (Please specify):	10

\_\_\_\_\_

3. Now could you tell me about your relationship Status, please? Are you: *(Circle ONE number)*

Single	1
Married	2
Civil Union	3
De-facto	4
Divorced/ permanently separated	5
Widowed	6
Other (please specify) _____	7

**4.** Now I'd like to ask about who lives with you in your household. I have some options to read and I'd like you to tell me which one applies to you: Do you: *Read out* (Circle ONE number)

Live alone 1

Live with a partner 2

Live with a partner and others 3

Live with others but not a partner 4

**5.** How many people live in your household? *Write number in box*

**6.** How many, if any, of them are aged less than 18 years? *Write number in box*

**7.** Could you tell me the highest qualification you have obtained, please? *Read out*  
(Circle ONE number)

No Qualifications 1

Secondary School qualification (school certificate, university entrance) 2

Post-secondary certificate or diploma 3

University Degree 4

**8.** In general do you feel your health is: *Read out* (Circle ONE number)

Excellent 1

Very good 2

Good 3

Fair 4

Poor 5

**9.** How would you rate your memory at the present time? *Read out* (Circle ONE number)

Excellent 1

Very good 2

Good 3

Fair 4

Poor 5



**10.** How would you rate your memory now compared to two years ago? *Read out (Circle ONE number)*

Better

1

The same

2

Worse

3

**NB**

***NOTE: THE ACE-R WILL OCCUPY THE NEXT 27 QUESTIONS, and begins on the next page. The ACE-R score entry boxes are numbered consecutively from 11 to 37 in the right hand margin to aid data entry.***

***The first question is about the respondent's handedness (whether they are right or left handed. Please ask them:***

**Are you left handed or right handed?**

*Record the response as instructed on the next page.*

***Important note: If you notice that the respondent does not use his or her dominant hand to perform tasks, such as writing and drawing, please note this on the notes section of the questionnaire cover.***

# ADDENBROOKE'S COGNITIVE EXAMINATION – ACE-R

## Revised Version C (2004) - NZ Adaptation 1f (December 2007)

Enter 1

Name :  
Date of birth :  
NHI number :

Date of testing :  
Tester's name :  
Age at leaving full-time education :  
Occupation :  
Handedness :

### ORIENTATION

➤ Ask: What is the	Day	Date	Month	Year	Season	[Score 0-5]
➤ Ask: Which	Building/ Address	Floor/Ward	Town/Suburb	City	Country	[Score 0-5]

### REGISTRATION

➤ Tell: 'I'm going to give you the name of three objects and I'd like you to repeat after me: shoe, flag, tree'. After subject repeats, say 'Try to remember those because I'm going to ask you later'. Score <i>only</i> the first trial (repeat 3 times if necessary). Register number of trials _____	[Score 0-3]
---	-------------

### ATTENTION & CONCENTRATION

➤ Ask the subject: 'could you take seven away from a hundred?'. And then seven from each response (5 subtractions). If subject fails, ask: 'did you mean ?' If subject still makes a mistake, switch to spelling. If subject corrects himself or herself, continue. Stop after five subtractions (93, 86, 79, 72, 65). _____	[Score 0-5]  (for the best performed task)
➤ Ask: 'could you please spell <b>WORLD</b> for me? Then ask him/her to spell it backwards:  <div style="text-align: center;"> <u>      </u> <u>      </u> <u>      </u> <u>      </u> <u>      </u>  <b>D    L    R    O    W</b> </div>	

### MEMORY - Recall

➤ Ask: 'Which 3 objects I asked you to repeat and remember?' _____	[Score 0-3] <div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>
---	--

### MEMORY – Anterograde Memory

➤ Tell: 'I'm going to give you a name and address and I'd like you to repeat after me. We'll be doing that 3 times, so you have a chance to learn it because I'll be asking you later'  Score only the third trial	[Score 0 – 7] <div style="border: 1px solid black; width: 40px; height: 20px; margin: 0 auto;"></div>
--	--

	1 <sup>st</sup> Trial	2 <sup>nd</sup> Trial	3 <sup>rd</sup> Trial
John Martin	--	--	--
24 Market Street	---	---	---
Masterton	-	-	-
Wairarapa	-	-	-

### MEMORY – Retrograde Memory

➤ Name of current Prime Minister _____ ➤ Name of British Royal family member who died in a car crash in Paris ? _____ ➤ Name of the current USA president _____ ➤ Name of the USA president who was assassinated in the 1960s _____	[Score 0 – 4]
--	---------------

## VERBAL FLUENCY - Letter 'P' and animals

### ➤ Letters

Say: 'I'm going to give you a letter of the alphabet and I'd like you to generate as many words as you can beginning with that letter, but not names of people or places. Are you ready? You've got a minute for that and the letter is letter P'

[Score 0 – 7]

>17	7
14-17	6
11-13	5
8-10	4
6-7	3
4-5	2
3-4	1
<3	0
total	correct

### ➤ Animals

Say: 'Now let's change. I'd like you to generate as many animals as possible, any kind of animal, beginning with any letter, it doesn't matter'.

[Score 0 – 7]

>21	7
17-21	6
14-16	5
11-13	4
9-10	3
7-8	2
5-6	1
<5	0
total	correct

## LANGUAGE - Comprehension

➤ Show written instruction:

[Score 0-1]

# Close your eyes

➤ 3 stage command:

**'Take the paper in your left hand. Fold the paper in half. Put the paper on the floor'**

[Score 0-3]

*(use right hand if subject is left handed)*

## LANGUAGE - Writing

➤ Ask the subject to make up a sentence and write it in the space below:

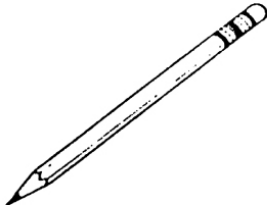
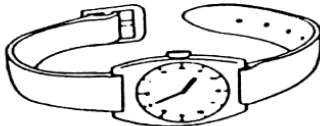
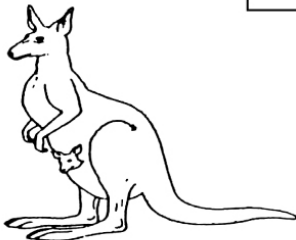

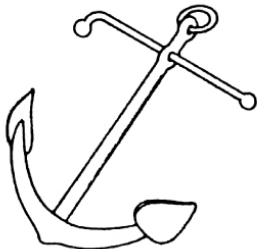
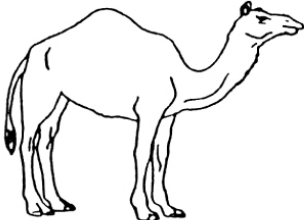

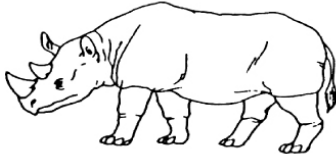



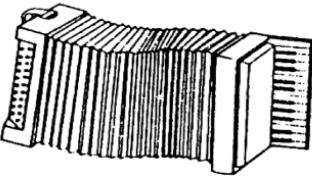
Score 1 if sentence contains a subject and a verb (see guide for examples)

[Score 0-1]

LANGUAGE - Repetition

➤ Ask the subject to repeat: 'hippopotamus'; 'eccentricity'; 'unintelligible'; 'statistician' Score 2 if all correct; 1 if 3 correct; 0 if 2 or less.	[Score 0-2] <input type="text"/> Language
➤ Ask the subject to repeat: 'Above, beyond and below'	[Score 0-1] <input type="text"/> Language
➤ Ask the subject to repeat: 'No ifs, ands or buts'	[Score 0-1] <input type="text"/> Language

LANGUAGE - Naming

➤ Ask the subject to name the following pictures:			[Score 0-2] pencil + watch <div></div>
<div><div></div><div></div></div>	<div><div></div><div></div></div>	<div><div></div><div></div></div>	Language
<div><div></div><div></div></div>	<div><div></div><div></div></div>	<div><div></div><div></div></div>	[Score 0-10] <div></div> Language
<div><div></div><div></div></div>	<div><div></div><div></div></div>	<div><div></div><div></div></div>	
<div><div></div><div></div></div>	<div><div></div><div></div></div>	<div><div></div><div></div></div>	

LANGUAGE - Comprehension

➤ Using the pictures above, ask the subject to: <ul style="list-style-type: none"><li>Point to the one which is associated with the monarchy</li><li>Point to the one which is a marsupial</li><li>Point to the one which is found in the Antarctic</li><li>Point to the one which has a nautical connection</li></ul>	[Score 0-4] <input type="text"/> Language
--	---

LANGUAGE - Reading

➤ Ask the subject to read the following words:

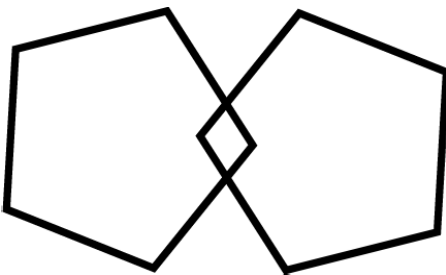
sew  
pint  
soot  
dough  
height

[Score 0-1]

VISUOSPATIAL ABILITIES

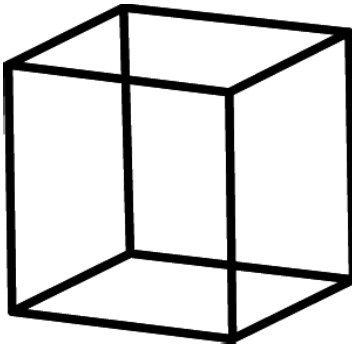
➤ **Overlapping pentagons:** Ask the subject to copy this diagram:

[Score 0-1]



➤ **Wire cube:** Ask the subject to copy this drawing (for scoring, see instructions guide)

[Score 0-2]



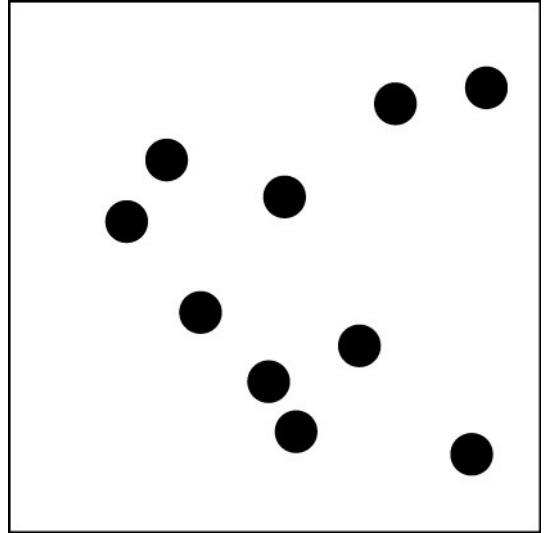
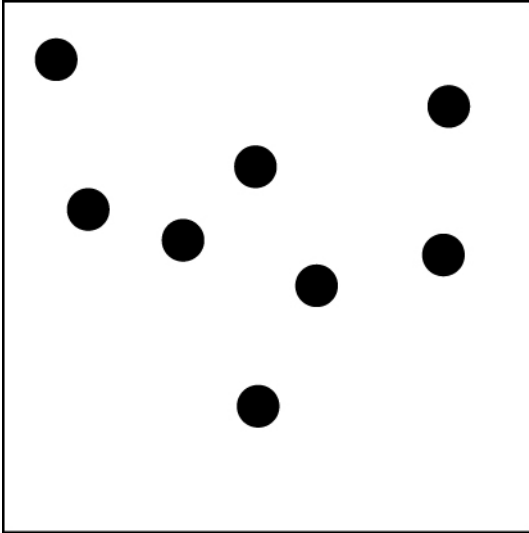
➤ **Clock:** Ask the subject to draw a clock face with numbers and the hands at ten past five.

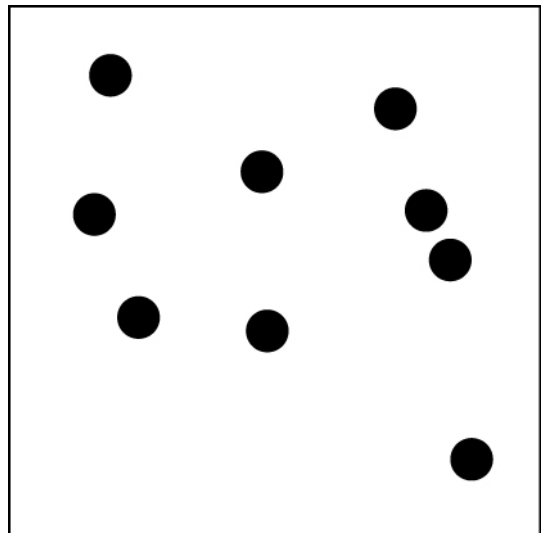
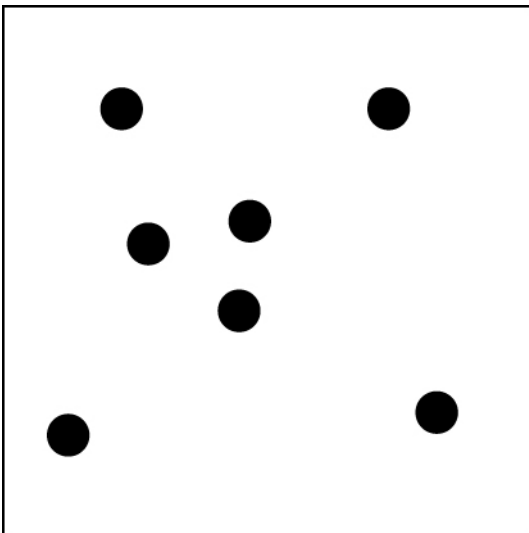
[Score 0-5]

➤ Ask the subject to count the dots without pointing them

[Score 0-4]



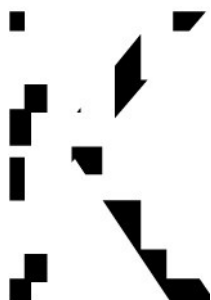


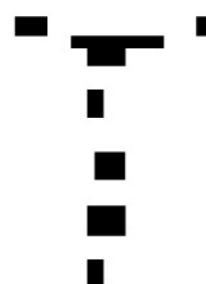



## PERCEPTUAL ABILITIES

➤ Ask the subject to identify the letters

[Score 0-4]



## RECALL & RECOGNITION

➤ Ask ' Now tell me what you remember of the name address we were repeating at the beginning'

John Martin  
24 Market Street  
Masterton  
Wairarapa

— —  
— — —  
—  
—

[Score 0-7]

**If subject fails to recall any of the 7 items, tick parts recalled and ask the question(s) that will help to recall only the missing one(s)**

[Score 0-5]

➤ Was it (score considering parts recalled and the recognised ones):

John Simmons		John Martin		Joseph Martin		recalled
42		24		28		recalled
Market Road		High Street		Market Street		recalled
Carterton		Masterton		Martinborough		recalled
Wairarapa		Waikanae		Wellington		recalled

### General Scores

MMSE /30

ACE-R /100

### Fractionated scoring

Cut-off <88 gives 94% sensitivity and 89% specificity for dementia	<b>Attention and Orientation</b>	<b>/18</b>
	<b>Memory</b>	<b>/26</b>
Cut-off <82 gives 84% sensitivity and 100% specificity for dementia	<b>Fluency</b>	<b>/14</b>
	<b>Language</b>	<b>/26</b>
	<b>Visuospatial</b>	<b>/16</b>

**38.** I am going to read a set of 10 words and ask you to recall as many as you can. We have purposefully made the list long so that it will be difficult for anyone to recall all the words – most people recall just a few. Please listen carefully as I read the set of words because I cannot repeat them. When I finish, I will ask you to recall aloud as many of the words as you can, in any order. Is that clear?

*Probe as needed for understanding of task. Read the items at a slow, steady rate – approximately one word every two seconds. Do NOT repeat words if asked.*

*When you have finished reading the words, ask the participant*

Now please tell me the words you can recall.

*Permit as much time as the respondent wishes – up to about 2 minutes.*

*Place a tick below each word that is correctly remembered, count up the ticks and place total number in the right hand box.*

										Total number Correct
<i>Hotel</i>	<i>River</i>	<i>Tree</i>	<i>Skin</i>	<i>Gold</i>	<i>Market</i>	<i>Paper</i>	<i>Child</i>	<i>King</i>	<i>Book</i>	

**\*\*\*\*[Continue with following tasks. After approximately five minutes undertake Delayed Free Recall Task – see below.]**



**39.** I'm going to read a series pairs of words, and for each pair I'd like you to please describe the way that the two words are alike or similar. I will write down what you tell me.

*Interviewer to record verbatim the participant's response to each item in the space provided below each pair on the list. Each response is scored from 0 to 2 depending on how correct it is.*

*For the first item (Orange and Banana), if the participant replies that they are both fruit, say "Good", score it 2, and proceed to the next item. If the participant gives a 1-point answer to item 1, give them an example of a 2-point response. For example, if the participant answers "You eat them both", say "That's right, you do eat them both. Also, they are both fruit". Then go on to the next item. If the participant fails to respond to item 1 or gives an incorrect answer (a 0-point response), say "They are both fruit, you eat them both" and go on to the next item. Give no further help on subsequent items. However, if a response is unclear or ambiguous, say "What do you mean? Or "Tell me a little more" or make a similar neutral inquiry.*

*Score responses after the interview when you can refer to the scoring guidelines and examples AND your verbatim record of what the participant said.*

Items	Score 0-2
1. In what way are an <b>"Orange"</b> and a <b>"Banana"</b> alike? <i>Write down response verbatim</i>	<div></div>
2. In what way are a <b>"Dog"</b> and a <b>"Lion"</b> alike? <i>Write down response verbatim</i>	<div></div>
3. In what way are an <b>"Eye"</b> and a <b>"Ear"</b> alike? <i>Write down response verbatim</i>	<div></div>
4. In what way are an <b>"Egg"</b> and a <b>"Seed"</b> alike? <i>Write down response verbatim</i>	<div></div>
5. In what way are <b>"Air"</b> and <b>"Water"</b> alike? <i>Write down response verbatim</i>	<div></div>
6. In what way are a <b>"Fly"</b> and a <b>"Tree"</b> alike? <i>Write down response verbatim</i>	<div></div>
<b>Total Score (0-12)</b>	<div></div>

**40.** I'm going to ask you to tell me the meanings of some words. I will read them to you one at a time and write down what you tell me.

*Occasionally it is difficult to determine whether a subject does or does not know the meaning of a word. In such instances you may say: "Tell me more about it" or "Explain what you mean", or make a similar neutral inquiry. No other form of questioning may be used. Record verbatim the participant's response to each item.*

*Score responses after the interview when you can refer to the scoring guidelines and examples AND your verbatim record of what the participant said.*

*Add scores on five items for total score. Total scores range from 0 to 10.*

The first word is **Repair**, could you tell me what that word means, please?.

*Repeat questioning for each item,*

Items	Score 0-2
1. What is the meaning of the word " <b>Repair</b> "? Write down response verbatim	<div></div>
2. What is the meaning of the word " <b>Fabric</b> "? Write down response verbatim	<div></div>
3. What is the meaning of the word " <b>Domestic</b> "? Write down response verbatim	<div></div>
4. What is the meaning of the word " <b>Remorse</b> "? Write down response verbatim	<div></div>
5. What is the meaning of the word " <b>Plagiarise</b> "? Write down response verbatim	<div></div>
Total Score (0-10)	<div></div>

**41.** Next I would like to ask you some questions which assess how people use numbers in everyday life.

*Record participant's answers below the questions. Score one point for each correct answer*

Items	Score 0-1
<p>1. If the chance of getting a disease is 10%, how many people out of 1,000 would be expected to get the disease?</p> <p>Answer:</p>	
<p>2. If 5 people all have the winning numbers in the lottery and the prize is 2 million dollars, how much will each of them get?</p> <p>Answer:</p>	
<p>3. Let's say you have \$200 in a savings account. The account earns ten percent interest per year. How much would you have in the account at the end of two years?</p> <p>Answer:</p>	
<b>Total Score (0-3)</b>	

**Delayed Free Recall – (\*\*\*) Approximately 5 minutes after Immediate Recall)**

**42.** A little while ago, I read you a list of words and you repeated the ones you could remember. Please tell me any of the words that you remember now.

*Permit as much time as the respondent wishes – up to about 2 minutes.*

Place a tick below each word that is correctly remembered, count up the ticks and place total number in the right hand box.

[illegible]

**43.** Now I am going to read you some descriptions of ways you may have felt or behaved. After I have read out each one, I would like you to tell me how often you have felt that way during the past week. When you tell me how often I would like you to use one of the following descriptions:

1. Rarely or none of the time; 2. Some or a little of the time; 3. Occasionally or a moderate amount of the time; 4. All of the time.

*(Circle ONE number on each line)*

		Rarely or none of the time	Some or a little of the time	Occasion- ally or a moderate amount of time	All of the time
1	I was bothered by things that usually don't bother me	1	2	3	4
2	I had trouble keeping my mind on what I was doing	1	2	3	4
3	I felt depressed	1	2	3	4
4	I felt that everything I did was an effort	1	2	3	4
5	I felt hopeful about the future	1	2	3	4
6	I felt fearful	1	2	3	4
7	My sleep was restless	1	2	3	4
8	I was happy	1	2	3	4
9	I felt lonely	1	2	3	4
10	I could not "get going"	1	2	3	4
11	I was bothered by things that usually don't bother me	1	2	3	4

**44.** I am going to read you a series of statements about how you might have felt in the last week. These may or may not be true for you. After I have read each one I would like you to tell me whether you mostly agree or mostly disagree with the statement.

*Note to interviewer: If the respondent does not feel strongly one way or the other, please ask them to choose the one that is more true than the other.*

*(Circle ONE number for either Agree or Disagree for each statement)*

		Agree	Disagree
1	I worry a lot of the time	1	2
2	I find it difficult to make a decision	1	2
3	I often feel jumpy	1	2
4	I find it hard to relax	1	2
5	I often cannot enjoy things because of my worries	1	2
6	Little things bother me a lot	1	2
7	I often feel like I have butterflies in my stomach	1	2
8	I think of myself as a worrier	1	2
9	I can't help worrying about even trivial things	1	2
10	I often feel nervous	1	2
11	My own thoughts often make me anxious	1	2
12	I get an upset stomach due to my worrying	1	2
13	I think of myself as a nervous person	1	2
14	I always anticipate the worst will happen	1	2
15	I often feel shaky inside	1	2
16	I think that my worries interfere with my life	1	2
17	My worries often overwhelm me	1	2
18	I sometimes feel a great knot in my stomach	1	2
19	I miss out on things because I worry too much	1	2
20	I often feel upset	1	2

## INCOME AND ASSETS SECTION

In this part of the interview we are going to ask some questions about income and assets that are similar to those we asked you in the postal survey. The difference now is that we are asking for a bit more detail.

**Note to interviewer: If participant is reluctant to answer these questions, please emphasise to them that their answers are confidential and that this sort of information is very important for making recommendations to government about the needs and wellbeing of people as they grow older.**

**If a participant has difficulty providing the information because they don't have it ready to hand, please give them the opportunity to find it, and offer to phone them back later to get the details if they are happy to do that.**

		Recipient categories				
		1	2	3	4	5
<b>45.</b> So now I'll go through different types of income sources that there are. Could you tell me whether you personally receive income from any of them? <i>Read through the list and circle any that the Respondent receives.</i>  <i>If Respondent lives alone there is no need to ask the next part of this question and you should move on to the next question.</i>  Now I'd like to learn about your household income. I'll go through the list again and ask you to tell me if any other members of your household receive income from them. <i>Read through the list and circle any that the other household members receive.</i>  <i>Refer to questions 3 and 4 to check the sorts of people who live in the household.</i>		Respondent	Partner	Child (ren)	Other family	Boarder, etc.
Wages, salary, commissions, bonuses...etc, paid by employer	1	1	2	3	4	5
Self-employment, or business owned and worked in	2	1	2	3	4	5
Working for Families Tax Credits	3	1	2	3	4	5
New Zealand Superannuation OR Veterans Pension	4	1	2	3	4	5
Other superannuation, pensions, annuities (other than those mentioned above)	5	1	2	3	4	5
Transitional Retirement Benefit	6	1	2	3	4	5
Regular payments from ACC OR a private work accident insurer	7	1	2	3	4	5
Interest	8	1	2	3	4	5
Dividends	9	1	2	3	4	5
Rent	10	1	2	3	4	5
Other investments	11	1	2	3	4	5
Any of these means tested government benefits						
<ul style="list-style-type: none"> <li>Accommodation supplement</li> <li>Domestic Purposes Benefit</li> <li>Invalids Benefit</li> <li>Student Allowance</li> <li>Unsupported Child Benefit</li> </ul>	12	1	2	3	4	5
Other government benefits, income support payments, or war pensions	13	1	2	3	4	5
Other sources of income, counting support payments from people who do not live in household and income from Trusts.	14	1	2	3	4	5
No source of income during that time	15	1	2	3	4	5

**46. Instruction to interviewer:**

*Responses to the next set of questions are recorded in the boxes on the next two pages. (If you need more boxes, please use one of the extra sheets you have been given and tie it securely to the main questionnaire through the holes using the string provided.)*

*How to administer: Refer to the Question 1 response sheet and work along each response row. Begin with the first Recipient code from the top for which there is a response and note also the Income source code that it relates to. Then ask how much that recipient receives from that income source. Repeat for each marked response. Take care to ensure that you write the Recipient code (1 to 5) and Income source code (1 to 15) in the "A" box at the top of each recording block that you complete below. Then complete boxes "B", "C", "D" and "E" for each set. Move from left to right.*

*For each of those types of income and for each member of your household who received each of them, I'd like you to tell me the amount received from each. You can tell me the amount either before or after tax as you did in the postal survey. So:*

*How much does [Recipient code] receive from [income source code], either before or after tax and either weekly, fortnightly, monthly or annually?*

*If the participant does not know something that their spouse or another household member might know, suggest:*

*Do you think we could ask [Other Person], or have them come and help with this part of the survey?*

*If they are not available:*

*Could you find out from them and let me phone you back later?*

*If the participant does not know or refuses to provide any income amounts for themselves or anybody else, WRITE the appropriate code in the box below:*

*In any case where the participant provides income amounts for some, but not does not know or refuses for others, please record the relevant recipient code and income and write the relevant response code in the dollar income box.*

46\_1

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	1	After tax <input type="text"/> 2
E	Weekly	1	Fortnightly <input type="text"/> 2
	Monthly	3	Annually <input type="text"/> 4
			<input type="text"/>



46\_2

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	1	After tax <input type="text"/> 2
E	Weekly	1	Fortnightly <input type="text"/> 2
	Monthly	3	Annually <input type="text"/> 4
			<input type="text"/>

46\_3

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	1	After tax <input type="text"/> 2
E	Weekly	1	Fortnightly <input type="text"/> 2
	Monthly	3	Annually <input type="text"/> 4
			<input type="text"/>



46\_4

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	1	After tax <input type="text"/> 2
E	Weekly	1	Fortnightly <input type="text"/> 2
	Monthly	3	Annually <input type="text"/> 4
			<input type="text"/>

46\_5

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	1	After tax <input type="text"/> 2
E	Weekly	1	Fortnightly <input type="text"/> 2
	Monthly	3	Annually <input type="text"/> 4
			<input type="text"/>



46\_6

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	1	After tax <input type="text"/> 2
E	Weekly	1	Fortnightly <input type="text"/> 2
	Monthly	3	Annually <input type="text"/> 4
			<input type="text"/>



46\_7

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	<input type="text"/> 1	After tax <input type="text"/> 2
E	Weekly	<input type="text"/> 1	Fortnightly <input type="text"/> 2
	Monthly	<input type="text"/> 3	Annually <input type="text"/> 4
		<input type="text"/>	<input type="text"/>



46\_8

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	<input type="text"/> 1	After tax <input type="text"/> 2
E	Weekly	<input type="text"/> 1	Fortnightly <input type="text"/> 2
	Monthly	<input type="text"/> 3	Annually <input type="text"/> 4
		<input type="text"/>	<input type="text"/>

46\_9

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	<input type="text"/> 1	After tax <input type="text"/> 2
E	Weekly	<input type="text"/> 1	Fortnightly <input type="text"/> 2
	Monthly	<input type="text"/> 3	Annually <input type="text"/> 4
		<input type="text"/>	<input type="text"/>



46\_10

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	<input type="text"/> 1	After tax <input type="text"/> 2
E	Weekly	<input type="text"/> 1	Fortnightly <input type="text"/> 2
	Monthly	<input type="text"/> 3	Annually <input type="text"/> 4
		<input type="text"/>	<input type="text"/>

46\_11

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	<input type="text"/> 1	After tax <input type="text"/> 2
E	Weekly	<input type="text"/> 1	Fortnightly <input type="text"/> 2
	Monthly	<input type="text"/> 3	Annually <input type="text"/> 4
		<input type="text"/>	<input type="text"/>



46\_12

A	Recipient code (1 to 5)		<input type="text"/>
B	Income code (1 to 15)		<input type="text"/>
C	Amount (whole \$)		<input type="text"/>
D	Before tax	<input type="text"/> 1	After tax <input type="text"/> 2
E	Weekly	<input type="text"/> 1	Fortnightly <input type="text"/> 2
	Monthly	<input type="text"/> 3	Annually <input type="text"/> 4
		<input type="text"/>	<input type="text"/>

**47.** I'd now like to ask some questions about assets that you [and partner, if any] might own. For each type of asset that you have, please tell me the exact value, if you know it, or the dollar range that you think is closest to the value, as far as you know it. There is table at the bottom of this page that has dollar ranges for you to select from.

*Interviewer, write range code in column #1, exact value in column #2*

	1	2	3	4
Asset type  SHOWCARD 2 A	Value Range Code from (1-34)	Exact value if available (Print very clearly)	If lost value during financial crisis, write in the number "1" <b>See Q 49</b>	Amount lost, if known  <b>See Q 50</b>
1. Own home		\$		\$
2. Farm or farms		\$		\$
3. Business or businesses		\$		\$
4. Holiday home		\$		\$
5. Rental property or properties		\$		\$
6. Shares		\$		\$
7. Managed funds		\$		\$
8. Bank deposits or savings		\$		\$
9. Motor vehicle or vehicles		\$		\$
10. Other major assets		\$		\$
(please specify below):		\$		\$

11. None of the above assets (Tick next box)	
12. Non-response code in next box (998 or 999)	

Code	Amount	Code	Amount	Code	Amount
1	Loss	12	\$45,001 to \$50,000	23	\$100,001 to \$200,000
2	\$0	13	\$50,001 to \$55,000	24	\$200,001 to \$300,000
3	\$1 to \$5,000	14	\$55,001 to \$60,000	25	\$300,001 to \$400,000
4	\$5,001 to \$10,000	15	\$60,001 to \$65,000	26	\$400,001 to \$500,000
5	\$10,001 to \$15,000	16	\$65,001 to \$70,000	27	\$500,001 to \$600,000
6	\$15,001 to \$20,000	17	\$70,001 to \$75,000	28	\$600,001 to \$700,000
7	\$20,001 to \$25,000	18	\$75,001 to \$80,000	29	\$700,001 to \$800,000
8	\$25,001 to \$30,000	19	\$80,001 to \$85,000	30	\$800,001 to \$900,000
9	\$30,001 to \$35,000	20	\$85,001 to \$90,000	31	\$900,001 to \$1,000,000
10	\$35,001 to \$40,000	21	\$90,001 to \$95,000	32	\$1,000,001 to \$1,500,000
11	\$40,001 to \$45,000	22	\$95,001 to \$100,000	33	\$1,500,001 to \$2,000,000
				34	\$2,000,001 or more

**48.** Compared to when you completed the postal survey, how would you rate your overall financial situation now? Would you say it is:

Better	1
The same	2
Worse	3
	<input type="text"/>

**49.** Did any of your investments lose value during the financial crisis of 2008 and 2009?

Yes	1
No	2
Not applicable	3
	<input type="text"/>

*If yes, ask:*

**50.** Which ones were these, and can you tell me approximately how much you lost?

*Write "1" beside each one in column 3 in the Question 47 table, above.*

## FUTURE HOUSING INTENTIONS

**51.** I'm going to read some statements one at a time and ask you to tell me how much you agree or disagree with each of them.

There are four options: strongly agree with it; agree with it; disagree with it; or strongly disagree.

Firstly, for as long as you are able to take care of your daily living needs yourself would you like to:		Strongly agree	Agree	Disagree	Strongly disagree
1	Remain living in your own existing home.	4	3	2	1
2	Move to another, smaller, home of your own to live in.	4	3	2	1
3	Move to another home of my own that is closer to your children or other family members.	4	3	2	1
4	Move from your present home to a rental flat or apartment provided by a city council or other provider of social housing.	4	3	2	1
5	Move to a retirement village where you will live independently in an apartment or flat.	1	2	3	4
6	Move to a retirement or rest home where meals can be provided and other housework and washing be done for you.	1	2	3	4

**52.** The next question is similar to the last one, but is about what you might want to do as you grow older but find it difficult to take care of your daily needs. I am going to read some statements to you and for each statement, I'd like you to tell me how much you agree or disagree with it.

There are four options: strongly agree with it; agree with it; disagree with it; or strongly disagree.

Now, if you find it difficult to take care of your daily living needs yourself and need help from others, would you like to:		Strongly agree	Agree	Disagree	Strongly disagree
1	Remain living in your own existing home with help to assist you with housework and shopping or meals.	4	3	2	1
2	Move to another, smaller, home of your own to live in with help to assist you with housework and shopping or meals.	4	3	2	1
3	Move to another home of your own closer to your children or other family members and have help with housework and shopping or meals.	4	3	2	1
4	Move to a rental flat provided by a city council or other provider of social housing and have help with housework and shopping or meals.	4	3	2	1
5	Move to a retirement village where you will live in your own apartment or flat but have help with housework and shopping or meals.	1	2	3	4
6	Move to a retirement or rest home where meals can be provided and other housework and washing be done for you.	1	2	3	4

**Thank you very much, we have reached the end of the questionnaire!**

**On behalf of the NZLSA team I'd like to say how much we appreciate your generosity in contributing your time and knowledge to this research.**

Thank you very much for agreeing to this interview. It will be very important for our study and I hope that you will find it interesting as well.

1) First of all, could you tell me your date of birth, please? *Write dates in box*

dd	mm	yyyy

(Circle ONE number)

Now we have some questions about your wellbeing and health

2) In general do you feel your health is: *Read out*

(Circle ONE number)

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

3) How would you rate your memory at the present time? *Read out (Circle ONE number)*

Excellent	1
Very good	2
Good	3
Fair	4
Poor	5

4) How would you rate your memory now compared to two years ago? *Read out (Circle ONE number)*

Better	1
The same	2
Worse	3

- 5) I am going to read you a series of statements about how you might have felt in the last week. These may or may not be true for you. After I have read each one I would like you to tell me whether you mostly agree or mostly disagree with the statement.

*Note to interviewer: If the respondent does not feel strongly one way or the other, please ask them to choose the one that is more true than the other.*

*(Circle ONE number for either Agree or Disagree for each statement)*

		Agree	Disagree
1	I worry a lot of the time	1	2
2	I find it difficult to make a decision	1	2
3	I often feel jumpy	1	2
4	I find it hard to relax	1	2
5	I often cannot enjoy things because of my worries	1	2
6	Little things bother me a lot	1	2
7	I often feel like I have butterflies in my stomach	1	2
8	I think of myself as a worrier	1	2
9	I can't help worrying about even trivial things	1	2
10	I often feel nervous	1	2
11	My own thoughts often make me anxious	1	2
12	I get an upset stomach due to my worrying	1	2
13	I think of myself as a nervous person	1	2
14	I always anticipate the worst will happen	1	2
15	I often feel shaky inside	1	2
16	I think that my worries interfere with my life	1	2
17	My worries often overwhelm me	1	2
18	I sometimes feel a great knot in my stomach	1	2
19	I miss out on things because I worry too much	1	2
20	I often feel upset	1	2

6) Now I am going to read you some descriptions of ways you may have felt or behaved. After I have read out each one, I would like you to tell me how often you have felt that way during the past week. When you tell me how often I would like you to use one of the following descriptions:

1. Rarely or none of the time; 2. Some or a little of the time; 3. Occasionally or a moderate amount of the time; 4. All of the time.

*(Circle ONE number on each line)*

		Rarely or none of the time	Some or a little of the time	Occasion- ally or a moderate amount of time	All of the time
1	I was bothered by things that usually don't bother me	1	2	3	4
2	I had trouble keeping my mind on what I was doing	1	2	3	4
3	I felt depressed	1	2	3	4
4	I felt that everything I did was an effort	1	2	3	4
5	I felt hopeful about the future	1	2	3	4
6	I felt fearful	1	2	3	4
7	My sleep was restless	1	2	3	4
8	I was happy	1	2	3	4
9	I felt lonely	1	2	3	4
10	I could not "get going"	1	2	3	4
11	I was bothered by things that usually don't bother me	1	2	3	4



7) Has a doctor or other healthcare worker ever told you that you have:

	No	Yes	Don't know
High blood pressure	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Congestive heart failure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diabetes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Osteoporosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cirrhosis or another liver condition	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cancer of the mouth or throat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Breast cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gout	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Memory disorder or dementing illness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Colorectal cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8) In the past 12 months, has a doctor or other healthcare worker told you that you have:

	No	Yes	Don't know
Hepatitis	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gastritis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ulcer of the stomach or small intestine	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pancreatitis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depression, anxiety or other emotional or mental health problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9) (a) Do you now use tobacco in any form, including cigarettes, cigars, pipes, chewing tobacco, etc?

Yes, I use tobacco

No, I used tobacco in the past,  
but I do not use it now

No, I have never used tobacco

(Current smoker)

(Ex-Smoker)

(Never smoked)

<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
----------------------------------	-----------------------	-----------------------

(b) If respondent is a current smoker, ask how many do you think you would smoke on an average day? (Please tick ONE circle) **Otherwise, tick "Not a regular smoker"**

1 to 10 a day

11 to 20 a day

21 to 30 a day

31 or more a day

OR

Not a regular smoker

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

**10) How much in the past 12 months did you have any of the following problems?**

(Tick ONE circle on each line)

	All of the time ▼	Most of the time ▼	Some of the time ▼	A little of the time ▼	None of the time ▼
Problems sleeping	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stomach pains	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heartburn	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nausea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vomiting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Diarrhoea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nervousness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Memory problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feeling depressed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tripping/bumping into things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Falling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Problems with bladder control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**11) How many different medications do you take EVERY DAY?**

None	1 to 2	3 to 5	6 to 7	8 or more
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**12) Do you take 2 or more regular or extra strength (100mg or more) aspirins?**

☐ Yes
 ☐ No
 ☐ Don't know

**13) Do you now take any of these medications at least ONCE A WEEK? Circle ONE number per row**

	No	Yes	Don't know
<b>Sedatives or sleeping medicines</b> (e.g., Apo-Zopiclone, Hypam, Ox-Pam, Normison, Nitrados)	1	2	3
<b>Anti-psychotic or anti-anxiety medicines</b> (e.g., Zyprexa, Ridal)			
<b>Narcotic medications</b> (e.g., Codeine Phosphate Tabs, M-Eslon, Oxycontin, Oxycontin, Tramal)	1	2	1
<b>Muscle relaxants</b> (e.g., Pro-pam)			
<b>Erectile dysfunction medicines</b> (e.g., Viagra, Cialis, Avigra, Vedafile, Silagra)	1	2	3

**14) Do you now take any of these medications EVERY DAY or ALMOST EVERY DAY? Circle ONE number per row**

	No	Yes	Don't know
<b>Ulcer and stomach medication</b> (e.g., Famox, Losec, Dr Reddys Pantoprazole, Somac, Ranitidine Arrow)	1	2	3
<b>Arthritis and pain medicines</b> (e.g., Apo-Allopurinol, Apo-Diclo, I-Profen, Panadol, Celebrex)			
<b>Diabetes medicines</b> (e.g., Apo-Gliclazide, Minidiab, Arrow Metformin)	1	2	3
<b>Blood pressure medicines</b> (e.g., Betaloc, Atacand, Dilzem, Felo, Apo-Prazo)			
<b>Nitrates</b> (e.g., Duride Tabs, Corangin, Nitrolingual pump spray)	1	2	3
<b>Other medicines for the heart</b> (e.g., Cordarone X, Lanoxin, Tambocor, Diurin)			
<b>Anticoagulants</b> (e.g., warfarin)	1	2	3
<b>Seizure medicines</b> (e.g., Tegretol, Arrow-Lamotrigine, Phenobarbitone PSM, Dilantin, Epilim)			
<b>Anti-depressant medicines</b> (e.g., Amitrip, Arrow-Citalopram, Anten, Fluox, Loxamine)	1	2	3
<b>Non-sedating, non-drowsy antihistamines</b> (e.g., Razene, Telfast)			
<b>Sedating, sleep inducing antihistamines</b> (e.g., Phenergan)	1	2	3
<b>Cholesterol lowering medicines</b> (e.g., Arrow-Simva, Lipitor, Bezalip)			
<b>Bladder medicines</b> (e.g., Apo-Oxybutinin, Apo-Prazo, Flomax, Hytrin)	1	2	3

**15) (a) During the past 12 months, how often did you have a drink containing alcohol?**  
(Please tick ONE circle)

Never	1 time a month or less	2 to 4 times per month	2 to 3 times a week	4 or 5 times a week	Daily or almost daily
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6

**(b) If you said 'Never' above, have you ever drunk alcohol in the past?**

Ye ☐ N ☒ → (If No please go to Q16)

**(c) On days that you drank alcohol during the past 12 months, how many drinks of alcohol (beer, wine and/or hard liquor) did you usually drink?** (Please tick ONE circle)

Less than 1	1	2	3	4	5 or more
<input type="radio"/> 1	<input type="radio"/> 2	<input type="radio"/> 3	<input type="radio"/> 4	<input type="radio"/> 5	<input type="radio"/> 6

**(d) In the past 3 months, how often did you have:**

(Tick ONE circle on each line)

	Never	1 time a month or less	2 to 4 times per month	2 to 3 times per week	4 or 5 times a week	Daily or almost daily
... <u>four or more</u> drinks of alcohol at one sitting?	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... <u>five or more</u> drinks of alcohol at one sitting?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**(e) Because of your alcohol use, how often in the past 12 months:**

(Tick ONE circle on each line)

	Never	Less than once a month	At least once a month, but less than weekly	At least once a week, but less than daily	Daily or almost daily
...did you fail to do what you were supposed to?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...were you unable to stop drinking once you had started?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...did you feel guilty or sorry for something you did or didn't do?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**(f) In the past 12 months, on how many days did you drive a car, truck, or other vehicle within 2 hours of having four or more drinks?**

I did not drive in the past 12 months

Never	1-2 days	3-5 days	6-9 days	10-19 days	20 or more days
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**(g) Has a doctor, other medical person, relative, friend, or anybody else ever been concerned about your drinking or suggested that you should cut down?**

No	Yes, but <u>not</u> in the past 12 months	Yes, during the past 12 months
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**16) The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so how much?**

(Tick ONE circle on each line)

	Yes, limited a lot	Yes, limited a little	No, not limited at all
Climbing <u>one</u> flight of stairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Walking one block	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bathing or dressing yourself	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**17) In general, would you say your health is:** (Please tick ONE circle)

Excellent	Very good	Good	Fair	Poor
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Now we are onto the last lot of questions which are like the ones you answered last time about cognitive processes.

*Interviewers should not fill in the Score boxes. This will be done separately by others*

### 18) Handedness

Are you left or right handed?

Left	Right
(1)	(2)

### 19) Orientation

Score

- (a) I'm going to ask you to tell me the present Day, Date, Month, Year, and Season, and write down your answers. So, please tell me what the \_\_\_\_\_ is at the moment:

[Score 0-5]

*Interviewer to ask for record answers in spaces below.*

Day	Date	Month	Year	Season

- (b) Now I'm going to ask some questions about where you live, and write down your answers. So please tell me the:

[Score 0-5]

*Interviewer to record answers in spaces below.*

Building/Address	Floor/Ward	Town/Suburb	City	Country

### 20) Registration

I'm going to give you the name of three objects and I'd like you to repeat after me: 'apple, coin, chair'

[Score 0-3]

*Interviewer to write down the names returned by the respondent. If the first attempt is correct, don't repeat. If it is not correct say the names again and ask the respondent to repeat them again. Don't repeat more than three times.*

Trial 1 (to be scored) Write down below	Trial 2 (not scored) Write down below	Trial 3 (not scored) Write down below	Number of Trials Write number below

After respondent repeats, say: 'Try to remember those names because I'm going to ask you again later'

## 21) Attention & Concentration

- (a) Ask the respondent: 'Could you take seven away from a hundred?'  
And then seven from each response (5 subtractions).

If respondent fails the first subtraction, ask: 'Did you mean \_\_\_?'

If respondent still makes a mistake, switch to spelling (b). If respondent corrects himself or herself, continue.

Please record the answers given in the space below the correct answer.

Stop after five subtractions (i.e., the last one is  $72 - 7 = 65$ ):

100	93	86	79	72	65

If the respondent has made any mistakes in (a), then ask (b), below as well.

- (b) Ask the respondent: 'Could you please spell WORLD for me?' Then ask him/her to spell it backwards:

Write down the letters in the order given by the respondent in the spaces below

D	L	R	O	W

[Score 0-5]

(For best performed task)

## 22) Memory - Recall

Ask the respondent: 'Please tell me the 3 objects I asked you to repeat and remember before?' (i.e., at Q20)

Write down the names as they are repeated by the respondent

--	--	--

[Score 0-3]

## 23) Memory – Anterograde Memory

Tell respondent: 'I'm going to give you a name and address and I'd like you to repeat it after me. We'll be doing that 3 times, so you have a chance to learn it because I'll be asking you again later'

Write down the responses as they are provided by the respondent. Record each trial

	1 <sup>st</sup> Trial	2 <sup>nd</sup> Trial	3 <sup>rd</sup> Trial (Score this)
Linda Clark	_____	_____	_____
59 Kings Road	_____	_____	_____
Richmond	_____	_____	_____
Canterbury	_____	_____	_____

[Score 0-7]

## 24)Memory – Retrograde Memory

Say: Please tell me the:

**Complete each question statement and write down the answer in the space provided.**

[Score 0-4]

Name of current Prime Minister	
Name of British Royal family member who died in a car crash in Paris?	
Name of current USA president	
Name of a USA president who was assassinated in the 1960s	

## 25)Verbal Fluency – Letter ‘P’ and animals

- (a) Say: ‘I’m going to give you a letter of the alphabet and I’d like you to generate as many words as you can beginning with that letter, but not names of people or places. Are you ready? You’ve got a minute for that and the letter is P’

[Score 0-7]

**Write down the words as they are stated by the respondent**

--	--	--	--

- (b) Say: ‘Now let’s change. I’d like you to generate as many animals as possible, any kind of animal, beginning with any letter, it doesn’t matter’

[Score 0-7]

**Write down the animals as they are stated by the respondent**

--	--	--	--



26) Language – Comprehension

(a) *Show this written instruction to the respondent. Don't speak it:*

**Say: Please Read this sentence and do as it says**

[Score 0-1]

# Close your eyes

(b) 3 stage command:

**Say: 'Take the paper in your left hand. Fold the paper in half. Put the paper on the floor'**  
*(use right hand if respondent is left handed – check at first question for this section. Don't let respondent take the paper until all three parts of the command have been stated)*

**Place a tick in the space beneath each command that is correctly carried out or a cross if incorrect.**

[Score 0-3]

Correct Hand	Fold in Half	Put on Floor

27) Language – Writing

**Ask the respondent to make up a sentence and to write it in the space below:**

[Score 0-1]

## 28) Language – Repetition

(a) Ask the respondent to repeat:

***Ask them one at a time, and place a tick below each word that is repeated correctly, and a cross for each that is incorrectly repeated.***

hippopotamus	eccentricity	unintelligible	statistician

[Score 0-2]

(b) Ask the respondent to repeat:

‘Above, beyond and below’

***Write down what the respondent says exactly as they say it.***

[Score 0-1]



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(c) Ask the respondent to repeat:

‘No ifs, ands or buts’

***Write down what the respondent says exactly as they say it.***

[Score 0-1]

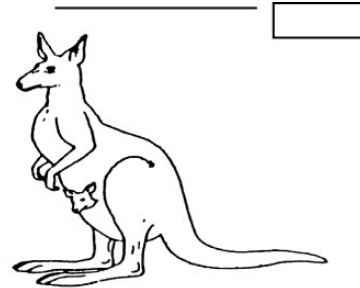
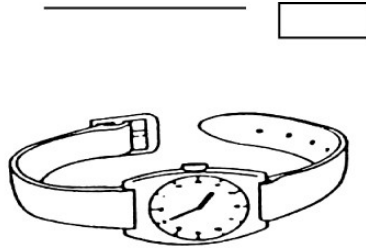
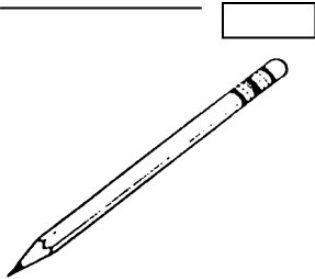


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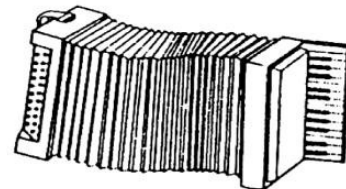
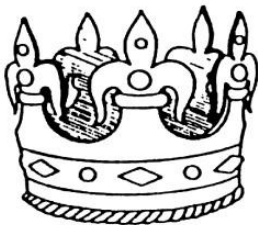
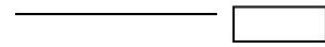
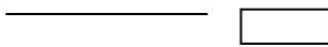
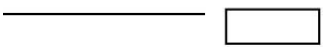
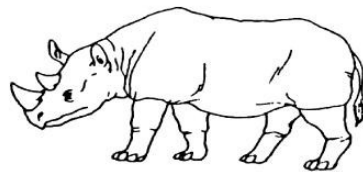
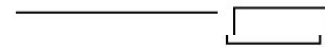
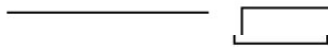
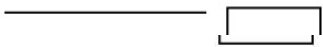
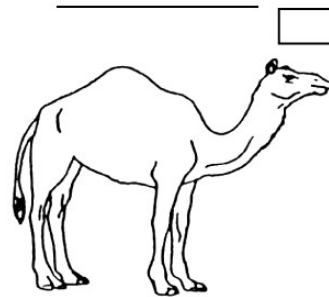
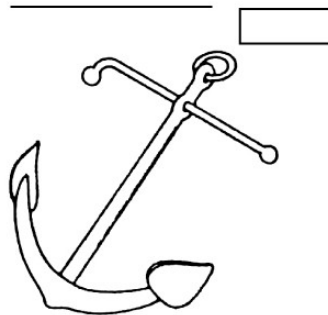
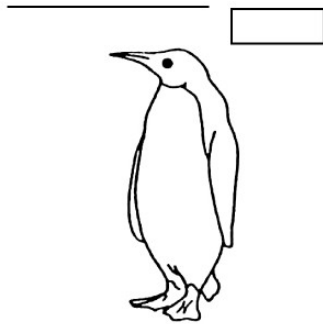
29) Language – Naming

30) Ask the respondent to name the following pictures and write down their answer in the space above each picture. It is important that you record (i.e., write down) all answers as they are given by the respondent:

[Score 0-2]  
pencil +  
watch



[Score 0-10]



### 31) Language – Comprehension

Using the pictures above, ask the respondent above to:

**Write down the name of the animal or object that the respondent points to for each question**

[Score 0-4]

Questions	Write answers in spaces below
Point to the one which is associated with the monarchy	
Point to the one which is a marsupial	
Point to the one which is found in the Antarctic	
Point to the one which has a nautical connection	

### 32) Language – Reading

Ask the respondent to read the following words:

[Score 0-1]

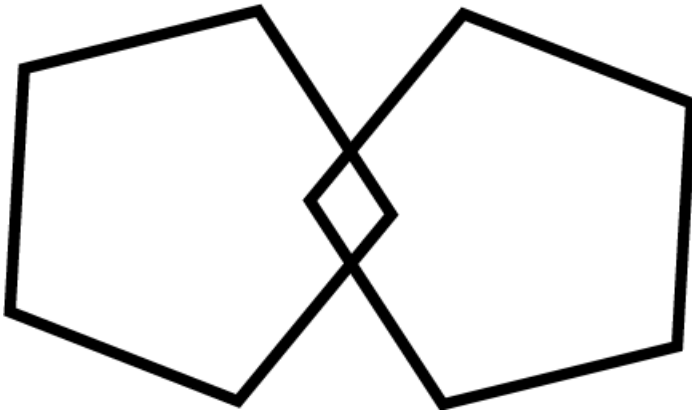
**sew**  
**pint**  
**soot**  
**dough**  
**height**

Words	Respondent's repetition <i>Record phonetically if possible</i>	Tick if correct, Cross if wrong
sew		
pint		
soot		
dough		
height		

### 33)Visuospatial Abilities

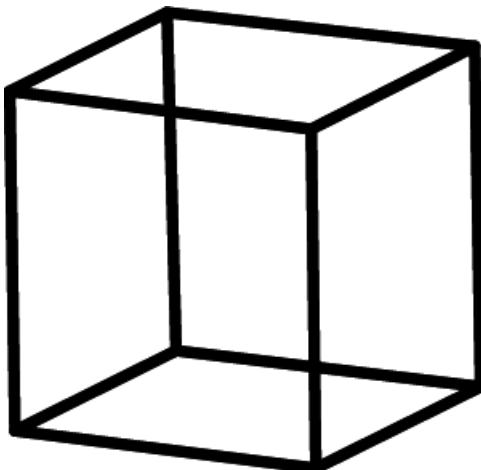
(a) Overlapping pentagons: *Ask the respondent to copy this diagram:*

[Score 0-1]



(b) Wire cube: *Ask the respondent to copy this diagram*

[Score 0-2]



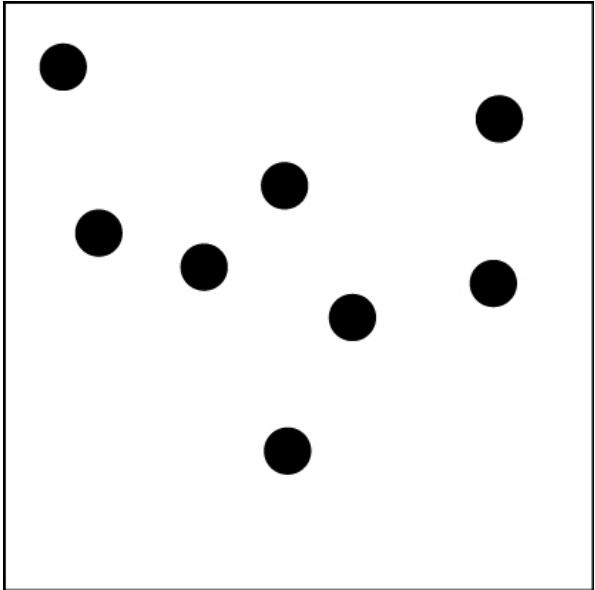
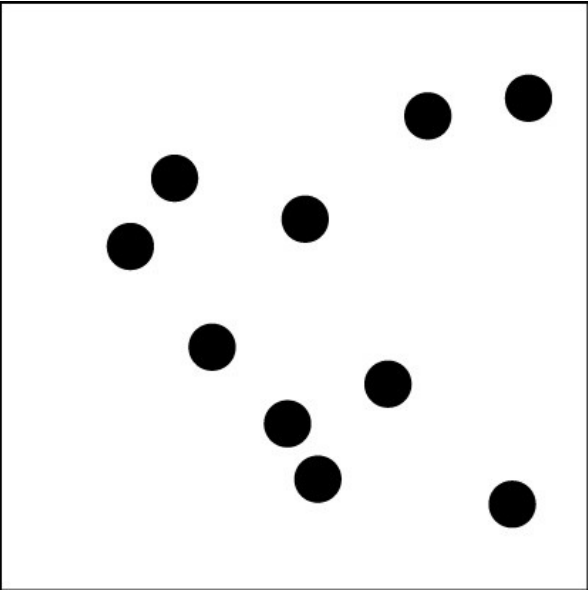
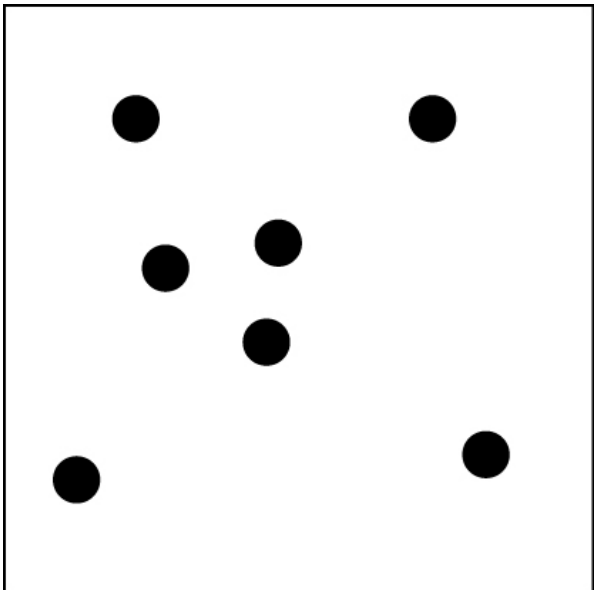
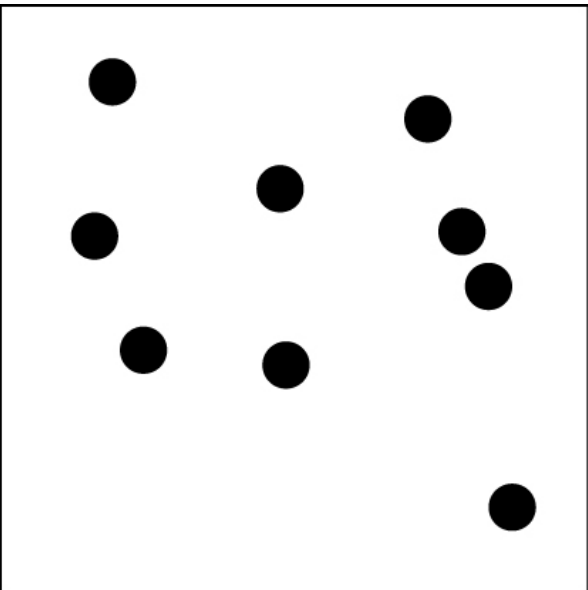
(c) Clock: Ask the respondent to draw a clock face with numbers and the hands at ten past five:

[Score 0-5]

### 34) Perceptual Abilities

*Ask the respondent to count the dots without pointing to them. Record their answer in the small box above each set of dots. In other words, write down the number of dots they have counted.*

[Score 0-4]

<div style="border: 1px solid black; width: 55px; height: 23px; margin-bottom: 5px;"></div> <div>  </div>	<div>  </div>
<div style="border: 1px solid black; width: 55px; height: 23px; margin-bottom: 5px;"></div> <div>  </div>	<div>  </div>

**35) Perceptual Abilities**

***Ask the respondent to identify the letters: Write down the letter they have stated in the small box.***

[Score 0-4]

### 36) Recall &

(a) Ask: 'Now tell me what you remember of the name and address we were repeating at the beginning':

[Score 0-7]

*Write down the respondent's answers in the spaces provided*

1	Linda Clark	_____
2	59	_____
3	Kings Road	_____
4	Richmond	_____
5	Canterbury	_____

*If the respondent has correctly recalled all seven parts of the name and address, don't continue on to the final question (37).*

*If the respondent has failed to recall one or more parts of the address, continue to the next question.*

### 37) Recognition

*The recording box in the previous question arranges the seven parts of the address into five items.*

*For any of the five items incorrectly recalled, say to the respondent:*

[Score 0-5]

*Was it: (Read out the items exactly as they are on the row, below; e.g., "Was it 52, 59, or 39")*

*Place a tick in the square beside the option that the respondent has chosen in either column A, B or C, below. THEN, if they chose the correct one place a tick, also, in the appropriate column D square.*

	A		B		C		D	
1	Linda Marshall		Linda Clark		Linda Crawford		Recalled	
2	52		59		39		Recalled	
3	Queen's Road		Kings Street		Kings Road		Recalled	
4	Fendalton		Richmond		Riccarton		Recalled	
5	Canterbury		Christchurch		Kaiapoi		Recalled	



**Thank you very much, we have reached the end of the questionnaire!**

**On behalf of the NZLSA team I'd like to say how much we appreciate your generosity in contributing your time and knowledge to this research.**

## Case Study Six

### **The effects of social isolation on cognitive performance in the ageing**

This case study was completed during the period of the internship as part of the Doctorate of Clinical Psychology, and represents the work of Catherine Whitehouse under the supervision of Stephen Hill.

In accordance with the Code of Ethics for Psychologists Working in Aotearoa/New Zealand the privacy of this client is maintained by utilizing pseudonyms and adapting identifying information.

Candidate: Catherine Whitehouse, Intern Psychologist

Supervisor: Dr Stephen Hill, Dr Fiona Alpass, Dr Joanne Taylor

Internship setting: Psychological Services, Department of Corrections, Palmerston North

Word Count (excluding references) 7,423

Candidate.....

Supervisor.....

Date.....

## **Abstract**

*The study aims to examine the influence of social isolation on cognitive performance among older adults aged 65-84 years old. This study will extend previous work on social isolation and cognition in two ways. Whilst previous research has found a link between social isolation and cognition, few have examined the relationship between different forms of social isolation and different domains of cognition simultaneously. Secondly, an association between different forms of loneliness (social and emotional loneliness) and cognition have not been examined. Therefore, the current study will investigate the impact of four different types of social isolation (social loneliness, emotional loneliness, perceived social support and objective social isolation) on global cognition and cognitive domains (memory, fluency, language and visuospatial ability. The cross-sectional and longitudinal data from the New Zealand Longitudinal Study of Ageing (NZLSA) (2010, 2012) is used for analysis.*

## **Critical Summary and Analysis of Relevant Literature**

### *Aging and Cognition*

The ageing population is a worldwide phenomenon and is indicated to be one of the most important demographic events in the twenty first century. Currently 14% of the population is over 65 years old; by 2032 the over 65 years will account for 22% of the population and by 2068 up to 32% (Statistics New Zealand, 2014). Hence, in New Zealand and other countries, understanding what factors contribute to successful ageing is rapidly becoming a public health and research priority. As the ageing population, will place significant demands on health and social service resources if the consequences of living longer are associated with increased disability and infirmity (Cornwell & Davey, 2004; Ministry of Health, 2012). The health, social and economic challenges posed by an ageing population have prompted governments, research communities and the medical fraternity worldwide to enhance their knowledge of the ageing process and age-related diseases, as well as understand what factors contribute to successful ageing and what factors undermine it (Davey & Glasgow, 2006; Deary et al., 2009; Hendrie, Purnell, Wicklund, & Weintraub, 2010). Rowe and Kahn (1997) offered a model of successful ageing that requires three essential factors: low probability of disease and disease-related disability, high cognitive and physical functional capacity, and an active engagement with life. Though all factors can influence each other as posited by the model, cognitive ability is the one factor that uniquely influences ability to engage with life, functional capacity and health status. Poorer cognitive function and cognitive decline is a risk factor in the development of functional impairment and disability (Herzog & Wallace, 1997; Johnson, Lui & Yaffe, 2007; Moritz, Kasl & Berkman, 1995). This can result in the inability to function independently and adequately in daily life, such as being unable to manage finances (Widera, Steenpass, Marson & Sudore, 2011), drive (Daigneault, Joly & Frigon, 2002), and manage self-care functions such as preparing meals, bathing and dressing (Dodge et al., 2005). Studies have reported that older adults with lower cognitive performance at baseline are more at risk for institutionalisation and death than those with higher cognitive ability (Barberger-Gateau & Fabrigoule, 1997; Johnson et al., 2007; McGuire, Ford & Ajani, 2006). Not surprisingly, cognitive decline is regarded as one of the most important health care issues facing the older population by government departments such as the New Zealand Ministry of Health, the Australian Government Department of Health and Ageing, and the US

National Institute of Health (Australian Institute of Health and Welfare (AIHW), 2006; Cornwell & Davey, 2004; Hendrie et al., 2010; Ministry of Health, 2002).

In turn, there has been increasing interest in identifying modifiable factors that may help protect cognitive functioning in older age. This has also come about due to evidence that the older population is heterogeneous, and that normative (non-pathological or normal) cognitive decline can differ significantly amongst the population (Fillit et al., 2002; Morris, 1999; Schaie, 1988). There are individuals who remain cognitively intact to over 100 years old (Silver, Jilinskaia, Perls, 2001), whilst others have observable cognitive impairment much earlier. Evidence strongly suggests that there is an almost universal decline in cognitive performance as one ages (Park, O'Connell, & Thomson, 2003), so inevitably there is some degree of ageing-related decline (Small, Dixon, McArdle & Grimm, 2011). This is referred to as normative ageing (Nesselroade & Baltes, 1979) or cognitive ageing, which Salthouse (1991) described as the “decrease in performance on various measures of cognitive functions associated with increasing ageing in the adult portion of the lifespan” (p. 2). There is consensus in the literature, with evidence from both longitudinal and cross-sectional studies, that cognitive functions have different development trajectories across the life span (Hedden & Gabrieli, 2004; Salthouse, 2009; Schaie, Willis, & Caskie, 2004). Cognitive functions such as vocabulary, word knowledge, general knowledge, and comprehension have been identified as more age-resistant. Studies also report that, through exposure to education, cultural and occupational experiences, these cognitive functions can improve up to the sixth and seventh decade of one's life (Anstey & Low, 2004). Age-prone cognitive functions such as fluid reasoning, information processing speed, episodic memory and spatial ability have consistently been reported as showing a mean-age decline in performance from early adulthood (Christensen, 2001; Salthouse, 2009, 2010).

Importantly, studies that have focused on individual differences and differential patterns of change have shown that in the ageing adult, the change in cognitive functioning was highly specific to the individual (Wilson et al., 2002). For instance, the Seattle Longitudinal Study (SLS), reported that, when analysing individual differences at the age of 81, less than half of all observed individuals experienced reliable decremental change on a particular ability over the preceding seven years (SLS; Schaie et al., 2004, p. 310). Furthermore, very few individuals showed a decline across all cognitive abilities even by 80 years of age (SLS; Schaie, 1990); similar findings have been reported in the Baltimore Epidemiological Catchment area study (Lyketsos, Chen, & Anthony, 1999) and in the work of Wilson et al., (2002).

These findings of substantial heterogeneity in cognitive decline amongst the older adults are consistent with comments of MacDonald, DeCarlo and Dixon (2011), who noted that, due to the considerable individual variation in rates, nature, timing, and extent of age-related decline in cognitive abilities, chronological ageing is not a causal mechanism underlying cognitive decline. Intimating that age could be seen as a vehicle that reflects the accumulation of biological, health, neurological, and environmental influences over a lifetime, and it is those factors that determine the variety in cognitive ageing (MacDonald et al., 2011; MacDonald, Dixon, Cohen & Hazlitt, 2004). Researchers have investigated the influence of various factors that may contribute to the individual differences in cognitive performance amongst the ageing. Factors investigated have included education and occupational attainment, health conditions, mental

health, nutrition, genetics, toxic exposure, and lifestyle factors such as smoking, physical activity, leisure activities, and alcohol use (Plassman, Williams, Burke, Holsinger & Benjamin, 2010).

### *Ageing and social isolation*

One other phenomenon that has received attention in recent years is the social world of the older adult and its influence on cognition. Research has indicated that the extent to which individuals have social ties or social connections with family, friends and community, access to social support, and active participation in stimulating intellectual and physical activities in the community (i.e. social integration) has been associated with good health and well-being, and may promote successful cognitive ageing in the older adult in some studies (Berkman, Glass, Brissette, & Seeman, 2000; Golden et al., 2009; Gow, Corley, Starr & Deary, 2013; Hertzog, Kramer, Wilson, & Lindenberger, 2009; Huxhold, Fiori & Windsor, 2013; Pinquart & Sorensen, 2000; Victor, Scambler, Bond, & Bowling, 2000).

Yet, for many older adults there is a risk of being socially isolated or lonely. As one ages many lifestyle events occur, such as increased likelihood of death of a spouse, siblings, and friends, transition from work to retirement, declining physical health, and financial restraints, which can result in reduced social integration and engagement. Such lifestyle events, coupled with recent trends such as encouraging the ageing to live longer in their own home, a highly mobile society, and families having fewer children, have the potential to increase opportunity for social isolation and loneliness (Routasalo & Pitkala, 2003; Tomaka, Thompson, & Palacios, 2006).

In aiming to explain how an older adult's social world and perception of that world affects the expression of cognitive impairment as well as offer opportunity to understand individual differences in the aging, guidance was offered by the suggestion that genetics play a large role in development of age-related changes or disease-related pathology; however, environmental factors may significantly contribute to the 'expression' of cognitive impairments (Mortimer, Borenstein, Gosche, & Snowden, 2005). One theoretical perspective that supports the contribution of environmental factors such as social isolation and loneliness proposed by Stern (2002) is used as the conceptual framework for this study.

### *The cognitive reserve hypothesis*

The cognitive reserve hypothesis posits that different life experiences, which are related to mental engagement and stimulation, such as level of education, type of occupation, physical and cognitive activities, and social engagement, may moderate brain pathology associated with cognitive decline and clinical outcome (Stern, 2002). The basis for cognitive reserve (CR) arose from reported findings that in some individuals the severity of neuropathological features of Alzheimer's Disease did not have a direct relationship with the degree of clinical manifestations (Katzman et al., 1988; Stern, Alexander, Prohovnik, & Mayeux, 1992). The cognitive reserve model refers to the brain's capacity to actively compensate for brain pathology with two forms: neural reserve and neural compensation (Stern, 2009, 2005). Stern (2009, 2005) suggests that, the idea guiding neural reserve is there are differences between individuals in the resilience of pre-existing cognitive processes that underlie

the performance of any task. The differences could be due to more efficiency or greater capacity of the pre-existing cognitive network, or greater flexibility in the networks when engaged to perform a task. The networks therefore are less susceptible to disruption. Neural compensation refers to the ability to shift operations to alternative neural networks when neural networks that would have normally been used for the task at hand are suffering from brain pathology.

Thus, the cognitive reserve model is based on the efficiency of neural circuits (Petrosini et al., 2009). It is suggested that when the neural circuits are stimulated by repeated use, they permit effective information processing, enhanced retrieval of memories, and increased ability for high-level problem solving (Petrosini et al., 2009). The cognitive reserve theory holds that cognitive stimulation encourages the development of neuroplasticity, which enhances brain resilience to pathological assault. Therefore, a more resilient brain due to increased cognitive reserve provides a delay in time between the pathological and clinical expression of significant cognitive decline (Scarmeas & Stern, 2003; Stern, 2002). That is, older people who have pathological cognitive impairment, but are regarded as having a greater cognitive reserve (as measured by premorbid IQ, education, social engagement and occupation attainment), would not show the same observable symptoms as a person with the same degree of cognitive impairment but lower cognitive reserves. Evidence for the cognitive reserve hypothesis has come from studies that have shown higher levels of social, recreational and intellectual activities to lead to greater tolerance against brain pathology (Scarmeas & Stern, 2003; Whalley, Deary, Appleton, & Starr, 2004). Likewise, there is a large body of evidence in support of the association between education, occupational attainment and intelligence scores, and cognitive decline (Karp et al., 2004; Le Carret et al., 2003; Manly, Schupf, Tang, Weiss & Stern, 2007; Richards & Sacker, 2003). Support for the benefit of the social environment on the brain initially came from animal studies. For example, a study on brain plasticity noted that the stimuli required to elicit plasticity may be activity-dependent (van Praag, Kempermann & Gage, 2000). Furthermore, exposure to an enriched environment providing opportunity for learning, social interaction and physical activity produced structural and functional changes in the brain (Scarmeas & Stern, 2003; van Praag et al., 2000). Longitudinal studies in Sweden have reported that both social interactions and intellectual stimulation may help maintain the cognitive performance in the ageing, as engagement in mental, social and productive activities were associated with a decreased risk of dementia (Wang, Karp, Winblad, Fratiglioni, 2002).

Another consideration regarding social interactions and cognitive reserve is the concept of social cognition. Social cognition refers to knowledge about one's self, perceptions of others, and interpersonal knowledge such as motivation (Adolphs, 2001; Amodio & Frith, 2006). All social interactions have some varying degree of complexity that involves the social cognitive processes (Fiske & Taylor, 1991). Processes involved in social cognition may be automatic or dependent on cognitive resources that are subsumed by the term 'executive functions' (Adolphs, 2001; Ybarra et al., 2008). These resources include attention capacity, working memory and cognitive control, which are required for flexible goal-directed behaviour (Adolphs, 2001; Amodio & Frith, 2006). Cognitive control involves the ability to coordinate thoughts and actions in relation to internal goals through selecting relevant information and organising and optimising information processing, which in turn subserves higher cognitive processes such as planning and reasoning (Miller, 2000; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Emerging literature in the area of social cognitive neuroscience has documented that social cognition relies on the prefrontal cortex, with the medial frontal

cortex regarded as having a special role in social cognition, as well as the limbic and associational cortical and subcortical brain regions (Adolphs, 2001; Amodio & Frith, 2006; Grady & Keightley, 2002). These regions have traditionally been associated with executive functions, semantic memory and episodic memory, respectively (Bennett et al., 2006; Ybarra et al., 2008). Therefore, it is possible that social interaction provides stimulation or exercises general cognitive resources, which consequently may promote cognitive reserve.

### *The effects of social isolation on cognitive ageing*

Though the research on social isolation and cognition is in its early stages compared to that on the relationship between social isolation and physical and mental health, some longitudinal studies and cross-sectional studies have indicated that older adults who are isolated or lonely are at greater risk of cognitive decline than their socially integrated peers (Bassuk, Glassman & Berkman, 1999; Crooks, Lubben, Petitti, Little, & Chiu, 2008). Various studies have investigated the effect of social isolation on cognitive functioning in the older adult, and as a predictor of cognitive decline. These have resulted in mixed findings and are inconclusive on how social isolation influences cognition. It has been suggested that this, in part, can be attributed to the myriad of ways social isolation has been conceptualised (Amieva et al., 2012; Shankar, Hamer, McMunn, & Steptoe, 2013). Objective social isolation measures have ranged from simple measures such as marital status, living arrangements or social network size, to the use of composite scales and validated social isolation measures. Some studies have reported that individuals who are married or living with a partner at midlife and in later life have better cognitive performance in later life than those single, widowed, or divorced (Håkansson et al., 2009; Helmer et al., 1999; van Gelder et al., 2006), whereas others have been unable to find any significant association (Amieva et al., 2010; Bickel & Cooper, 1994; Yoshitake et al., 1995). Other researchers have focused on social network size as a measure of objective social isolation. This has included items such as number of close ties (Albert et al., 1995; Bennett, Schneider, Tang, Arnold & Wilson, 2006), frequency of contact with family and friends within a time frame such as weekly or monthly (Barnes, Mendes De Leon, Wilson, Bienias, & Evans, 2004; Seeman et al., 2010), or a combination of size and frequency of contact (Green, Rebok & Lyketsos, 2008; Holtzman et al., 2004). Findings have been mixed for both cross sectional and longitudinal studies. In one study, larger social networks as measured by the number of relatives and family members outside the house, and number of friends and neighbours an older adult has contact with, were associated with better cognitive maintenance and less decline at follow up 12 years later in 354 older adults aged 50 years and over (Holtzman et al., 2004). An association between social network size and cognitive decline has been reported by others (Beland, Zunzunegui, Alvarado, Otero & Del Ser, 2005; Hughes, Andel, Small, Borenstein & Mortimer, 2008). In contrast, social network size was not associated with cognitive functioning in the older adult in a cross-sectional study (Krueger et al., 2009), or with cognitive decline in a 15-year longitudinal study (Amieva et al., 2010).

When studies have used composite scales of social isolation, including social activities as well as frequency of contact with family and friends or marital status, results have also been inconsistent on the effect of social isolation on cognition, with some studies reporting an association (Ertel, Glymour & Berkman, 2008) and others not (Wilson et al., 2007). For example, one of the first evaluations of the structural aspects of social network and cognitive decline was performed by Bassuk et al. (1999). The participants were community-dwelling adults aged 65 years and older, from New Haven, Connecticut. The term 'social disengagement' was used to conceptualise a composite measure that referred to the level of social ties and

participation in social activities. Cognitive performance was assessed through the Short Portable Mental Status Questionnaire (SPMSQ; Pfeiffer, 1975). This study concluded that older adults with no social ties were at increased risk of cognitive decline, compared to their counterparts with five or six social ties, after adjusting for risk factors for cognitive decline such as, age, gender, education, income, health, physical activity, and depressive symptomology. In a longitudinal study, a composite index of social network measures such as size of network, participation in activities, and perception of network was predictive of cognitive functioning at baseline, but not predictive of cognitive decline over the twenty years follow-up in a sample of 2055 participants with a mean age at baseline of 75 years (Stoykova, Matharan, Dartigues & Amieva, 2012).

Studies that have focused exclusively on assessing social engagement, including variations on the act of physical or cognitive participation with others such as volunteer work, paid employment, or participation in social and leisure group, have yielded positive results regarding the protective factor of increased participation in social, leisure and work-related activities on cognition (Barnes et al., 2004; Hertzog et al., 2009; Small et al., 2012; Zunzunegui, Alvarado, Del Ser & Otero, 2003). Social engagement has been linked with better performance on both global cognitive performance (Barnes et al., 2004; Fratiglioni, Paillard-Borg, & Winblad, 2004) and specific cognitive domains such as episodic memory tasks and verbal fluency (Ertel et al., 2008; Small et al., 2012).

Researchers have also been investigating the effects of the subjective qualities of one's social network on cognitive performance in the ageing. Some studies have reported an association between cognitive performance and qualitative factors such as emotional support (Seeman, Lusignolo, Albert, & Berkman, 2001), satisfaction with relationship (Amieva et al., 2010), and loneliness (Wilson et al., 2007). Loneliness and cognition was examined in a four-year study based on adults 65 years or older who resided in Chicago (Wilson et al., 2007). Emotionally lonely people had poorer cognitive performance at baseline for episodic memory, semantic memory, working memory, processing speed and visuospatial ability, and more rapid decline in global cognition, semantic memory, perceptual speed, and visuospatial ability than non-lonely people, controlling for social network factors such as size and participation in activities.

The importance of perception of one's social network on cognitive functioning was also reported by Amieva et al. (2010) based on data from PAQUID, an epidemiological prospective study on cerebral and functional ageing in French residents aged over 65 years ( $n = 3,777$ ). Amieva and colleagues (2010) assessed the influence of both structural and qualitative characteristics of social networks on cognitive decline in this 15-year longitudinal study. Findings from the study indicated that structural characteristics of social networks, such as size, social integration or social engagement had no association with dementia, whereas the perception of one's relationships was determined to be a protective factor for dementia. Assessing reciprocity of social interactions, older adults who perceived they had received more in their lifetime from others than they had given out, had a 53% reduction in risk of Alzheimer's disease. Satisfaction with one's relationships reduced the risk of dementia by 23%.

Amieva et al. (2010) concluded that their findings supported those of Wilson et al. (2007), postulating that the frequency of interactions or the number of people with whom one interacts in older age may be less important than the quality of interactions, such as being satisfied with the support available or the perception that the interactions met one's expectations or desires at that stage of life. Yet, in other studies perceived



emotional support (Bassuk et al., 1999), perceived social support (Eisele et al., 2012) and loneliness (Yeh & Liu, 2003) were not revealed as having an association with cognition in the ageing.

More recently, researchers have focused on the examination of both perceived social isolation in the form of loneliness and objective social isolation amongst the same population. Holwerda and colleagues (2012) reported that feelings of loneliness, which were assessed by the question “do you feel lonely or do you feel very lonely”, but not objective social isolation (defined as living alone, being unmarried or without social support), predicted dementia in a three-year study on non-demented community-living older adults. Yet, after four years results from the English Longitudinal Study of Ageing suggested that perceived social isolation and objective social isolation were both associated with poorer cognitive function amongst older adults, though domain specific (Shankar et al., 2013). That is, loneliness was significantly associated with poorer recall after four years, whereas social isolation was associated with lower scores on verbal fluency, immediate recall and delayed recall. Education also had a significant interaction with loneliness and social isolation for delayed recall, in that social isolation and loneliness were only associated with poorer delayed recall among those adults who had no formal qualifications from high school (Shankar et al., 2013). Similar findings to the study by Shankar et al. (2013) were indicated by DiNapoli, Wu, and Scogin (2013) in a cross-sectional study investigating the relation between social isolation and cognitive functioning in Appalachian older adults aged 70 years and above, who were community dwellers. Both perception of being isolated as well as being socially disconnected had an association with overall cognitive functioning across all cognitive domains measured (memory, attention, language abilities, and executive functioning). DiNapoli et al. (2013) noted that the perception of isolation accounted for nearly double the amount of variance in overall cognitive functioning compared to the measure of objective social isolation.

In conclusion, the literature review shows that since the late 1990s various studies have investigated whether the social world of the older adult has an association with their cognitive performance. Overall, the literature appears to provide direction that differing aspects of the social network may have an influence on cognitive functioning in the older adult. Important questions, such as which components of the older adult’s social world are risk factors or protective factors for cognitive functioning, and should therefore be incorporated into cognitive interventions, have yet to be answered conclusively. Patrick O’Reilly suggested in a review of the literature of social support and social networks (1988) that “as long as conceptual and operational confusion remains, the predictive utility of the concepts will not progress to the stage where logical and meaningful interventions can be developed” (p. 872). Twenty five years later, the words of O’Reilly are just as meaningful. For example, in the study by Holwerda et al., (2013), social isolation is associated with someone who lives alone, is not married, or has no social support. Shankar et al (2013), on the other hand, conceptualises social isolation as a combination of marital status, cohabitation status, low frequency of contact with family and friends, and low participation in a variety of social, recreational, religious and community groups and clubs. In the study by DiNapoli and colleagues (2013), social disconnectedness was determined by how many relatives or friends participants see or hear from at least once a month. Likewise, the concept of perceived social isolation itself has been operationalised in a variety of ways, with the majority of studies using a variation on the single item question “are you lonely”, or “do you have family and friends you can call on for help”. There is a paucity of studies that have used reliable and valid measures of loneliness such as the UCLA Loneliness scale, or the De Jong Gierveld Loneliness scale. As mentioned by Victor et al.

(2000), regarding the studies on the older adult's social world, the validity and reliability of the single items and indexes used to assess social isolation and loneliness in the older person is of concern.

While need for the use of different variables to assess the older adult's social network does not dismiss the authors' findings, it does lead to increased complexity in making meaningful comparisons between the studies. How researchers define objective and perceived social isolation is relevant, because it influences how they will operationalise and measure the concepts. As also suggested by Valtora & Hanratty (2012), though social isolation and loneliness have been studied from the various viewpoints of different disciplines, which has contributed to increasing knowledge, the lack of a clear message from any single body of work has in essence offered government and policy makers the opportunity to ignore the potential health gains from providing interventions to address loneliness and isolation. Furthermore there is an alleged failing of those conducting investigations in this field to adequately measure the two constructs of social isolation and loneliness, with many studies overlapping the measures (Coyle & Dugan 2012). It is the aim of this study to mitigate these concerns.

### **The present study**

The first question this study will investigate is to determine what are the "active ingredient" in objective social isolation. It is predicted that various measures of social isolation will differ in their association with cognition. The strongest association between different forms of objective social isolation and cognition is predict to be measures of social engagement and social interaction and cognition. These may include frequency of contact with family and friends, voluntary work, participation in social activities, attendance at a religious organisation, involvement in community groups. These measures offer an individual opportunity for mental stimulation, as well as interactions that are novel and challenging. Furthermore one function often provided by social engagement activities is that the experiences can be rewarding and stress relieving, thereby creating positive emotions that may help assist with maintenance of cognitive reserve. For socially isolated individuals the lack of engagement and interaction, it is hypothesised may result in poorer cognitive performance than their peers with higher levels of social engagement and interaction.

#### *Perceived social isolation*

Three measures of perceived social isolation (social loneliness, emotional loneliness and social support) and their relationship with cognition will be analysed. The cognitive reserve and neuroplasticity model posits that negative affect and depressive symptoms may result in negative neuroplasticity. There is support for this as in recent years both animal and human studies have provided evidence that chronic stress and major depressive disorder have deleterious effects on the brain, both structurally and functionally (Kays, Hurley & Taber, 2012). Perceived social isolation has been empirically linked with mental health illness (Coyle & Dugan, 2012), and as a predictor of changes in depression (Cacioppo, Hawkey & Thisted, 2010). However, research has shown that even when controlling for depression, loneliness still had a significant association with cognition (Wilson et al., 2007). It is predicted that perceived social isolation will have a significant association with cognition. Therefore, based on evidence from the literature and my previous work on perceived social isolation, I hypothesise that different forms of perceived social isolation will have different associations with cognition both in the cross-sectional studies and the longitudinal studies.

Social loneliness as a form of loneliness and the relationship with cognition has received little attention in the literature. Turning to the literature on social exclusion/rejection/ostracism, it was suggested by Peplau and Perlman (1982) that loneliness is a protracted and negatively valenced feeling of social exclusion. Loneliness is like acute social exclusion in that both describe a deficit in 'belongingness'. Social loneliness as suggested by Weiss (1973) is associated with boredom, aimlessness, marginality, and meaninglessness. As discussed in the works of Williams (2001) on ostracism, four fundamental human needs are threatened by ostracism, the need to belong, the need for self-esteem, the need for control, and the need for meaningful existence. When these needs are threatened, the evidence supports the claim that individuals exhibit pathological consequences beyond mere temporary distress (Baumeister & Leary, 1995, p. 498). Psychological distress is regarded as a factor that may promote negative neuroplasticity (Wilson et al., 2006; Vance, 2012), and cognitive reserve may be weakened as a consequence. In this study, social loneliness is predicted to have a negative association with cognition. That is older adults who self-report as being socially lonely may have poorer cognitive functioning than their non-lonely peers. For the current study, I predict that emotional loneliness will have a negative association with cognition over the two-year period as consistent with the findings of Wilson (2007). There are no specific predictions on which form of emotional or social loneliness will have the more significant negative association with cognition.

Of all the perceived social isolation measures, social support has been the least consistent with cognition. I am predicting that low levels of social support will have an association (though weak) with cognition over the two-year period.

#### *Interaction effect of objective social isolation and perceived social isolation*

The aim of this study is to understand the interaction effect of objective social isolation and the different forms of perceived social isolation (emotional loneliness, social loneliness and social support) on cognition over time. The research question being asked is whether cognitive performance worsens with increases in perceived social isolation for older adults who are objectively socially isolated.

The study will also investigate whether health and education moderate the effect of the various forms social isolation on cognition over time.

## **Method**

### *Participants*

The data used for this analysis are from the NZLSA (NZLSA; Towers et al., 2012) which is a longitudinal study of the health, wealth, social, and demographic factors underpinning successful ageing in New Zealanders aged 50-84 years old. The 2010 NZLSA sample were all drawn from the New Zealand electoral roll using equal probability random sampling to ensure a nationally representative sample. Māori were oversampled using the Māori descent indicator in the electoral roll database in order to increase the Māori subsample. The sample of 4,339 older New Zealanders was provided with questionnaires and invited to complete the first NZLSA postal data collection wave in 2010. Of those provided with a questionnaire, 3,317 older adults responded. The NZLSA 2010 postal questionnaire included an item asking the participants if they would be willing to volunteer for a face-to-face interview in 2010. Of the 3,317 who completed the questionnaire 1,077 agreed to participate in a face-to-face interview. One thousand and four participants

were able to be interviewed before the cut-off date of 1 December 2010. For the current study the sample will included all participants who: a) had completed the postal survey; b) were interviewed face-to-face; and c) were 65 years or older as at 7 March 2010.

The 2010 NZLSA data collection was based on two principle methods. All NZLSA participants completed a paper-based, retrospective, self-report postal survey focusing on six major domains: general health, social support, care-giving roles they may perform, financial well-being, characteristics of neighbourhood, and demographic information. Of the total sample that completed the postal survey, approximately 1,000 were then selected for face-to-face interviews which measured cognitive performance, mental health, and financial well-being and socio-demographic factors.

### **Measures**

For the present study, global cognition and cognitive domains (memory, fluency, language and visuospatial) are individually treated as dependent variables. Social isolation measures are treated as independent variables and include indicators of social integration, perceived social support, emotional loneliness and social loneliness are treated as independent variables. Education, age, gender, depressive symptomology, smoking status, physical functioning and medical conditions (diabetes, heart trouble and stroke) are used as covariates.

The data for global cognition and the cognitive domains, relationship status and education status were collected in the face-to-face interviews. These data were merged with the postal survey data, which provide the information for all other measures. Measures are described below and the specific questions are provided at the NZLSA website (refer to: <http://nzlsa.massey.ac.nz/surveys.htm>).

#### *Cognition measures.*

The Addenbrooke's Cognitive Examination – Revised is a brief sensitive and specific test battery to detect early cognitive dysfunction (ACE-R; Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006). Five cognitive domains are assessed by the test: attention and orientation, memory, fluency, language and visuospatial abilities. All five cognitive domain scores contribute to the total score of a possible 100 for global cognitive performance. A higher score indicates better cognitive performance. The alpha coefficient for the ACE-R total score is .80 which is considered very good (Mioshi et al., 2006). The ACE-R total score in clinical practice is used to screen for dementia by reference to cut-off points. In this study the total score will be analysed with no reference to cut-off points, other than for descriptive purposes. Similarly, the subscales in this study will be used without reference to cut-off points as has been the case in previous research (Mathew, Bak, & Hodges, 2011; Ordonez, Yassuda, & Cachioni, 2011).

#### *Perceived social isolation – The Social Provisions Scale.*

The Social Provisions Scale (SPS; Cutrona, 1986; Cutrona & Russell, 1987) was developed to assess the provision of social relationships as described in work by Weiss (1973, 1974). The provisions of social support reflect what the participant perceives they are able to receive from the relationships they have with other people in their social network. The SPS has six subscales that assess guidance (advice or information),

reliable alliance (assurance that others can be counted on in times of stress), reassurance of worth (recognition of one's competence), attachment (emotional closeness), social integration (a sense of belonging to a group of friends), and opportunity for nurturance (providing assistance to others). All subscales are summed to provide the total support provision score (0-96), which reflects a global or general perception of available social support from an older person's network. The higher the score the more social support an older adult perceives they have available to them. The SPS has sound internal consistency with Cronbach alpha coefficient reports of .91 to .92 for the Total Social Provision Scale (Cutrona et al., 1986; Langeland & Wahl, 2009). Individual scales report a Cronbach alpha coefficient range from .65 to .84 (Cutrona, 1986; Langeland & Wahl, 2009).

#### *Perceived social isolation – de Jong Gierveld Social and Emotional Loneliness Scales.*

The 11-item de Jong Gierveld Loneliness Scale (de Jong-Gierveld & Kamphuis, 1985; de Jong Gierveld & van Tilburg, 1999) was developed to assess the subjective experience of loneliness based on Weiss's (1973) distinction between social and emotional loneliness. Of the 11 items there are six negative items which measure aspects of emotional abandonment and missing companionship (de Jong Gierveld & van Tilburg, 1999). Examples of negative items are "I experience a general sense of emptiness" and "I often feel rejected". The total of the negative items produces a score for the subscale emotional loneliness with a range from 0 (not emotionally lonely) to 6 (severe emotional loneliness). The remaining five positive items measure feelings of sociability and meaningful relationships. Positive items include "I can call on my friends whenever I need them" and "There are many people I can trust completely". The total of the positive items produces a score for the subscale social loneliness with a range from 0 (not socially lonely) to 5 (severe social loneliness). The two subscales, emotional loneliness and social loneliness, can be used as separate measures of different forms of loneliness or the subscales can be combined to provide an 11-item loneliness scale. In the present study the subscales of emotional and social loneliness are used as separate measures. The de Jong Gierveld Loneliness Scale has reported internal consistency in the range of 0.80-0.90. In the current study the benefit of using the two subscales over a general measure of loneliness will provide greater insight into how different forms of loneliness may influence cognition in the older person (Ó Luanaigh & Lawlor, 2008; van Baarsen, Snijders, Smit & van Duijn, 2001).

#### *Covariates.*

As a decline in cognitive performance may be due to factors other than social isolation, a selected set of potential confound variables are considered to reduce the possibility of spurious associations. Confound variables selected that have been shown to be associated with cognitive decline and are commonly controlled for when assessing cognitive performance in the older adult (Park et al., 2003; Plassman et al., 2010). In the study of cognitive decline it was recommended by Park et al. (2003) that age, sex, and education must be addressed. Other potential confounds to be controlled for in this study were drawn from a systematic review of factors associated with cognitive decline (Plassman et al., 2010) and previous studies. Based on 127 observational studies, 22 random control trials, and 16 systematic reviews, factors such as diabetes, metabolic syndrome conditions, depression and smoking were identified as have an association with cognitive decline. General physical functioning was controlled for in this study as physical functioning has been associated with cognitive performance in the older adult. Marital status and ethnicity are also included, which is common

practice when researching social isolation and cognition (Ertel et al., 2008; Seeman et al., 2001; Wilson et al., 2007).

## **Statistical Analysis**

### *Statistical Analysis*

There will be a number of analyses performed on the data, such as correlations, factor analysis, hierarchical multiple regression. Initial data analysis will include the screening of variables through appropriate analytical tools for the following; missing values, fit between their distributions and the assumptions of multivariate analyses. Descriptive statistics will then occur to provide a variety of information on the variables used in this study (this will also include change over time of cognition and loneliness).

*Study One : Active ingredient of objective social isolation and conceptualisation of objective social isolation for this study.*

Key idea is to understand a) what is the relationships between the different objective social isolation measures that have been used throughout the literature such as marital status, cohabitation status, social engagement, recreation. Then for this study b) conceptualisation or build a measure of objective social isolation that will be used in the next step of the data analysis.

Measures available include: Marital Status, Co-habitation Status, Social Engagement Scale, Recreation Scale, Working Status, Religion Activity, Childcare duties, Committee/Leadership Duties (Volunteering). Pearson's correlation will be used to determine a) What is the different relationships between the different objective social isolation measures and b) What is the different relationships between the different objective social isolation measures and the perceived social isolation measures.

For the remaining questions to be answered measures of cognitive function at follow up will be regressed on to objective social isolation measures determined from study 1 and perceived isolation measures at baseline. Regression models will be run for each of the cognitive function outcomes. Models will be run in three steps. The first step includes all covariates and baseline cognitive function. All measures of isolation will be added in step two. Each of the interactions will be evaluated in separate models, with objective social isolation and emotional loneliness interaction in the final step in one model, objective social isolation and social loneliness in the final step in model two, objective social isolation and perceived social support in the final step in model three. The following models will occur which is the interaction effect between each form of isolation and health, and each form of isolation and education.

## **Discussion**

The current research will be noteworthy as it will extend previous research on social isolation and cognitive functioning through the use of social isolation measures. One of the key aims of this study is to investigate the relationship between different forms of social isolation and cognitive performance in the ageing over a two-year period. Though there have been lengthier longitudinal studies than the one proposed,

there are few studies that have used a variety of social isolation measures on the same population. This in itself is perhaps one of the reasons there has been a lack of progress in determining which factors of social isolation and loneliness influence cognitive functioning.

In the last ten years, across a number of studies, using indicators of social isolation have been associated with cognitive decline but, as House (2001) noted, when the components of social isolation are examined separately in various studies, it is increasingly difficult to identify the ‘active ingredient’ of social isolation that is a pathway to negative outcomes on physical, mental and cognitive health in the ageing. The current study’s relevance will be to fill in the current deficit by an examination of a variety of social isolation measures, both qualitative and quantitative, and their influence on cognitive functioning on the same population.

In the current study, the objective measures available are marital status, frequency of contact with family and friends, voluntary activities, as well as social engagement activities. Recreational activities and social activities will be independently analysed with regard to their association with cognitive functioning. This study will also have the ability to analyse social engagement activities data from other social network data when investigating objective social isolation and its effect on cognitive functioning. There are three forms of perceived social isolation measures: perceived social support, emotional loneliness and social loneliness. This use of different measures of perceived social isolation has received scant attention in the literature with the common focus being on a general feeling of loneliness. My research intends to bridge the gap of knowledge in the following areas: the influence of social loneliness, emotional loneliness and perceived social support on cognitive functioning in the older adult. In my previous research on different forms of social isolation and cognitive performance in the ageing, results showed that only one form of perceived social isolation influenced cognition, and that was social loneliness. Emotional loneliness and perceived social support did not have a significant association with cognitive performance in adults over 65 years old in the cross sectional study. To my knowledge, my research has been the only study that has looked at different forms of loneliness and cognitive performance. According to Heylen (2010), distinguishing between different forms of loneliness will provide a more in-depth understanding of the development of loneliness in older age, as well as the consequences of various types of loneliness. As suggested by Weiss (1973) and Hawkey et al. (2005), social and emotional loneliness are separable dimensions of loneliness. Current research has shown that risk factors for social loneliness and emotional loneliness differ. Social loneliness has a higher correlation with social network size than emotional loneliness, and also with lack of contact with friends, lack of social integration, poorer health and age (Dahlberg & McKee, 2013; Drennan et al., 2008; Heylen, 2010; van Barsen et al., 2001). Emotional loneliness has a stronger association with marital status (Dahlberg & McKee, 2013; Drennan et al., 2008). Empirical evidence is supporting the conceptual separation of emotional and social loneliness. It seems prudent to investigate the different forms of loneliness and their predictors to gain greater understanding of how the social world may influence cognitive functioning in the older adult.

One other area the present research will expand on is whether the impact of social isolation on cognitive functions is direct or whether it is moderated by health and education. As discussed in the literature review, social isolation has consistently been reported as having a negative association with physical and mental wellbeing. Likewise, hypertension, heart disease, diabetes, and depression have been shown to have a negative effect on cognitive functioning in the ageing. Health is commonly used as a controlling variable in

studies on social isolation and cognition; however, to my knowledge there is no research on the possible moderating role of health in the relation between different forms of social isolation and various cognitive domains in the same population. It would be expected that health is an important moderator in relation to cognitive performance. Also, education is regarded as being an important contributor to the individual differences in cognitive reserve (Stern, 2002). The interaction effect of education and social isolation on cognition will provide knowledge as to whether the effects of social isolation on cognition is moderated by the levels of education.

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