The Effects of Social Isolation on Cognition: Social Loneliness Reduces Cognitive Performance in Older Adults

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

Master of Science

in

Psychology

at Massey University, Palmerston North

New Zealand

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2013

Abstract

The present cross-sectional study examined the influence of social isolation on cognitive performance among older adults aged 65-84 years old. This study extended previous work on social isolation and cognition in two ways. While 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, a link between social loneliness and cognition has not been examined. Therefore, the current study examined 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 data from the New Zealand Longitudinal Study of Ageing (NZLSA) (2010) was used for analysis. The NZLSA study included questions about demographic information, mental and physical well-being, loneliness, social support, social networks and cognition. Using multiple regression analyses the influence of social isolation on cognitive functions was investigated. Results showed that various forms of social isolation may be differentially important for cognitive performance in the older adult, with social loneliness the only measure of social isolation that influences cognition. The results also suggested that if a form of social isolation affects cognition, the different cognitive domains such as global cognition, fluency, language and visuospatial ability respond in a similar pattern. Explanations of why social loneliness influences cognition is discussed. Limitations of the study and implications for future research, such as the need for a longitudinal study that simultaneously assesses the links between the various forms of social isolation and cognition, is also discussed.

Acknowledgements

I would like to acknowledge and give my thanks to those who have provided support, advice and encouragement throughout my journey of this Master thesis.

First, I would like to acknowledge Dr Stephen Hill and Dr Andy Towers, my academic supervisors, for the expert advice and assistance they have given me throughout the year. Thank you, your perspectives and insights were extremely valuable in helping me with this study and I believe stand me in good stead going forward with future research.

To my partner David thank you for providing me all the support and encouragement that is needed. I am forever grateful. To my daughters Eilis and Sophia, your ability to understand my desire and need to study is something that I am so proud of and something that I treasure. Thank you.

To my mother and friends who have given me the words of encouragement throughout the year. Thank you.

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Chapter One: Introduction

This chapter provides a background context for the present study. It presents descriptive statistics of New Zealand's ageing population, a brief discussion on one of the most pressing issues (cognitive ageing), and an introduction to the emerging issue of social isolation.

New Zealand, like other countries, has an ageing population. The last 50 years has seen a rapid expansion in the proportion of New Zealanders aged 65 years and over. More so than any other age group in the country they have repeatedly outpaced the growth of the total population of New Zealand (Statistics New Zealand, 2007). In 2006 the older population (65 years and over) made up 12.3% of the total, whereas in the early 1970s they were only 8.5% of all New Zealanders. By 2051 the 65-year-and-over age group is expected to be slightly over one-quarter (26.3%) of the total population (Statistics New Zealand, 2007). The changes in population are due to three demographic trends: the 'baby boomer' generation, born between 1946 and 1965, is approaching retirement age; lower birth rates since the 1970s; and advancements in medicine, science and technology that have resulted in increased lifespans (Butler, Forette, & Greengross, 2004; Dustan & Thomson, 2006). This 'greying' of the population brings with it far-reaching implications for society. The rapidly 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 developing specialised services for the older adult such as geriatric psychology (Davey & Glasgow, 2006; Deary et al., 2009; Hendrie, Purnell, Wicklund, & Weintraub, 2010).

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 Institutes of Health (Australian Institute of Health and Welfare (AIHW), 2006; Cornwell & Davey, 2004; Hendrie et al., 2010; Ministry of Health, 2002). It was reported by the Ministry of Health (2011) that there were approximately 40,000 (1%) of New

Zealanders who had cognitive impairment in 2008. This was estimated to increase to 75,000 or 1.5% of New Zealanders by 2026 (Ministry of Health, 2011). In a worldwide study on the prevalence of cognitive impairment, it was estimated that 24.3 million people had this which will increase to over 81 million people by 2040 (Ferri et al., 2006), indicating that every seven seconds there is a new case of cognitive impairment. A decrease in cognitive ability has a variety of consequences such as increased: likelihood of a reduction in effective and independent functioning in the individual; risk of disability and dementia: institutionalisation; and risk for death (Deary et al., 2009; Habib, Nyberg, & Nilsson, 2007; Njegovan, Man-Son-Hing, Mitchell, & Molnar, 2001; Wilson et al., 2012; Yaffe et al., 2009). Cognitive decline has costs to both the individual and society. For example, it has been associated with an increase in medication non-adherence (Insel, Morrow, Brewer, & Figueredo, 2006), poor medical decision-making capacities (Okonkwo et al., 2007), and poor mental health outcomes (Alexopoulos et al., 2000). These are factors that are detrimental to the individual but are also associated with increase health care costs (Mackin, Delucchi, Bennett, & Areán, 2011). In a report by Alzheimers New Zealand (2012) the total cost of severe cognitive impairment (dementia) was estimated at $954.8 million for 2011. This includes costs such as aged care, medication, specialists, general practitioners, informal care and productivity loss. Consequently, researchers are placing emphasis on understanding the mental, physical and social factors that promote successful cognitive ageing, as well as risk factors with a detrimental influence on cognitive ability (Deary et al., 2009; Fillit et al., 2002). One such possible risk factor of cognitive decline that has emerged in the last decade is social isolation.

Lifestyle events such as the death of a spouse, siblings or friends, transition from work to retirement and accompanying financial restraints, as well as declining physical health become increasingly likely for older adults. All of these factors may result in reduced social integration and engagement. In a survey by the Ministry of Social Development on the living standards of the older New Zealanders aged 65 years and over (N=3060), it was notable that 53% of the older population were divorced, widowed, separated or had never married (Fergusson, Hong, Horwood, Jensen, & Travers, 2001). Marriage offers a protective factor from social isolation and those who are married report less of this than their non-married counterparts (Andersson, 1998; Dykstra, van Tilburg, & de Jong Gierveld, 2005; Fratiglioni, Wang, Ericsson, Maytan, & Winblad, 2000; Wenger, Davies, Shahtahmasebi, & Scott, 1996). For the older adult, with the advent of retirement

and children leaving home there is an increase on reliance placed on one's immediate social environment. Studies have noted in particular that the attachment with one's cohabiting partner can provide a protective factor towards loneliness and social isolation (de Jong Gierveld & Tilburg, 2010; Pinquart & Sorensen, 2000).

It was also reported in the Ministry of Social Development survey that the majority of the single population lived alone (82%) and nearly three-quarters of the single population were female (74%). In a review of studies on social isolation, it was viewed that living alone could be equated with social isolation and loneliness, as nearly all older adults who were socially isolated or lonely lived alone (Wenger et al., 1996). In an Australian study, adults who were living alone were six times more likely to be isolated or very isolated than those who lived with a companion (Hawthorne, 2008). Recent trends, such as the aged living longer in their own home, a highly mobile society, and families having fewer children, have the potential to increase the occurrence of social isolation and loneliness further (Routasalo & Pitkala, 2003; Tomaka, Thompson, & Palacios, 2006). For example, a consequence of the mobile society is family members may have great geographic distances between each other which may result in reduced contact between kin. This may increase social isolation and loneliness as the older adult loses the opportunity of useful social roles such as providing family support and childcare and likewise having familial support and interaction as they age (Heller, 1993).

Researchers have now begun to study the influence of social isolation on cognition in the older adult, drawing on existing knowledge about its association with poorer health and general well-being (Cohen, 2004; Tomaka et al., 2006; Uchino, 2006). Research concerning the role that an older person's social world plays in cognitive decline is in its infancy compared to the understanding of, for example, depression in late life or the effects of medical conditions such as cardiovascular disease on cognition (Ó Luanaigh & Lawlor, 2008; Seeman, Lusignolo, Albert, & Berkman, 2001). At this stage the majority of the literature is exploratory and inconclusive regarding the relationship between cognition and the social world of the older person (Amieva et al., 2010; Small, Dixon, McArdle, & Grimm, 2012). The inconclusiveness of results may be in part due to the complexity of an individual's social environment. As the social world of each individual involves structural characteristics such as size of network, density of network, frequency of contact, and, how an individual perceives their social network in terms of support, friendship and satisfaction

with the relationships. Indicators of social isolation used to research social isolation and cognition have included size of network, frequency of contact and marital status, whereas perception of network may involve measures of satisfaction with support received, or perception of support available (Amieva et al., 2010; Bassuk, Glass, & Berkman, 1999; Beland, Zunzunegui, Alvarado, Otero, & del Ser, 2005; Seeman et al., 2010; Zunzunegui, Alvarado, Del Ser, & Otero, 2003). The majority of studies have assessed one component of the social network such as structural characteristics or perception of emotional support and the link with cognition (Amieva et al., 2010; Hughes, Andel, Small, Borenstein, & Mortimer, 2008). However, as already mentioned, the social world is complex and it would be beneficial to ascertain if various forms of social isolation have a differential association with cognition in the same sample. This would enable the ability to determine if all forms of social isolation influence cognition or if some components of the older person's social network have a greater influence on cognitive performance than others. The research currently cannot provide an answer due to the noticeable lack of studies that have compared simultaneously the association between the different types of social isolation and different aspects of cognition. This also has implication for intervention. For example, if a lack of social ties influences cognitive performance, regardless of how an older person perceives their social network interventions, focusing on increasing contact and friendships with others may prevent or reduce cognitive decline due to social isolation. However, if research shows that perception of the social network, regardless of the number of social ties or frequency of contact influences cognition, then intervention strategies will differ. Rather than a focus on increasing social ties, it may require therapy such as cognitive behaviour therapy that identifies automatic negative thoughts or maladaptive social cognition, thereby changing how one perceives one's social network.

Another limitation of much current research is that cognitive outcomes have commonly been assessed through the use of a global measure of cognitive performance such as the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), or a summary score of various cognitive abilities (Barnes, Mendes De Leon, Wilson, Bienias, & Evans, 2004; Bassuk et al., 1999; Holtzman et al., 2004; Yeh & Liu, 2003; Zunzunegui et al., 2003). Yet research indicates that cognitive functions have different developmental trajectories and different response patterns to environmental factors (Kramer, Bherer, Colcombe, Dong, & Greenough, 2004; Salthouse, 2009). Examining whether various cognitive domains respond in a similar pattern to social isolation would

further increase the knowledge in this area and may give greater insight into why social isolation may be a risk factor for cognition. This leads into the purpose of the current study which is to determine whether global cognition and specific cognitive domains are differentially influenced by various forms of social isolation and, if so, what form of social isolation is most detrimental to cognition in the older adult. Research that increases the understanding of the relationship between social isolation and cognition is vital to ensure that policies and interventions can strategically target those areas of social isolation that are the most detrimental to the older adult's cognitive well-being.

Chapter Two: Cognition

"Even where there was a statistically significant association between increasing age and greater cognitive decline a proportion of individuals demonstrated no such change in cognition"

(Park, O'Connell, & Thomson, 2003, p. 1130)

Overview

This chapter introduces cognition and its importance for day-to-day living in the ageing population. A review of changes in cognitive performance with age and a discussion on the documented risk factors associated with cognitive decline follows. Finally, social isolation is discussed as a possible risk factor for cognitive decline.

Cognition

Cognition refers to the acquisition, storage, transformation and use of knowledge (Matlin, 2003; Reed, 2012). Within this description reside a wide range of mental processes such as attention, learning, memory, language, perception, spatial manipulation and executive functions (e.g., reasoning, decision-making, planning and goal-setting) (Jurado & Rosselli, 2007). These mental processes are commonly referred to as cognitive domains or cognitive functions. Empirical evidence suggests that ageing is accompanied by changes in cognitive performance (Craik, 1998; Hedden & Gabrieli, 2004; Park et al., 2003; Salthouse, 2010), which is referred to as cognitive ageing or cognitive decline. Cognitive ageing is defined as "a decrease in performance on various measures of cognitive functions associated with increased ageing in the adult portion of the lifespan" (Salthouse, 1991, p. 2). Cognitive decline, on the other hand, reflects a continuum of changes in cognitive abilities. This continuum ranges from non-pathological cognitive decline to sub-clinical cognitive impairments, where decline exceeds what is expected and may represent a transitional state between normal ageing at one end of the continuum and dementia at the other (Deary et al., 2009; Park et al., 2003; Petersen et al., 2001).

Cognitive ability, which reflects an individual's capacity to process, reason, plan, comprehend information and solve problems (Jex, 2002; Landy & Conte, 2004), is regarded by researchers and the ageing population themselves as a key determinant for

successful ageing and one's ability to lead a productive and fulfilling life in old age (Depp & Jeste, 2009; Reichstadt, Depp, Palinkas, Folsom, & Jeste, 2007). It is therefore not surprising that a decline in cognitive ability and the resulting loss of independence is one of the most greatly feared aspects of ageing for the majority of older people (Butler et al., 2004; Deary et al., 2009).

An independent lifestyle requires not just adequate physical functioning in daily life but adequate cognitive ability, because cognitive functions underlie performance in all daily living tasks (Bosworth & Ayotte, 2009). Instrumental Activities of Daily living (IADL) such as cooking, housework, driving, shopping, managing finances, and taking medications are highly dependent on adequate cognitive ability. These skills require both basic and complex levels of cognitive functions such as attention, working memory and executive functions (Johnson, Lui, & Yaffe, 2007; Njegovan et al., 2001; Ward, Jagger, & Harper, 1998). For example, driving is one of the most important skills for retaining independence and involves a range of cognitive functions including attention, working memory, visuospatial skills, and executive functions for decision-making and reasoning (Daigneault, Joly, & Frigon, 2002). Similarly, the ability to handle finances is crucial to the older person's independence and well-being (Widera, Steenpass, Marson, & Sudore, 2011) and this involves a mix of simple tasks (e.g., counting cash, remembering personal identification numbers on transactional cards) and more complicated tasks (e.g., balancing the cheque book, anticipating bills and managing budgets). Such tasks require working memory, long-term memory, mental calculation, and executive functions such as decision-making, planning, and semantic knowledge (Griffith et al., 2003; Okonkwo, Wadley, Griffith, Ball, & Marson, 2006). To a lesser extent, even routine activities such as self-care functions (dressing, bathing, toileting, and eating) are reliant on adequate cognitive functioning (Fauth et al., 2012).

Declining cognitive ability is an important risk factor in the development of functional impairment and disability and can result in the inability to function adequately in daily life (Herzog & Wallace, 1997; Johnson et al., 2007; Moritz, Kasl, & Berkman, 1995). In longitudinal studies, older adults with lower cognitive performance at baseline were more likely to have functional disability and an increased risk for institutionalisation or death than those with higher cognitive performance (Barberger-Gateau & Fabrigoule, 1997; Johnson et al., 2007; McGuire, Ford, & Ajani, 2006). The consequences of such

cognitive decline include increased risk for progression to mild cognitive impairment and dementia (Petersen, 2002; Plassman, Williams, Burke, Holsinger, & Benjamin, 2010), for a first stroke (DeFries, Avendaño, & Glymour, 2009), and an increased risk of falls (Holtzer et al., 2007).

Is cognitive decline inevitable?

The older population is heterogeneous. Many older adults avoid severe cognitive decline, with examples of the oldest old[1] (85 years of age or older) having the cognitive vitality required for maintaining an independent life, while others are institutionalised before they are 70 (Evert, Lawler, Bogan, & Perls, 2003; Luscombe, Brodaty, & Freeth, 1998; Silver, Jilinskaia, & Perls, 2001). Yet in a review of the 19 papers on cognitive ageing, Park et al. (2003) concluded that cognitive decline is almost universal in an ageing general population and can be expected in the majority of the oldest old. This supports the findings of other researchers, which link increased age with a general decrease in cognitive performance (Christensen, 2001; Salthouse, 2009; Salthouse, 2010). However, longitudinal studies have demonstrated that the onset of normal (non-pathological or normative) decline can differ significantly for different cognitive functions, as can the rate and extent of decline for these separate functions across the lifespan (Anstey & Low, 2004; Christensen, 2001; Salthouse, 2009; Schaie, Willis, & Caskie, 2004). Cognitive functions that involve the use of accumulated knowledge and expertise and rely on long-term semantic memory (e.g., vocabulary, word knowledge, general knowledge and comprehension) are the functions most resistant to deterioration with ageing (Anstey & Low, 2004; Salthouse, 2010). In fact, evidence suggests that they can actually improve with age up to the sixth and seventh decade (Anstey & Low, 2004; Salthouse, 2010). On the other hand, cognitive functions such as information processing speed, episodic memory, and reasoning show age-group related decrements in performance from early adulthood (Salthouse, 2009). Salthouse (2010) highlights a key distinction between these age-resistant and age-prone cognitive functions; the former set involves products of processing carried out in the past, whereas the latter reflect processes "carried out at the time of assessment" (Salthouse, 2010, p. 754). Table 1 (p. 13) provides a more in-depth description of the various cognitive domains and changes associated with ageing. In

[1] 'Oldest old' has been used to refer to adults aged 85 years or over by some authors (Ling et al., 2010; Suzman, Willis, & Manton, 1995) and those 90 years or over by other researchers (Corrada, Brookmeyer, Paganini Hill, Berlau, & Kawas, 2009).

determining the relationship between social isolation and cognition, if the wider set of cognitive functions are not homogenous as suggested by Salthouse (2010), then it is more appropriate to monitor the effects of social isolation on each cognitive function individually, rather than only use of a global measure of cognition. Individual assessment of the association between cognition and different forms of social isolation will provide greater insight into the mechanisms of how social isolation may influence cognition.

Table 1. Cognitive Domains and Changes Associated with Ageing

Description of Domain	Changes associated with ageing	References
Short Term Memory – brief retention of a simple span, i.e. repeat back a list of numbers.	Very little decline with age.	(Luo & Craik, 2008)
Working Memory processes information across a series of tasks and modalities (auditory, visual or spatial information), which is temporarily held and manipulated in conscious awareness, and once again held in short term.	Working memory tasks are highly influenced by age: the more difficult the task, the greater the decrease in performance by the older adult. For example reorganising a short list of numbers into ascending order, age-related decrements normally occur.	(Baddeley, 2003; Bopp & Verhaeghen, 2005; Craik, 2008; Luo & Craik, 2008)
Episodic Memory is the memory of personal experiences or recently acquired information (memories tied to specific episodes in time). Examples of episodic memory are "What did I have for breakfast this morning" or "What are the words I just read to you on the list".	Episodic Memory is the memory system most affected by age. Specifically tasks such as free recall, in which participants are asked to recall information they have learnt without any guidance, have notable age-related decrements. Also, more specific information required from memory shows an increased decline compared to general information.	(Christensen, 2001; Craik, 1999; Jonker, Geerlings, & Schmand, 2000)
Semantic memory refers to declarable facts/ general knowledge that are not associated to a specific learning episode. Semantic memory begins to be acquired early in life and continues to expand throughout the lifetime. Organised conceptually without reference to the time and context in which it was acquired, for example knowing a cat is a mammal.	Semantic memory holds up well with ageing; differences, if noted, are small. Specific areas of semantic memory such as word-finding failure and retrieval of names do increase with age.	(Craik, 1998; Hedden & Gabrieli, 2004; Heine, Ober, & Shenaut, 1999; Maylor, 1990; Park & Reuter-Lorenz, 2009)
Attention is a broad term to describe a set of dynamic processes that involve a concentration of mental activity. It involves specific functions or combinations of functions such as distinguishing between relevant and irrelevant stimuli (selective attention), ability to concentrate or focus on one source of information (focused	Attentional efficiency varies with the complexity of the task or situation in the ageing. Simple spans of attention remain relatively intact in the 80s. Focused attention remains stable. Deficits occur in selective attention and sustained attention with age. Divided attention decreases, though, relative to the task. Simple tasks result in little or no decreases. The more complex the task, the	(Commodari & Guarnera, 2008; de Fockert, 2005; Filley & Cullum, 1994; Hendrie et al., 2010; Palmer & Dawes, 2010;

attention), ability to actively process incoming information over a period of time (sustained attention), and ability to simultaneously perform more than one task at a time (divided attention). Driving is one activity that involves various forms of attention.	more likely deficits increase; such as older people responding more slowly or making more errors.	Rogers, 2000; Verhaeghen & Cerella, 2002)
Visuo-spatial ability is the recognition of objects and their location or orientation in three-dimensional space, identification of shape of objects. It includes coordination of motor movements with visuospatial information (such as hand eye coordination required for drawing). Everyday examples are the ability to get dressed, to copy drawings, to find one's way around the house.	Object and shape recognition remain relatively intact throughout the lifespan. Visuo-perceptual judgement for spatial stimuli declines from early 60s. Basic perceptual analysis is intact. Greater age-related decline is found in substantial problem-solving tasks that involve perceptual integration and reasoning. Copying of drawings becomes less accurate with increased complexity of the drawing.	(Jenkins, Myerson, Joerding, & Hale, 2000; Lezak, Howieson, & Loring, 2004; Robitaille, Muniz, Piccinin, Johansson, & Hofer, 2012)
Language/ verbal ability is the production and comprehension of appropriately sequenced speech sounds, assignment of meaning to words and production of linguistically appropriate individual words, and assembly of strings of words into sentences, using pronouns, prepositions, and tenses.	Most verbal abilities resist the regressive effects of aging. Vocabulary and verbal reasoning scores remain relatively stable, even increasing throughout the lifespan.	(Alwin & McCammon, 2001; Schum & Sivan, 1997)
Executive functions involve the capacity to plan, organise and monitor the execution of behaviours that are strategically directed in a goal-oriented manner. Cognitive abilities in executive functioning include search for knowledge, planning, cognitive flexibility, response inhibition, attentional control, evaluation/ decision-making skills, fluency and self-monitoring.	Executive abilities have been reported as differing in their rates of decline in the ageing process. Deficits in ability of response inhibition increases with age, as does inhibiting irrelevant information. Decreased ability to regulate behaviour in accordance with a strategy; however this is task-dependant with increased complexity and familiarity being mediating variables. Category fluency reduces with age.	(Andrés & Van der Linden, 2000; Brennan, Welsh, & Fisher, 1997; Jurado & Rosselli, 2007; Lustig, Hasher, & Tonev, 2001; Rodriguez-Aranda & Martinussen, 2006; Zook, Welsh, & Ewing, 2006)

Although Park et al. (2003) concluded that there is an "almost" (p. 1132) universal decline in cognitive performance as we age, they noted that longitudinal studies reported a proportion of older adults demonstrating no decrease in cognitive performance or, in fact, an improvement. The Seattle Longitudinal Study (SLS),[2] for example, focused on individual differences and differential patterns of cognitive change. 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 universal decline in cognitive performance even by 80 years of age (Schaie, 1990). In the Baltimore Epidemiologic Catchment Area Study 32% of participants demonstrated either no change in cognitive performance or demonstrated an improvement during an 11.6-year follow-up (Lyketsos, Chen, & Anthony, 1999). The Cambridge Project for Later Life reported that 43% of participants had no change in cognition or improved their cognitive performance in a 28-month follow-up (Brayne, Huppert, Paykel, & Gill, 1992).

It is this salient feature of cognitive aging – the considerable individual variation in rates, nature, timing and extent of age-related decline in cognitive abilities – that suggests chronological ageing is not a causal mechanism underlying cognitive decline (MacDonald, DeCarlo, & Dixon, 2011). Rather, age is a temporal dimension that reflects the accumulation of biological, health, neurological and environmental influences over a lifetime. These factors determine the variation in cognitive ageing (MacDonald, Dixon, Cohen, & Hazlitt, 2004). As suggested by La Rue (1992) in the study of cognition and ageing, emphasis should be placed on the diversity of ageing-cognition relations and the marked individual differences amongst the ageing population, rather than an inevitable cognitive decline due to age. Interest is growing in understanding which of these factors are likely to be responsible for the differences in cognitive-ageing trajectories. By identifying the key factors in the enhancement, maintenance or decline in cognitive ability in later life, interventions can be implemented that may potentially delay or reduce cognitive decline.

[2]SLS was initiated in 1956 and has carried out psychometric testing on a population from young adulthood through to old age, in cycles of seven years up to 1998.

Differing factors affecting cognitive performance within age groups.

To date contributions for understanding the individual differences in cognitive ageing has come from research on genetics, general health, diet and nutrition, lifestyle behaviours and activities, education and social class. Of all these factors, only education and health status (both physical and mental) have a substantial body of research supporting their association with intra-individual differences cognitive ageing (Agrigoroaei & Lachman, 2011; Deary et al., 2009; Park et al., 2003). The following section will provide a brief overview of the literature on education and health factors and the relationship with cognition in the ageing.

Education.

Studies of ageing have consistently found a relationship between higher levels of education attainment obtained in early life and higher levels of cognitive functioning in later life (Cagney & Lauderdale, 2002; Lee, Kawachi, Berkman, & Grodstein, 2003; Schaie et al., 2004)**,** a relationship reported across all age groups (Alley, Suthers, & Crimmins, 2007; Wilson et al., 2009). It has been suggested by Stern (2002) that when a person with a higher education reaches old age, they enter at a higher cognitive functioning level than those less educated and therefore have to experience a greater decline to reach an impaired level of cognitive ability. This hypothesis postulated by Stern (2002) is based on the concept of cognitive reserve. The cognitive reserve hypothesis suggests that aspects of life experiences such as education, career, hobbies and social activities may supply a set of skills that creates 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 cognitive impairment, but are regarded as having a greater cognitive reserve (as measured by premorbid IQ, education and occupation attainment), would not show the same observable symptoms as a person with the same degree of cognitive impairment but lower cognitive reserves. The cognitive reserve concept is regarded as an active model, as it relates to the ability of the brain to actively cope with brain damage through the use of cognitive processes (Stern, 2002). One of the relevant set of skills associated with higher levels of cognitive reserve is more efficient use of pre-existing cognitive processes. For example, in one study more highly skilled people had reduced brain activity during cognitive processing than those with poorer skills, which was regarded as an indicator of more efficient use of their cognitive networks (Solé-Padullés et al., 2009). Greater efficiency may be due to the use of alternative cognitive strategies, which results in using

existing cognitive networks more efficiently or greater ability to recruit alterative cognitive network circuits to solve the problem at hand (La Rue, 2010). A second set of skills refers to compensation strategies. These involve the use of alternative cognitive networks, due to existing networks being impaired by brain pathology. Therefore, to compensate for this the individual engages other networks to complete the task at hand. To illustrate, a study that used fMRI imagining reported that adults who were diagnosed with clinical mild Alzheimer's disease, but were assessed as having high cognitive reserves (as estimated by IQ, education, occupation and activities), had increased brain activity compared to those with low cognitive reserves. This suggested that they were actively engaging in a compensation strategy (Solé-Padullés et al., 2009). What has also been hypothesised by Stern (2009) is that for those with greater cognitive reserve, when clinical dementia beings, their progression to severe dementia is rapid due to the pathology being far more advanced than was observable through clinical symptoms.

In relation to education, the level of cognitive performance at baseline and rate of cognitive decline in older adults, in research has provided support for the concept of cognitive reserve. This is illustrated by two studies on education and cognitive performance that found that older educated people have a higher cognitive functioning at baseline than their less educated peers (Alley et al., 2007; Wilson et al., 2009). However, the findings are mixed regarding the relationship between cognitive reserve and rate of cognitive decline. It was observed by Wilson et al. (2009) that there was no significant association between education and rate of cognitive decline in their 14-year longitudinal study. Those with a higher education had a slower decline in the initial years of follow-up, but in later years they had a more rapid decline than those with lower education. The findings reported by Alley et al. (2007) on education and cognitive decline differed due to the cognitive functions assessed. Higher educated adults (minimum of 16 years of education) had greater absolute decline in complex and verbal working memory tasks than those with 12 years or less of education over a seven-year period. Yet higher educated older adults had less decline in basic cognitive functions such as general mental status, language, orientation to time and place, as measured by the Telephone Interview for Cognitive Status (TICS; Brandt, Spencer and Folstein 1988, as cited in Alley et al., 2007), than those with lower levels of education. This result concurs with the findings from the Baltimore cohort of the Epidemiological Catchment Area study which reported that older adults with more than eight years of formal education experienced less cognitive decline,

as measured by the MMSE, over a 11.5-year follow-up than less educated peers (Lyketsos et al., 1999).

The research is not conclusive in this area but suggests that education is a protective factor for cognitive performance in the ageing. However, the length of this protection is not yet well known and understood. For example, the findings of Alley et al. (2007) and Lykestos et al. (1999) indicate that educated adults are more efficient than their less educated peers at processing simple cognitive tasks such as those undertaken in the TICS and MMSE, yet education does not offer the same protection for more complex tasks as one ages. However, it was concluded by Alley et al. (2007) and Wilson et al. (2009) that the findings from the studies on education and cognition provide evidence that that education affects the rate of cognitive decline primarily by virtue of its association with the level of cognition pre cognitive decline.

Health.

There has been an accumulation of evidence showing that certain health characteristics are risk factors for cognitive decline including hypertension, cardiovascular disease, diabetes, and obesity (Duron & Hanon, 2008; Hughes & Ganguli, 2009; Raz & Rodrigue, 2006; Spiro & Brady, 2011). Mental health factors such as depression and depressive symptomology in the older adult have also been linked with greater risk of cognitive decline (Paterniti, Verdier-Taillefer, Dufouil, & Alpervotich, 2002). The lifestyle factors that often accompany these diseases, such as tobacco consumption, heavy alcohol use, lack of a balanced diet and little or no physical exercise, have been shown to contribute to the risk of cognitive decline. For example, older adults were more likely to have poor cognitive performance if they smoked, abused alcohol, were overweight, or did not participate in exercise (Engelhardt, Buber, Skirbekk, & Prskawetz, 2009). While there is evidence of a link between cognitive decline and health these links are somewhat tenuous. There is no causal evidence to support many of these relationships, and systematic reviews of randomised control trials fail to show a continuous association between health factors and cognition performance (Plassman et al., 2010). Therefore, factors other than health need to be considered in understanding the risks for cognitive decline in the older adults.

Social isolation.

A factor that has gained considerable interest in the last decade is social isolation, which can be viewed as a deprivation in social resources (Luskin Biordi & Nicholson, 2009). Deprivation can be understood as 'objective' (i.e., characterised by a lack of contacts, frequency of contacts, or actual support received from contacts); or 'subjective' (where participants perceive their relationships as inadequate or deficit in some form, be it a perceived lack of support, intimacy or social connectedness, which can manifest as loneliness) (Cornwell & Waite, 2009b; Havens, Hall, Sylvestre, & Jivan, 2010; Luskin Biordi & Nicholson, 2009; Wenger et al., 1996). Research on the relationship between social isolation and cognitive functioning is relatively recent and follows three decades of research of the relationship between social isolation and mental and physical health. Much of the research on social isolation and health was initiated after a ground-breaking study in the late 1970s documented a relationship between mortality and size of social networks (Berkman & Syme, 1979). It found that older people who were socially isolated, as measured by a lack of social ties, were less likely to be alive after nine years than their counterparts who had more extensive social networks. Studies have gone on to replicate the findings of Berkman and Syme (1979). For example, socially isolated people have a significantly higher risk of all-cause mortality compared to those with increased social ties (Brummett et al., 2001; House, Robbins, & Metzner, 1982; Kaplan et al., 1994).

Research also links social isolation with poorer health-related quality of life and well-being in general. Social isolation has also been linked to increased rates of depression and depression symptomology, disability, institutionalisation, hypertension, higher incidence of coronary heart disease, poorer prognosis in cancer and cardiovascular disease, and delayed recovery from major health events (Bowling & Grundy, 1998; Brummett et al., 2001; Golden, Conroy, Bruce, et al., 2009; Kaplan & Reynolds, 1988; Kaplan et al., 1988; Reynolds & Kaplan, 1990). The health risks associated with social isolation have been compared in magnitude to the risk inherent in factors such as smoking, obesity, lack of exercise and high blood pressure (House, Landis, & Umberson, 1988).

The majority of studies assessing the relationship between social isolation and cognition have been longitudinal, and have thus enabled the tracking of cognitive performance over periods up to 20 years (Amieva et al., 2010; Barnes et al., 2004; Bassuk

et al., 1999; Beland et al., 2005; Seeman et al., 2001; Stoykova, Matharan, Dartigues, & Amieva, 2011). One of the first evaluations of older adults' social environment 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 of social ties (e.g**.**, indication of one of the following: presence of a spouse, monthly visual contact with at least three relatives or close friends, yearly non-visual contact with at least 10 relatives or close friends) and participation in social activities (e.g., religious services, membership and participation in social groups and recreational activities). Cognitive performance was assessed through the Short Portable Mental Status Questionnaire (SPMSQ; Pfeiffer, 1975). Bassuk et al. (1999) and concluded that older adults with no reported social ties were at increased risk of cognitive decline compared to those with five or six social ties after adjusting for risk factors such as age, gender, education, income, health, physical activity and depression.

Similar findings regarding the relationship between lack of social ties and risk of cognitive decline were observed by Fratiglioni et al. (2000) in their three-year study of 1,203 community-dwelling cognitively intact Swedish people aged over 75 years. The Mini Mental Status Examination (Folstein et al., 1975) was used to assess global baseline cognition and to rule out any participants with dementia. Social ties were assessed by marital status, living arrangements, and frequency and satisfaction of contact with children and friends. It was found that individuals with a lack of social ties, and who lived alone, were at greater risk of cognitive decline than those who had extensive social networks. Other longitudinal studies have also concluded that older adults who self-report higher levels of social isolation than their peers have lower cognitive performance at baseline or are at greater risk for cognitive decline (Holtzman et al., 2004; Tilvis et al., 2004; Zunzunegui et al., 2003). Both Bassuk et al. (1999) and Fratiglioni et al. (2000) hypothesised that the mechanisms by which a lack of social ties may influence cognition are based on the increase in mental stimulation that comes with a greater social network, thereby providing cognitive stimulation that maintains or enhances cognitive reserve.

A Model of Social Networks' Influence on Health, Including Cognition

Although studies indicate that social isolation is a risk factor for cognitive decline, some questions, such as whether or not the association is causal, are yet to be elucidated.

Single pathways, as well as integrated models, where the effect on health in general is considered, have been proposed, with cognition being an addition (Fratiglioni, Paillard-Borg, & Winblad, 2004). One model that has integrated various theoretical perspectives and the literature concerning the relationship between social isolation and health is offered by Uchino (2006). This broad model highlights how the structures and functions of our social relationships and social world might impact (both positively and negatively) on an individual's physical and mental health. An important point to note is that a number of the key health outcomes associated with social isolation such as coronary heart disease (Heffner, Waring, Roberts, Eaton, & Gramling, 2011), obesity (Lauder, Mummery, Jones, & Caperchione, 2006) and depression symptomology (Cacioppo, Hawkley, & Thisted, 2010) have also previously been noted risk factors for cognitive decline. This provides a plausible reason to hypothesise that a model of the relationship between social isolation and health may also be utilised to understand the relationship between social isolation and cognition.

Research suggests that there are common pathways between social isolation, health and cognitive decline. Those who perceive themselves as lonely or socially isolated have more negative, non-supportive interactions than those who are socially integrated (Cacioppo et al., 2006; Seeman et al., 2001), while older individuals who are socially isolated report less satisfaction with the limited interactions they do have compared with non-isolated older adults (Brummett et al., 2001). Research has reported that negative, non-supportive interactions are shown to result in heightened physiological reactivity such as increased neuroendocrine and cardiovascular reactivity (Uchino, Cacioppo, & Kiecolt-Glaser, 1996). Heightened levels of neuroendocrine and cardiovascular reactivity have been identified as risk factors for cognitive decline (Juster, McEwen, & Lupien, 2010; Karlamangla, Singer, Chodosh, McEwen, & Seeman, 2005). In addition, those with limited social ties and negative social interactions have poorer immune systems than those who are socially integrated (Seeman, 1996), and older adults with immune deficiencies are at greater risk for cognitive decline (Yaffe et al., 2003). Bearing these factors in mind we now discuss the proposed model by Uchino (2006).

This model (see Fig. 1) suggests that the structural features (e.g., size of network, availability of support, engagement with friends and families, and the wider community) and functional features (e.g., emotional support, intimacy and attachment, feelings of social connectedness) of social networks may influence morbidity and mortality through

two different pathways, and that these pathways can interact. The first pathway is based on behavioural processes such as health behaviours that can be influenced directly or indirectly by the social network. Social network members may directly influence an individual's choice to exercise, eat healthily, smoke or drink moderately (Berkman, Glass, Brissette, & Seeman, 2000). For example, physical inactivity, smoking and obesity are associated with an increased risk of cognitive decline (Whitmer, Gunderson, Barrett-Connor, Quesenberry-Jr, & Yaffe, 2005), so shared social norms towards healthy behaviours may positively influence cognitive well-being, while shared norms that favour risk may heighten risk for cognitive decline. Health behaviours can also be affected indirectly by the social network. For example, social networks provide opportunities to access information regarding primary care medical services, resulting in possible early treatment of diseases that may affect cognition indirectly (e.g., depression or diabetes).

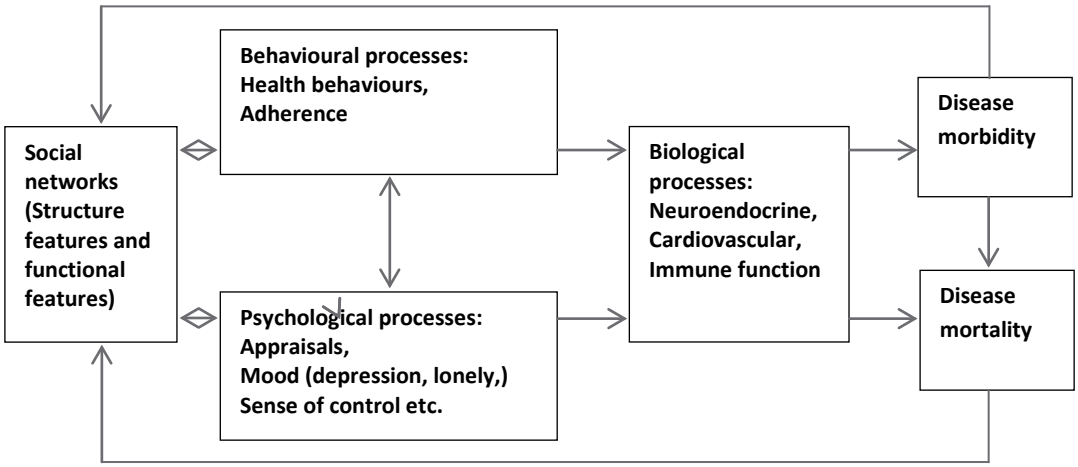

Figure 1. Broad Model Highlighting Potential Pathways Linking Social Support to Health (adapted from Uchino, 2006, p. 378).

The second pathway by which social networks may influence morbidity and mortality in Uchino's model involves the psychological processes that are linked to appraisals and moods such as stress, depression, self-esteem and feelings of control. Within this pathway there are two different possibilities of how psychological processes may influence cognition. First, the perception that support is available from the personal social network may reduce or eliminate the affective reaction to stressful events. This reduces the potential negative emotional and behavioural responses that could lead to

detrimental coping behaviours such as smoking, alcohol abuse, drug use and decreased sleep (Cohen, 2004), which may have an influence on cognition (Hawkley & Cacioppo, 2010; Plassman et al., 2010; Thomas & Rockwood, 2001). Secondly, stress has been linked with physiological systems, resulting in activation of the sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) cortical axis (Pariante, 2003). Prolonged or repeated periods of activation of the HPA leads to increased glucocorticoid production, which can cause hippocampal damage, which in turn is linked to cognitive impairment and substantial damaging effects on physical and mental health (Thoits, 2010). Social support is believed to buffer the effects of stress-induced cardiovascular reactivity (Cohen, 2004) such as assisting in lowering blood pressure (Uchino, 2006). However, stress is not the only psychological state that may influence health. For example, psychological states that have been linked with low levels of support or social isolation such as negative affect, sense of alienation, loneliness, lack of perceived control and decreased self-esteem have been reported to increase neuroendocrine and cardiovascular responses, which consequently can suppress immune function and interfere with the performance of health behaviours and cognition (Cacioppo et al., 2006; Hawkley & Cacioppo, 2010; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004).

Finally the two pathways, behavioural processes and psychological states may interact with each other to influence morbidity and mortality. For example, stress may affect behaviours, or behaviours may influence psychological states such as resorting to beneficial health behaviours like exercise to reduce stress levels. There is also opportunity for behaviours or psychological states to affect the social support available. For instance, psychological states such as a lack of perceived control may influence the perception of support given and result in negative social interactions, thereby affecting the social support processes (Uchino, 2006). The model thus captures many of the complexities of the relationship between the social world and aspects of health.

There is a third possible way in which the social world of an older adult may influence cognition that is not included in the model by Uchino (2006). It was proposed by Fratiglioni et al. (2004) that a possible consequence of being actively involved with a social network is that it provides opportunity for cognitive stimulation that may preserve intellectual capabilities built up over a lifetime through the on-going use of these capabilities. That is, social interactions and participation in intellectually stimulating

activities and conversations that are novel or challenging can stimulate our cognitive processes (La Rue, 2010). For example, it has been reported that increased mental activity through learning may result in the adult brain responding by adding new neurons (Churchill et al., 2002). By contrast, the "disuse hypothesis" suggests that a lack of mental stimulation arising from changes in our everyday experiences and activity patterns, such as ceasing employment or decreased interest in hobbies, results in less use of our cognitive functions, and the result of this is atrophy of cognitive skills (Salthouse, 1991). Therefore, socially isolated people may have less opportunity to engage in mental activity than those who are socially integrated and consequently this could result in poorer cognitive performance. Furthermore, this third pathway of the relationship between social network and cognitive stimulation would more than likely interact with the behavioural and psychological pathways proposed by Uchino (2006). That is, if social isolation results in poorer mental and psychological health outcomes, a consequence of poorer health may be a reduction in social interaction with network members, thereby reducing opportunity for cognitive stimulation. Although the proposed model by Uchino (2006) and suggested pathways of Fratiglioni et al. (2004) provide insight into how the social network of the older adult may influence cognition, the evidence regarding the relationship between social isolation and cognition is not consistent.

Inconsistent Findings for the Influence of Social Isolaton on Cognition

Although the research highlighted above provides evidence for a strong link between social isolation and cognitive decline in older adults, a number of longitudinal studies have found no evidence of a relationship. For example, a longitudinal cohort study of 1,189 high-functioning adults aged between 70 to 79 years reported no significant association between various indicators of social isolation (e.g., number of close ties, number of groups, received support) and measures of cognition (e.g., global cognition, memory, language, abstraction and spatial ability either at baseline or at the seven-year follow-up) (Seeman et al., 2001). Similar results have been found in other studies. The Charlotte County Healthy Aging Study reviewed the relationship between indicators of social isolation and cognition in 217 participants aged 72 years (on average), and baseline data indicated that measures of social isolation (e.g., number of family and friends, or receipt of emotional, informational and instrumental support) were not associated with global cognitive performance, memory performance or speed and attention (Hughes et al., 2008). In a 20-year longitudinal study Stoykova et al. (2011) assessed the impact of

social networks on cognitive decline in a group of community-dwelling French older adults 65 years or older, and concluded that having limited or poor social networks had no impact on age-related decline in cognitive performance. However, it was associated with poorer performance at baseline.

Whilst prior research on the relationship between social isolation and cognitive decline seemingly offers inconsistent findings, the majority of studies conclude (regardless of their findings) that the social world of the older adult may play a part in successful cognitive ageing or cognitive decline. Also, as will be discussed below, closer inspection of these studies indicates that such inconsistency in findings may actually result from variation in the measures of social isolation used in these studies.

In comparing the outcomes of previous studies of social isolation and its impact on cognition, a lack of commonality in measures of social isolation is notable. The majority of studies have used single-item measures, or composite indexes of various indicators of single-item measures of social isolation, with very little use of scales constructed specifically to measure social isolation. This is illustrated in the differences between two studies: Seeman et al. (2001) analysed marriage status, number of children, they feel "close to", number of family and friends they feel "close to", perception of support, and social engagement as a separate indicators to assess social networks. On the other hand, Stoykova et al.'s (2011) assessment of social networks was based on a four-item composite scale related to size of network, feelings of being misunderstood, satisfaction with network and participation in social activity. The Seeman et al. (2001) and Stoykova et al. (2011) studies appear to have conceptual and operational differences of the definition of 'social network' which may reduce the predictive utility of the concept of social networks (O'Reilly, 1988). Another example of how operational differences in studies may hamper comparisons is regarding specificity of numbers. For example, in the study by Bassuk et al. (1999), if a respondent did not have monthly visual contact with at least three relatives or close friends and yearly non-visual contact with a minimum of 10 relatives or close friends, as well as monthly participation at religious services and recreation social activities, they were regarded as socially disengaged. The study by Bassuk et al. (1999) specified the number of relatives and friends the responded could include as a social network member. Therefore, if someone had daily visits from two friends they would be scored differently from someone who had a once a month visit from three

friends to determine their social disengagement. By contrast, other studies have required participants to report only contact with those they see on a weekly basis instead of monthly visits (Ertel, Glymour, & Berkman, 2008; Wang, Karp, Winblad, & Fratiglioni, 2002). In a study on perceived social isolation Wilson et al. (2007) utilised various indicators of social participation such as attendance at religious services, membership of groups and regular participation in recreational social activities (e.g., walking, gardening, going to movies) as measures of social network size. Each study discussed differs from the others in some respect. For instance, some count only those members in the social network seen on a weekly basis, whereas others count only those seen monthly, for some social participation at an activity must occur weekly while for others it must be monthly, some include no question on frequency of contact with social members and just ask for the numbers of members in network, and marriage is used in some studies as an indicator of social isolation but not in others. The researchers do not provide any clear reasoning for why specific numbers of network members were selected. As noted by O'Reilly (1988) it appears that specificity of numbers is designed more around the "logistics of data collection rather than with the logic of scientific investigation" (p. 871). Similarly, questions regarding perception of the quality of one's social network ask whether the individual feels supported or misunderstood, or satisfied, or lonely. All questions which are capturing conceptually different qualitative aspects of the network and therefore make cross-study comparisons tentative.

This lack of commonality across studies is a cause of concern for a number of reasons. First, in the study of social isolation many of the measures used as discussed are not standardised and the items may not be independent of each other (Victor, Scambler, Bond, & Bowling, 2000). There is also the concern regarding the validity and reliability of the single items and composite indexes used to assess social isolation in the older person, as the unreliability of single items has been well-documented and is a canon of psychometric theory (Marangoni & Ickes, 1989; Victor et al., 2000). Furthermore, the majority of studies do not provide theoretical reasoning for the choice of indicators. For example, in the study by Stoykova et al. (2011) if a participant reported less than eight members in their network they were categorised as more socially isolated than those who scored more than eight members. However, studies have reported that the mean size of an older person network is in the range of five to seven (Victor et al., 2000). Although a person with more than eight in their social network may be less isolated than a person

with seven, the question does not take into consideration the frequency of contact or the nature of the relationship with network members. As mentioned the use of different variables to assess the older adults' social network has led to difficulty in making meaningful comparisons between studies, and in turn our ability to gaining greater understanding of the influence of social isolation on cognition. These issues also suggest the possibility that social isolation can be viewed as a multi-dimensional construct that is operationalised and assessed in various ways. If social isolation is a multidimensional construct as suggested by Cornwell and Waite (2009b), the complexity of an individual's social world cannot be assessed by one or two indicators of social isolation in trying to determine the mechanisms of how social isolation influences health. Therefore, a discussion on social isolation and the various forms it may take follows. This exploration will provide more insight into why so many indicators have been used to assess social isolation.

Chapter Three: Social Isolation

"The variety of indicators of isolation and loneliness used across research in different disciplines is both a blessing and a curse" (Cornwell & Waite, 2009b, p. 139).

Overview

As indicated in the previous chapter, different types of social isolation measures have been used to determine the relationship between cognition and social isolation, and this may have given rise to the conflicting findings we now witness in this area, rendering cross-study comparisons impracticable. In order to clarify the various types of social isolation and indicators used to capture social isolation in previous research, this chapter reviews social isolation as a broad term that has been conceptualised over the years to include both objective and subjective indicators.

Defining Social Isolation

Social isolation has been defined in diverse ways over the last three decades. One of the earliest definitions relating to the ageing population was derived from the findings of a study on social ties and mortality by Berkman and Syme (1979), with social isolation defined as an irreversible loss of social attachments and community ties (Berkman, 1983). In the study by Berkman and Syme (1979), indicators of social isolation were objective measures such as marital status, the level of contacts with friends and relatives, and whether the older person belonged to groups or a religious organisation. Berkman and Syme's (1979) defining work on the detrimental consequences of social isolation on mortality produced a move towards researchers focusing on the influence of the structural features of the older adults' social network such as the number of members in a network or how integrated a person was within it. However, in the 1990s research found increasing evidence for social isolation not being limited to small or poorly integrated networks, leading to the inclusion of subjective characteristics of relationships within social networks (Nicholson Jr, 2009). The concept of social isolation was expanded to factor in subjective experience: the perception of personal position in relation to others, as well as the perception of the personal social network such as quality of support provided by members. For example, Biordi (1998) captured the subjective component of social isolation in the following definition: "Where it is involuntary and perceived as negative and where the social network is shrinking in quality or quantity of contacts, it is

defined as social isolation"(p. 198). A more recent definition by Hawthorne (2006) indicates that "social isolation can be defined as living without companionship, having low levels of social contact, little social support, feeling separate from others, being an outsider, isolated and suffering loneliness" (p. 526). There are seven different dimensions of social isolation in Hawthorne's (2006) definition and, combined with the alternative definitions such as that of Biordi's (1998), it suggests that social isolation is multidimensional, or that there are several distinct types. Cornwell and Waite (2009b) concurred with Hawthorne (2006) that social isolation is a multidimensional construct, but viewed it as manifesting itself in two forms: objective social isolation; and subjective (or perceived) social isolation.[3] Objective social isolation is characterised by social networks that are small in size (Berkman & Syme, 1979; Brummett et al., 2001), marked by a lack of relationships with family (Sorkin, Rook, & Lu, 2002) and friends (Fratiglioni et al., 2000), and a lack of diversity (Barefoot, Grønbæk, Jensen, Schnohr, & Prescott, 2005), infrequent contact with network members (Brummett et al., 2001) and low levels of participation in social activities (Cornwell & Waite, 2009b). Perceived social isolation, on the other hand, is associated with feelings and the experiences of loneliness (Cacioppo & Hawkley, 2009), a perceived lack of support from the social network (Cornwell & Waite, 2009a), or the subjective feeling of living without social connectedness (Uno, Uchino, & Smith, 2002) regardless of network size.

It is evident from the literature that social isolation is more complex than a single-dimension construct could describe such as one pertaining to limited social ties. However, there are no universally agreed upon definitions of social isolation, whether objective or perceived (Grenade & Boldy, 2008). The lack of a clear consensus on definitions likely underlies the use of a variety of different social isolation measures in studies on social isolation and cognition. Both Hawthorn (2006) and Machielse (2006) suggest that to gain insight into social isolation, both objective and subjective dimensions of social isolation needed to be measured, allowing a more systematic analysis of the phenomenon on the variable of interest. The objective social isolation approach provides a basis for increasing knowledge of the scope, composition and structure of someone's social network and their available support. The perceived isolation approach allows the researcher to understand how the subjective perception of social and/or emotional isolation is experienced, its

[3] 'Subjective isolation' and 'perceived social isolation' are terms that are used interchangeably within the literature. For the current study the latter term will be used.

relationships with objective social isolation, and its influence on, for example, cognition. The following diagram (see Figure 2) has been designed by the author of the present study, to demonstrate how social isolation in the older person might best be understood as a multidimensional concept. The data collected from social network studies is categorised into two classes: the structural and quantitative aspects of social connectedness, which are assessed through social integration and social network sizes; and the qualitative characteristics of the network, social support and loneliness (Machielse, 2006; Pillai & Verghese, 2009). A discussion of objective and perceived social isolation and associated examples from the literature on social isolation and cognition follows:

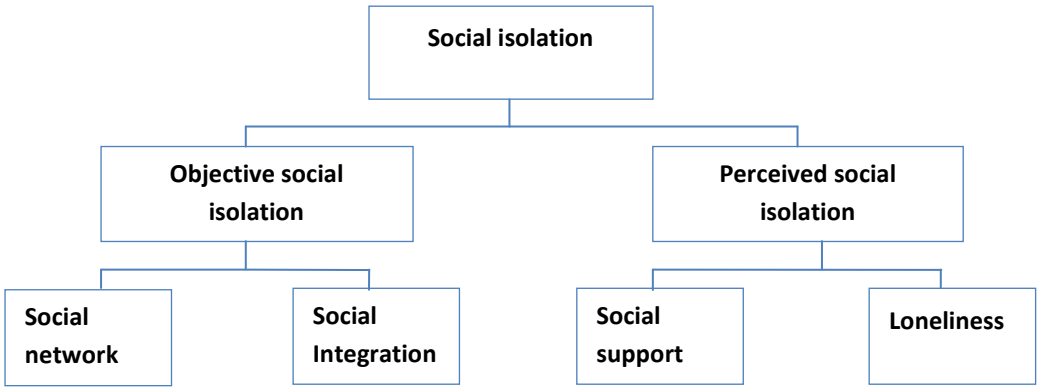

Figure 2. Model of the Objective and Subjective Components of Social Isolation

Objective Social Isolation

Objective social isolation is approached by analysing the structure of an individual's social network, such as assessing the size of a network, or the degree to which an individual is integrated within a network. Those who have small or poor social networks may be regarded as socially isolated or not socially integrated, and such reduced social ties may limit the opportunity for a person to receive quality social support and participate in social and productive activities. It was highlighted by Machielse (2006) that in researching social isolation, different approaches are available, one being the assessment of an individual's social network and the other how socially integrated they are (Machielse, 2006). The social network approach emphasises the structure of the individual's social network. The social integration approach attempts to determine the level and depth of an

individual's engagement with other social network members and the wider community. A more detailed discussion on both approaches follows.

Social network.

Berkman et al. (2000) described social networks as "the web of social relationships that surround an individual and the characteristic of those ties" (p. 847) while Langford, Bowsher, Maloney and Lillis (1997) describe them as the interactive group of persons who provide the "give and take" of helpfulness and protection to an individual (p. 97). Victor, Scrambler and Bond (2009) indicate that social networks include relationships based around kinship, or friendship ties, neighbourhood co-location, or professionally-based care. In summary, it appears that the term 'social network' generally refers to the number, frequency and density of interactions and social reciprocity people have within their social environment.

The social network approach to social isolation focuses on gaining understanding of the structure of the network by analysing the characteristics of the social ties that constitute this network, and the degree to which someone is embedded within their network. Being 'embedded' refers to the number of social ties connected within a network, with greater frequency of social ties reflecting greater levels of embeddedness. The more connected the social ties, the more opportunity is provided for mutual involvement to grow around the older adult, decreasing the risk of social isolation. Therefore, low numbers in a network, or a lack of connection between network members, can indicate social isolation.

Approaches to measuring social networks include assessing network size (i.e., the number of members in a network), network density (i.e., the network interconnectedness, comparing the actual number of direct ties with the potential for all ties to be connected), and degree of network embeddedness (i.e., the average number of direct ties a network member has with other network members). Measures of network range and density include the Lubben Social Network Scale (Lubben et al., 2006) and Social Network List (Brissette, Cohen, & Seeman, 2000), yet in the study of social isolation and cognition these measures have had scant use. Instead, an assessment of the size of the social network is the most commonly utilised indicator of social isolation in studies that involve health outcomes, including cognition (Brissette et al., 2000; Wilson et al., 2007). One of the issues with using network size as an indicator of social isolation is that researchers will normally

determine who the older person can nominate as network members. For example, some studies do not include household members (Holtzman et al., 2004). Others use friends and families regardless of frequency of contact (Amieva et al., 2010), or only family and friends with minimum of monthly personal contact (Wilson et al., 2007), or include only friends and family that the participant would call on for help (Bennett, Schneider, Tang, Arnold, & Wilson, 2006) . This significantly restricts the utility of network size as an indicators of social isolation, limiting any benefits of the wider network outside that indicated by the researcher that may in fact provide substantial social support for an individual, for example, community groups or religious organisations. Perhaps for this reason studies have found that network size alone is a weak predictor of health and well-being (Uchino et al., 1996).

A number of studies have previously explored cognitive decline in older adults using social network size as an indicator of social isolation, but findings from these studies have been mixed. An American-based study whose participants consisted of African-American and white older adults aged 65 and over (n=6,102) found that adults with larger social networks (determined by size and frequency of contact) had less cognitive decline than those in smaller social networks (Barnes et al., 2004). An individual with 16 social ties (90^{th} percentile) had a 39% reduction in rate of cognitive decline compared to a person with one social tie (10^{th} percentile). Fratiglioni et al. (2000) also found that adults 65 years and older with no close social ties (e.g., friends or relatives) had an adjusted relative risk for developing dementia of 1.5 times compared to those who had friends and relatives after adjusting for age, sex, education and baseline MMSE score. Single people and those living alone had an adjusted relative risk of nearly twice that compared to married people living with their spouse. However, other studies found no evidence that the size of network predicts cognitive decline after seven years (Glei et al., 2005) and after 15 years (Amieva et al., 2010). Social network size as quantified by the number of family and friends, as well as frequency of contact, was not related to cognitive functioning in 838 adults who averaged 80 years old, and who were assessed as being without dementia (Krueger et al., 2009). Only Barnes et al. (2004) and Krueger et al. (2009) used the same indicators of social network size, both combining the number of family and friends with frequency of contact to determine social network size. In summary, previous studies focusing on social networks have more often than not measured networks based solely on network size, and there appears to be mixed evidence for the utility of such a measure

concerning an exploration of the relationship between social isolation and cognitive decline.

Social integration.

Social integration refers to the extent to which individuals have social ties or connections (Seeman, 1996). Socially integrated older adults are involved with family, friends and colleagues/co-workers/fellow members in employment, volunteer work, religious activities, clubs and various organisations, and may extend care to others. They can be regarded as well-connected within their social network and not socially isolated. Therefore, social integration is "broadly conceived in sociologic terms as the converse of objective social isolation" (Seeman, 1996, p. 442).

Social integration 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 provided by social roles (Brissette et al., 2000; Thoits, 1983). Social integration comprises social roles (i.e., different types of social relationships such as parent, spouse, relative, friend, church member, volunteer, or group member), social participation (i.e., the frequency with which individuals engage in various activities such as visits with friends, going to church or a social organisation), perceived integration (i.e., 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 a combination of information regarding social ties, community involvement and frequency of contact with friends and relatives.

The use of a specific measure of social integration is contingent on the researcher's theory regarding the benefits of social integration or the risk factors of not being socially integrated (Brissette et al., 2000). If the hypothesis being tested focuses on the cognitive consequences that arise when socially integrated individuals participate in more meaningful social and physical activities, then a measure that assesses social participation is appropriate. If the hypothesis is that being socially integrated provides more information or support compared to being socially isolated, the measure used might be role-based. Combining different components of social integration into a single index provides the researcher with the least information about what characteristics of social ties are significant in the relationship between, for example, cognition and personal network (Brissette et al., 2000).

A number of studies have previously evaluated the link between social integration and cognitive decline in older adults, and results show mixed support for this relationship, primarily contingent on the type of social integration measure used. The majority of studies that include acts of participation with friends and within the community report social integration as a protective factor for cognition (Beland et al., 2005; Glei et al., 2005; Holtzman et al., 2004; Wang et al., 2002). Adults aged over 65 years and self-reporting poor social integration, as measured by involvement in community associations and attendance at religious services and senior centres, had greater global cognitive decline after four years than those older adults who were highly integrated (Zunzunegui et al., 2003). In a six-year longitudinal study Ertel et al. (2008) found that social integration, which was assessed by marital status, volunteer activity and frequency of contact with family and neighbours, was a predictor of memory change, and that the least socially integrated older adults had a decline in memory performance twice the rate of those who were regarded as most integrated. Higher frequency of contact with family and friends was also associated with better executive functioning over an 11 year period for midlle age to older adults (average age of 56 years old) (Seeman et al., 2010). However, a minority of studies report that social integration does not have a relationship with either global cognition or cognitive domains such as speed and attention or memory (Aartsen, Smits, van Tilburg, Knipscheer, & Deeg, 2002; Hughes et al., 2008).

A review of the studies on objective measures of social isolation and cognition show that social integration appears to have a stronger association with cognition than social networks, but that research in this area still does not provide consistent evidence for the strength (or even presence) of this relationship.

Perceived Social Isolation

The second approach to understanding social isolation is perceived social isolation. Empirical evidence has shown that there is a weak correlation between the structural characteristics of personal social network, such as size and frequency of contacts, and subjective experience of the network (Cornwell & Waite, 2009b). Having a limited network may categorise an older adult as socially isolated. However, the quality of the relationships within that network may meet the needs and expectations of that person (de Jong Gierveld, 1998). Likewise, a larger network, although it may be supportive

in many aspects, may not offer the specific support that a person requires, resulting in a negative perception of the network or feelings of increased loneliness (de Jong Gierveld, van Tilburg, & Dykstra, 2006; Fiori, Antonucci, & Cortina, 2006; Pinquart & Sorensen, 2000). While the social network approach can map out the scope, composition and structure of the network, it does not provide insight into the subjective experience of those social contacts and how they may influence cognition. Perceptions of the availability of social support and the degree to which people perceive themselves to be lonely (irrespective of the frequency of social contact) are two principle indicators of perceived social isolation which we now be explored in more detail.

Social support.

The need for intimate relationships, a confidante, and an attachment to an individual who provides a perceptual and emotional sense of linkage to another, form the basis of the social support approach. Social support has been described as an interactive process in which support 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 et al., 1997). Weiss (1974) contended that, to feel adequately supported, all provisions needed to be met, although some provisions are more crucial than others at different times in life. Cobb (1976) proposed that the positive effects of support, such as facilitating coping with adverse events and the ability to adapt to events or change, are based on "information leading the individual to believe that he is cared for and loved … esteemed and valued … and belongs to a network of communication and mutual obligation" (p. 300). The individual must have a sense of social embeddedness or connectedness within social networks too have or perceive social support (Stephens, Alpass, Towers, & Stevenson, 2011). The social support approach thus views social isolation as a lack of perceived supportive relationships that would provide an individual with the necessary emotional and tangible resources (Machielse, 2006).

Social support research focuses on behavioural components of the network, in essence the quality of the relationships and not the quantity or type of relationship, and measurement of perceived social support occurs via subjective evaluation satisfaction with this support. Measures used can be brief and unidimensional, assessing one function of support such as emotional support (e.g., How often do [spouse, children, relatives, close friends] make you feel loved and cared for?), or more complex and multidimensional, assessing up to 70 items in a variety of functions (e.g., The Social Provision Scale assesses provisions such as tangible, informational, emotional support). Multidimensional measures may provide an overall general level of support as well as scores for different forms of support such as emotional or informational support (Brissette et al., 2000; Cutrona, Russell, & Rose, 1986). Commonly used measures to assess the influence of perceived social support on cognition have been brief and unidimensional, assessing one aspect of social support including statements such as: "How much do you believe your spouse cares for you?" or "Do you have friends you can call on for support?" (Holtzman et al., 2004; Yeh & Liu, 2003).

A comparison of the studies exploring the relationship between social support and cognitive decline unfortunately provide mixed findings regarding the existence of this relationship. The MacArthur studies of successful ageing (Seeman et al., 2001) examined the relationship between emotional support and patterns of cognitive ageing over a 7.5-year period for 1,118 initially high-functioning older adults. Perceived emotional support was measured using questions such as "How often do you feel loved and cared for by spouse/children/close friends?" and "How often are your spouse/children/close friends/relatives willing to listen when you need to talk about your worries or problems?". At baseline, those with greater availability of perceived emotional support had significantly better cognitive function (e.g., language, abstraction, spatial ability and memory) than those with low emotional support, and longitudinal results indicated that poor emotional support also predicted cognitive decline. Similarly, a longitudinal study of older adults (M=72.4 years, SD = 6.2) by Hughes et al. (2008) found that those who had lower satisfaction with the emotional support received were at greater risk of a decline in episodic memory than those satisfied with the support given to them. In contrast to these findings Bassuk et al. (1999) found that emotional support was not considered responsible for either the maintenance of good cognitive performance or a decreased level of cognition in a 12-year longitudinal study of community-residing adults over the age of 65

years (n=2,812). Likewise, in 18-month longitudinal study Eisle et al. (2012) found no evidence that perceived emotional social support influenced cognition over and above the influence of multiple factors such as socio-demographics, medical conditions, physical and cognitive activity, sensory impairment and lifestyle activities such as smoking and drinking.

Studies of social support and health have indicated that subjective evaluations of social support are stronger predictors of well-being in the elderly than objective evaluations but, to date, the same cannot be said of the relationship between social support and cognition specifically. A possible explanation for this is that, in the above-mentioned studies, social support is operationalised in such a manner that few functions of support are considered. Focusing on just one aspect of support, such as the emotional, may mean that the researcher overlooks the importance of other aspects, such as instrumental support or guidance, which provide tangible outcomes such as being taking to the doctor or giving information on health and well-being. This narrowed focus also results in the inability to understand the relationship between various functions of support and cognition in the ageing. Measuring various functions of social support in the same population will enable the researcher to decipher more accurately what provisions of an older person's social network carry the greatest benefits or risks to cognition. A single function approach provides less consistency and conclusiveness when comparing results.

Loneliness.

Loneliness is a subjective experience, but one for which there is no universal definition. There are however three points on which researchers are in agreement regarding the concept of loneliness. First, loneliness results from a deficiency in a person's social relationships. Second, loneliness is a subjective experience not synonymous with objective social isolation (i.e., people can be lonely although not alone, or alone but not lonely). Third, loneliness is a subjective experience that is distressing and unpleasant (de Jong Gierveld, 1998; Marangoni & Ickes, 1989; Perlman & Peplau, 1984).

There are two conceptual approaches to measuring loneliness: the unidimensional and the multidimensional. Proponents of the unidimensional approach conceptualise loneliness as a unidimensional global phenomenon which differs from person to person in the intensity of the experience, regardless of the particular cause, duration, or perceived

remediation of the condition (Perlman & Peplau, 1981). A unidimensional approach holds that loneliness influences all aspects of interpersonal, social, cultural and psychological experiences. According to this approach, the scale for measuring loneliness should be sensitive to all experiences, as there are common themes in loneliness regardless of cause. The unidimensional approach has been widely used in attempts to measure loneliness (Routasalo & Pitkala, 2003). Two common unidimensional measures used to assess global loneliness are the University of California Loneliness Scale (UCLA: Russell, Peplau, & Cutrona, 1980; Russell, Peplau, & Ferguson, 1978; Russell, 1996), and the single-item, self-rating measure of loneliness such as variations of "How often are you lonely? (Routasalo & Pitkala, 2003). For those who advocate a multidimensional approach, loneliness is conceptualised as a multifaceted phenomenon that cannot be captured by a single global loneliness measure. Three dimensions of loneliness were distinguished in a qualitative study (de Jong-Gierveld & Kamphuls, 1985). The first dimension relates to types of deprivation, and was regarded as the core dimension of loneliness. For example, a sense of social or emotional deprivation was prompted due to the feelings associated with an absence of intimate attachment, feelings of emptiness or abandonment. The second dimension involves the emotional characteristics of loneliness. That is, the absence of positive affect such as joy, happiness, affection, contentment, and the presence of negative affect such as fear and uncertainty. The third dimension was related to a time perspective and differentiates between people who experienced loneliness as temporary and those who experienced it as unchangeable.

Within a multidimensional approach to loneliness, the types experienced can range from social and emotional loneliness (Weiss, 1973) to as many as 12 theoretically distinct loneliness subtypes (Young, 1982). Loneliness for Weiss (1973) was a response to the absence of a relationship that could provide social integration, nourishment, validation and a feeling of trust and help in stressful situations. Deficiency in an individual's social interactions could also lead to loneliness. Weiss (1973) based his theory of loneliness on an interactionist approach which holds that loneliness is a function of the combined effect of personality and situational factors, with neither working in isolation. Weiss (1973) 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 and is characterised by anxiety and perceived isolation. Inadequate social networks, and the lack

of satisfying and valued friendships within that network, result in the loneliness of social isolation characterised by feelings of boredom, social exclusion and rejection, as well as disconnectedness, weariness and aimlessness (Perlman & Peplau, 1981; Weiss, 1973). The two forms of loneliness are distinct and each is a response to a unique relational deficit, yet they share common symptoms demonstrated by lonely individuals (restlessness and a yearning to fill the void).

The de Jong Gierveld Loneliness Scale (de Jong-Gierveld & Kamphuls, 1985) was developed to measure multiple dimensions of loneliness: social and emotional characteristics and time perspective. In a study reviewing the de Jong Gierveld Loneliness Scale as a multidimensional measure of loneliness, van Baarsen, Snijders, Smit and van Duijn (2001) concluded that it is important to distinguish between the social and emotional loneliness of the older adult, as their social networks decrease with age due to the deaths of partners, family and close friends. Consequently, if loneliness is due to the lack of an intimate partner, increasing the size of one's social network may not reduce it. Although not as widely used as the UCLA Scale, the de Jong Gierveld Loneliness Scale is regarded as appropriate for use with older adults (Dykstra et al., 2005).

Studies assessing loneliness as a form of perceived social isolation and cognition are limited, but evidence shows that loneliness is detrimental to cognitive performance in the older adult. Tilvis et al., (2004) reported that loneliness, as measured by the single question "Are you lonely?", was a predictor of global cognitive decline at 10 years. However, it was not associated with cognition at the initial five-year follow-up. Perceived social isolation operationalised as emotional loneliness and cognition was examined in a four-year study of older Chicago residents (Wilson et al., 2007). 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. This was controlling for social network factors such as size and participation in activities. Two studies based on older adults in Ireland concurred that perceived loneliness was detrimental to global cognition regardless of size of network (O'Luanaigh et al., 2011) or available support from it (Conroy, Golden, Jeffares, O'Neill, & McGee, 2010). One study based in Taiwan reported that in a group of adults with an average age of 72 years, loneliness was not found to have an association with cognition, whereas perceived

support did as indicated by scores from the Short Portable Mental Status Questionnaire (Yeh & Liu, 2003) .

A better understanding of the relationship between loneliness and cognition has only recently begun to emerge in the literature. Although research is limited at this stage, the available results suggest that loneliness is a risk factor for cognitive decline regardless of social integration or network size. The perception of how a person perceives themselves to be socially connected within society appears to be of such strength that it can compromise all aspects of well-being.

Summary of the Literature on Social Isolation and Cognition

The review of the literature of the influence of social isolation on cognition indicates that social isolation has been operationalised and assessed in many different ways. The majority of studies have measured social isolation through the use of single-item indicators of various aspects of isolation, yet as previously mentioned not one study provided a theoretical reasoning for choosing the specific indicators to assess social isolation. The use of a variety of indicators may have come about because isolation has been characterised in a number of different ways. It was suggested by Victor et al. (2000) that there has been very little development of theoretical perspectives on social isolation to help increase the understanding in the area. This lack of theoretical development may also hamper the ability for consensus or standardisation in the areas of assessment of social isolation. However, although there are validated and reliable scales to assess social isolation in the ageing there has been scant use of them in the literature on social isolation and cognition. Fratiglioni et al. (2000) note that when assessing the link between social networks and cognitive decline one of the limitations in their study was the “simple, limited to essential features” description of social network and its “crude assessment” (p. 1318). While the studies reviewed here generally indicate that an older person’s social environment has some form of influence on cognitive performance, the lack of standardisation of social isolation measures and the heterogeneity of variables utilised in studies has made a comparison of results difficult (Amieva et al., 2010; Victor et al., 2000). For example, studies have used single-item measures, composite indexes of a conceptualised term such as social support, social engagement, social isolation and social integration, or a composite index of ‘social network’, which includes a combination of single-item variables that assess social isolation, social support and social engagement.

The validity and reliability of the items and indexes used to assess social isolation and loneliness in the older person is of concern (Victor et al., 2000).

Although some studies have assessed social isolation using reliable and valid instruments (Hughes et al., 2008; O'Luanaigh et al., 2011; Wilson et al., 2007), scales have been modified or potentially incorrectly dichotomised in accordance with research findings (Golden, Conroy, & Lawlor, 2009). For example, Wilson et al. (2007) performed the first longitudinal study on loneliness and cognition in the older person using a reliable and valid measure of loneliness, the de Jong Gierveld Loneliness Scale. However, modifications were made to the scale such as word changes and combining of items. Modification of scales may alter the psychometric properties of a measure (Schwarz, 1998). Studies that have used a reliable and valid instrument to assess the various types of social isolation and loneliness in the same population appear to be missing in the examination of the relationship between social isolation and cognition.

In addition to the overall concern regarding the validity and reliability of individual measures employed in previous research on social isolation, researchers have voiced concern over the lack of studies which directly compare different measures of social isolation. House (2001) noted a lack of research that compared various types of social isolation on a specific phenomenon, yet the review conducted in this chapter reveals that most of the studies regarding social isolation and cognition have only looked at a very narrow aspect of the social network of the older adult, rather than a multifaceted approach to studying social isolation and cognition. As concluded by House (2001) and Cornwell and Waite (2009b) the separate examination of different types of social isolation has not provided the ability to identify an "active ingredient" of social isolation, which may have the most detrimental influence on cognition in the ageing. One question currently debated in the literature is whether objective social isolation, perceived social isolation, or a combination of both has the more important (or any) influence on cognition. A recent study by Amieva et al. (2010) was one of the first studies to specifically employ both objective and subjective measures of the social network in assessing dementia development in a 15-year longitudinal study. The data was taken from the PAQUID study, an epidemiological prospective study on cerebral and functional ageing in French residents aged over 65 years (n= 3,777). The 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 perception of relationships was determined to be a protective factor for dementia. Assessing reciprocity of social interactions in older adults who perceived they had received more in their lifetime from others than they had given out, the researchers found a 53% reduction in risk of Alzheimer's disease, while satisfaction with personal relationships reduced the risk of dementia by 23%. This study supported the conclusions of Wilson et al. (2007), who analysed the influence of perceived social isolation on cognitive performance, that the frequency of interactions or the number of people with whom a person interacts in older age to be less important than the quality of interactions. This includes being satisfied with the support available or the perception that the interactions meet personal expectations or desires at that stage of life.

The studies of Wilson et al. (2007) and Amieva et al. (2010) highlight how different forms of social isolation may have differing relationships with both global cognition and specific cognitive domains. Although the two studies indicate that perception may be the "active ingredient" sought by House (2001) and Cornwell and Waite (2009b), neither Wilson et al. (2007) nor Amieva et al. (2010) assessed more than one indicator of perceived social isolation. It is evident that considerably more research is needed in this area in order to explicitly compare multiple measures of social isolation and therefore to determine the degree to which distinct measures of perceived and objective social isolation are related to cognitive performance in older adults.

Chapter Four: Present Study

The aim of the present study is to add significant value to the growing body of literature on social isolation and cognition by assessing the relationship of various forms of social isolation with both global cognition and the different components of global cognition. The present study is unique in including three forms of perceived social isolation: perceived social support, emotional loneliness and social loneliness, as well as measuring objective social isolation. To date, no study has examined the relationship between social loneliness and cognition. The inclusion of the various forms of perceived social isolation extends the work of Wilson et al. (2007) on loneliness and cognitive decline by assessing two forms of loneliness rather than one. It also extends the work of Amieva et al. (2010), on qualitative and quantitative features of the social network and cognitive decline. Although Amieva et al. (2010) reviewed qualitative features such as satisfaction with the network, the study did not assess loneliness or a global measure of social support. Another point of difference in this study is the use of scales constructed specifically to measure the various forms of social isolation and that are valid for use with the older population.

This study is exploratory in nature and the research questions asked are: a) do the different types of social isolation have differing relationships with global cognition and cognitive subsets; and b) which measures of social isolation have the strongest association with cognition?

Chapter Five: Method

Overview

This chapter discusses the research design, the NZLSA, sample composition, procedures, as well as the variables of focus for this study.

Research Design

The cross-sectional study examined the relationship between social isolation and cognition in the older adult aged 65 years and over. 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 NZLSA study, which began in 2010, is a successor of the Health, Work and Retirement (HWR), a longitudinal study conducted in New Zealand (Alpass et al., 2007). The NZLSA study is funded by the Ministry of Science and Innovation for two waves of data collection in 2010, and 2012, and is run as a collaborative study by research teams at Massey University and the Family Centre Social Policy Research Unit. 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.

Sample

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. This occurred due to the historically poor research participation rates found in older ethnic minority populations (Gorman, Scobie, & Towers, 2012). 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 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.

Representativeness of Sample

The NZLSA sample diverged from the New Zealand population data from the 2006 census in the following areas: gender, highest qualification, full-time employment and marital status. The NZLSA sample consisted of 44.6% of males compared to the national population (NP) of 48%. NZLSA participants were more likely to be in full-time employment (NZLSA = 40.5% vs. NP= 35%), tertiary qualified (NZLSA= 19.1% vs. NP=11.5%) and married (NZLSA = 67.1% vs. NP = 59.6%).

Procedures

For the NZLSA survey the Tailored Design method (Dillman, 2000) was used in in order to increase the response rate. This involves a five-stage posting schedule. First, a pre-notice letter is sent to potential participants informing them of the research and of their random selection from the electoral roll and that a questionnaire would follow. Secondly, a week later a questionnaire, information sheet and free-post envelope are sent to the participants. Thirdly, a reminder postcard was sent three weeks after the questionnaire. Fourthly, three weeks later all participants who had not responded were sent a replacement questionnaire. Finally, a second reminder card was sent to all participants who had not yet responded after a five-week period.

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 was still wished to be interviewed. This was then followed up with another phone call to arrange 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. Interviewers were under the management of the Family Centre Social Policy Research Unit. Participants were geographically spread throughout New Zealand.

Measures

For the present study, global cognition and cognitive domains (memory, fluency, language and visuospatial) were individually treated as dependent variables. Social isolation measures that included indicators of social integration with social network members, perceived social support, emotional loneliness and social loneliness were treated as independent variables. Education, age, gender, depressive symptomology, smoking status, physical functioning and medical conditions (diabetes, heart trouble and stroke) were 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. Attention and orientation involves answering questions such as "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 assessment involves having to remember an address given during testing and recall it after a period of time. There are also questions such as "Who is the current Prime Minister?", or questions on very well-known people such as the royal family. The total possible score for memory is 26.

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 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.

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.

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 was analysed with no reference to cut-off points, other than for descriptive purposes. Similarly, the subscales in this study were used without reference to cut-off points as has been the case in previous research (Mathew, Bak, & Hodges, 2011; Ordonez, Yassuda, & Cachioni, 2011).

Social isolation measures.

The 2010 NZLSA postal questionnaire 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.

Objective social isolation – Wegner's Practitioner Assessment of Network Type: Locally Integrated Network Type.

The measure of objective social isolation is taken from the Wegner's Practitioner Assessment of Network Type (PANT; Wegner, 1991), which measures the size, composition and function of the older persons community-based support network (Wenger, 1991, 1997). The PANT consists of eight items that assess: distance of close kin (e.g., "How far away in distance does your nearest child, sibling, or relative live?"); 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 PANT measure provides indications of the degree to which participants are involved in five different network types: Locally Integrated, Wider Community, Family Dependent, Local Self Contained and Private. The PANT's traditional scoring algorithm categorises participants as belonging to one of the five network types based on which network they score highest on (Wenger, 1991). For analytical purposes the current study utilised only the Locally Integrated network type as a proxy for objective social isolation because, of all the networks, the Locally Integrated network is more likely to be associated with low social isolation, better mental and physical health (Wenger, 1993; Wenger, 1997). Older adults who score highly on Locally Integrated network type are also more likely to have more frequent social participation with family, friends and the wider community and ultimately greater social support availability from their network (Wegner, 1997). Loneliness in this network type is more likely to be associated with bereavement and lack of emotional closeness rather than a limited social network (Wenger, 1997). This approach to using the Local Integrated network as an indicator in determining levels of social isolation has been used in previous studies (Golden, Conroy, Bruce, et al., 2009; O'Luanaigh et al., 2011). For data analytical purposes, the Locally Integrated network type was scored on a continuous scale. This approach has also been used previously (Stephens et al., 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). There are four items that assess each provision. Two of the items describe the presence of the provision, whereas the other two indicate the absence of the

provision (Cutrona et al., 1986). For example, two items used to assess social integration are, “I feel part of a group who share my attitudes and beliefs” and “There is no-one who likes to do the things that I do”. Participants respond on a four-point scale (ranging from strongly disagree to strongly agree). For scoring purposes the negative items are reversed and the scores are summed for each subscale (0-16). 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 & Kamphuls, 1985; de Jong Gierveld & van Tiburg, 1999) was developed to assess the subjective experience of loneliness based on Weiss’s (1973) distinction between social and emotional loneliness. The measure conceptualises loneliness as existing on a continuum of deprivation from severe feelings of loneliness to less intense feelings of loneliness. Of the 11 items there are six negative items which measure aspects of emotional abandonment and missing companionship (de Jong Gierveld & van Tiburg, 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 scores are transformed so they could be interpreted in the same direction, so the higher the score the greater indication of either emotional or social loneliness. For example, for the item “I miss having a really close friend”, if the response is “no”, it receives a score of 3, whereas if the answer is “yes” it receives 1. Therefore, the scores are reversed for all the negative items. 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 were 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 et al., 2001).

Covariates.

As a decline in cognitive performance may be due to factors other than social isolation, a selected set of potential confound variables were considered to reduce the possibility of spurious associations. Confound variables were 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 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 were also included, which is common practice when researching social isolation and cognition (Ertel et al., 2008; Seeman et al., 2001; Wilson et al., 2007). The measures of all control variables are discussed below.

Age.

Participants were asked to provide their date of birth, and age was generated by subtracting this from the year the survey was administered.

Education.

Participants were asked to indicate what their highest educational qualification was, with the following response options provided: No qualification, Secondary school qualification, Post-secondary certificate, diploma or trade diploma, and University degree. For the regression analyses, education was transformed into a dichotomous variable: (0) = no qualification, = (1) qualifications.

Gender.

The dichotomous response choices for gender included 1 = male, 2 = female. For use in the multiple regression analyses the variables were coded: 0 = female, 1 = male.

Relationship status

Available response categories for relationship status were: 1 = single, 2 = married, 3 = civil union, 4 = de-facto, 5 = divorced/permanently separated, 6 = widowed, 7 = other. The categories were collapsed into groups based on the presence of a spouse/partner and previous relationship status: 0 = married/civil union/de facto, 1 = divorced/permanently separated 2 = widowed, 3= single/other. The reference group was married/civil union/de-facto for the multiple regression analyses.

Ethnicity.

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

Depressive symptomology.

Depressive symptomology has been associated with having a detrimental effect on cognitive performance in the older adult (Austin, Mitchell, & Goodwin, 2001; Porter, Bourke, & Gallagher, 2007) and is a 'probable' risk factor for cognitive decline in the ageing (Plassman et al., 2010; Saczynski et al., 2010). Also, it is commonly controlled for when assessing the relationship between social isolation and cognition (Wilson et al., 2007). To assess the rate of depressive symptomology in the study the Centre for Epidemiologic Studies Depression Scale was employed (CES-D10; Kohout, Berkman, Evans, & Cornoni-Huntley, 1993; Radloff, 1977). The CES-D10 is a 10-item self-report scale which

is constructed to identify depressive symptoms that are experienced in the last week by the respondent. The measurement properties of the CES-D10 have been assessed with satisfactory test-retest correlations and good predictive accuracy for depression in the elderly (Andresen, Malmgren, Carter, & Patrick, 1994; Irwin, Artin, & Oxman, 1999). Responses are recorded using a four-point Likert scale. The range is 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. The range of score is 0-30 with the higher the score the greater the indication of depressive symptomology. One item on the CES-D10 asks the participants if they felt lonely during the past week.

As loneliness is one of the independent variables, in order to decrease the overlap between the CES-D10 and the measures of loneliness, the 'felt lonely' question was deleted prior to calculating 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 α=0.80 to Cronbach α=0.72) (Cornwell & Waite, 2009b). The CES-D10 modified scale is referred to as CES-DMod for this study.

Medical Conditions.

Diabetes, heart disease and stroke were the medical conditions controlled for in this study. 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 study participants ticked "yes" if a health professional had told the individual that they had a health condition which included diabetes, heart trouble (e.g., angina or heart attack), or stroke. Each medical condition was dichotomised for the multiple regression analyses as a dummy variable with No condition = (0) and Medical condition Yes = (1).

Physical functioning.

The SF-12 is a 12-item health status measure that produces a physical component summary score (PCS-12) and a mental component summary score (MCS-12). There are eight components represented (physical functioning, role functioning physical, bodily pain, general health, vitality, social functioning, role functioning emotional and mental health) that create the meta-scores for either the PCS-12 or MCS-12. For the current study only the PCS-12 score was used. The 12 items are scored and normalised using a complex algorithm described in the standard scoring procedure in the test manual. The resulting PCS-12 score was transformed to a distribution with a mean score of 50 and a standard deviation of 10 for the general United States of America (USA) population. Older adults studies from Canada and the USA have reported the mean scores in the 65-74 year age group as 42.84 and the 75+ age group as 35.88 (Johnson & Pickard, 2000; Utah Department of Health, 2001). A New Zealand study reported mean scores in the 65-74 age group as 45.3 and the 75+ age group as 39.4 (Scott, Tobias, Sarfati, & Haslett, 1999).

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).

Chapter Six: Data Analyses and Results

Data Analyses

Means and standard deviations of the untransformed variables are included in the descriptive analyses. Initial data analysis included the screening of variables through appropriate SPSS for Windows Version 19 analytical tools for the following: missing values, fit between their distributions, and the assumptions of multivariate analyses as recommended by Tabachnick and Fidell (2013).

Missing data.

Univariate statistics showed that the PANT and SPS had missing cases of 11.5% and 11.1%, respectively, and the de Jong Gierveld Social Loneliness Scale was 5.9%. All other variables had less than 5% data missing. Examination then occurred for the PANT, SPS and de Jong Gierveld Social Loneliness scales, which revealed that, no items that contributed to these three had more than 5% missing data for any specific item. Missing value analysis using Little's MCAR test of significance revealed no clear pattern to the missing data, so no transformation of the data was required to account for it (Tabachnick & Fidell, 2013). Listwise deletion was included in analyses to exclude cases with missing data on the variables of concern.

Outliers.

Responses for the ACE-R, PANT, SPS, de Jong Gierveld emotional loneliness scale and social loneliness scale were all assessed for potential outliers (an observed value that deviates or is extreme from other observed values; see Tabachnick & Fidell, 2013). The ACE-R variable was identified as having 13 cases considered as univariate outliers (scores that were ≤ 75); the SPS variable was identified as having four cases considered as univariate outliers (scores that were ≤ 52); and no outliers were identified for the PANT or the two loneliness scales. Further investigations of each individual outlier revealed that the ACE-R and SPS outliers had been correctly entered and to have come from the intended population. No deletion or transformation of the outliers occurred, as it is more than likely that these values represent cases that would be found in the normal population.

Assumptions of normality.

Assessment of normality of variables showed that the SPS Scale and the Wegner Locally Integrated scale were normally distributed. The De Jong Gierveld Emotional Loneliness scale and the De Jong Gierveld Social Loneliness scale were mildly to moderately skewed in a positive direction. Logarithmic and square root transformation did not improve the distribution of the data. As the sample size was large in this study mild to moderate skewness would not make a meaningful difference in the analysis, thus enabling the use of the untransformed data (Tabachnick & Fidell, 2013).

The ACE-R total score and the subscales of ACE-R violated the assumption of normality. Logarithmic transformations were used on the ACE-R and the subscales of ACE-R which improved the distribution of the data for all subscales except for the Attention and Orientation scales. Various transformations were used for the Attention and Orientation data, with no success. A review of the data deemed it a very non-normal distribution, in that it was similar to a J-shaped distribution with extreme negative skewness. Of the 461 participants 87.2% received the top score of 18, 8.7% received a score of 17, and the remaining 4.1% (19) were in the score range of 12-16. The ACE-R has been validated in geriatric clinics and memory clinics but not yet in a community sample and primary care setting. Also, there is an absence of reliability data for older adults who are not cognitively impaired (Cullen, O'Neill, Evans, Coen, & Lawlor, 2007 ; Lonie, Tierney, & Ebmeier, 2009). As the ACE-R is a screening tool for dementia, and with the prevalence of moderate to severe dementia being 5% of the general population aged over 65 years old (Sadock & Sadock, 2007), it is safe to assume that the scores for attention and orientation should have a ceiling effect particularly in the young old adults (e.g., 65 to 85 years old) who are in a community dwelling. This also explains why majority of participants in this study scored above the cut-off point of 16 offered in the 70-75 age group, and only .03% scored below. Due to the high ceiling effect resulting in non-normal distribution of data (e.g. 99.7% scoring between 16-18), it was decided that no further analysis would occur on the attention and orientation as the data would be unlikely to reveal any useful patterns.

Bivariate data analyses.

Bivariate correlations (Pearson's *r*) were used to examine the association between social isolation measures and cognition measures. Due to the overwhelming evidence that

various forms of social isolation are detrimental to the health and well-being (including cognitive health) to individuals, directional (one-tailed) tests were used (Cacioppo & Hawkley, 2009; Shankar, McMunn, Banks, & Steptoe, 2011; Uchino, 2006). Also, because of the lack of evidence in the literature that social isolation has beneficial effects on health and cognition (House, 2001), a directional one-tailed test was deemed appropriate for the bivariate analyses (McCall, 1986). This strategy of using one-tailed tests has been used in other studies that have researched the effects of social isolation on aspects of health and cognition (Baumeister, Twenge, & Nuss, 2002; Hawkley, Thisted, Masi, & Cacioppo, 2010; Luo & Waite, 2011).

Multivariate data analyses.

For the second part of the study hierarchical multiple regression analysis was performed to test the relationship between social isolation and cognition, whilst controlling for covariates (age, education, gender, marital status, ethnicity, medical conditions, depression, physical functioning, and smoking). This provided the opportunity to examine the relationship between social isolation and cognition, and to evaluate changes in the regression model when social isolation measures were added. The chosen method of entry for the control variables (covariates) was simultaneous (forced) entry. This method was chosen as it allowed for the effect of known predictors to be controlled for before the entering of social isolation predictors. For example, in step one control variables were entered: age, education, gender, marital status, ethnicity, diabetes, heart trouble, stroke, smoking status, CES-D10, SF-12. In step two the social isolation measures identified in the bivariate correlation as having a significant relationship with the dependent variable were entered in simultaneous (forced) entry. The dependent variables tested were ACE-R and the following four subscales of the ACE-R: memory, fluency, language, and visuospatial. After an initial run of the regression analysis, marital status and ethnicity were removed as they contributed the least to the models, and removal of them did not significantly alter the models. This process of removal of unimportant predictors is recommended by Field (2009). It also improves the ratio of cases to independent variables, which is needed when the DV is skewed, or a small effect size is anticipated (Tabachnick & Fidell, 2013). In this study the number of cases available ranged from 329 to 389 depending on which social isolation measure was used. These numbers were above the minimum proposed guideline by Tabachnick and Fidell (2013), where $N \geq 50 + 8m$ (where m is the number of IVs), which in this case would be 146 cases. With the

removal of marital status and ethnicity, the final step was performing regression analysis to test the relationship between social isolation and cognition, whilst controlling for the remaining covariates (age, education, gender, medical conditions, depression, physical functioning, and smoking).

Multicollinearity.

Multicollinearity was assessed by examining variance inflation factors (VIF) and tolerance levels. 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 2.0, well below the level of 5.0, and the lowest tolerance level was 0.613, well above the 0.2, hence multicollinearity was not found.

Assumptions of linearity and homoscedasticity.

Examination of scatterplots of residuals enabled a test of the assumptions of linearity and homoscedasticity between the predicted dependent variable scores and errors of prediction; there was no violation of assumptions (Tabachnick & Fidell, 2013). Following analysis of residuals, three multivariate outliers were removed when ACE-R was the criterion, two multivariate outliers were removed when memory was the criterion, one multivariate outlier was removed when fluency was the criterion, and two multivariate outliers were removed when visuospatial was the criterion. Final examination of residuals was based on Cook's distance, to determine if any cases had this distance >1. The highest Cook's distance was 0.09, so there were no individual cases that had a large effect on the regression analysis (Stevens, 2002; Tabachnick & Fidell, 2013).

Results

Summary descriptive statistics for the study variables are displayed in Table 2. The table presents the statistics for the overall sample.

Table 2. Summary of the Participants' Demographic Characteristics

	Participants (N=407)			
Variables	Frequency	%	Mean	SD
Age (65-84)			71.01	(4.62)
Gender				
Female	235	(51.0)		
Male	226	(49.0)		
Ethnicity				
Maori	329	(71.5)		
Non Maori	131	(28.5)		
Education				
No School Qual	117	(25.4)		
School Qual	109	(23.6)		
Post-School Qual	161	(34.9)		
University Qual	74	(16.1)		
Med Conditions				
Diabetes	49	(10.6)		
Heart	91	(19.7)		
Stroke	31	(6.7)		
Smoking				
Non smoker	244	(53.2)		
Smoker	215	(46.8)		
Relationship				
Married/De-facto	298	(64.7)		
Divorced	44	(9.5)		
Widowed	91	(19.7)		
Single	28	(6.0)		
Cognitive Domains				
ACE-R			91.77	(6.09)
Memory			23.24	(2.99)
Fluency			10.87	(2.36)
Language			24.66	(1.69)
Visuospatial			15.20	(1.16)
Social Isolation				
Social Loneliness			1.40	(1.81)
Emotional Loneliness			1.70	(1.69)
Social Support			79.95	(9.58)
Locally Integrated			3.70	(1.65)
SF12 Physical			45.86	(10.72)
CES -DMod.			5.60	(4.27)

Demographic characteristics.

The age of participants ranged from 65 to 84 years old. Mean age of participants was 71 years ± 4.62 SD years. The majority of participants were non-Māori (71.5%). Being married or in a de-facto relationship (64.7%) was reported more than any other relationship status, with the next largest group being those who are widowed (19.7%),

whereas never being married accounted for 6% of the participants. Slightly over half of the participants (51%) had a post-school qualification or university qualification. One-quarter of participants (25.4%) had no qualifications. The scores for both physical health and depression were indicative of a relatively physically and mentally healthy group of participants. Of the medical conditions, more respondents reported being diagnosed with heart trouble (19.7%) than either diabetes (10.6%) or a stroke (6.7%). At some stage in their lives nearly half of the participants had smoked (46.8%).

Descriptive statistics for cognition.

The mean score of global cognition (M = 91.77) was higher than the guideline ACE-R cut-off score of 88 (the lower the score the poorer the cognitive performance), which is shown to have 94% sensitivity and 89% specificity for indicating potential dementia (Mioshi et al., 2006). These results from the ACE-R score provided evidence that most of our participants had high-functioning cognitive ability.

Descriptive statistics of social isolation measures.

Scores for the social isolation measures showed that the majority of older adults did not report high levels of social isolation. Social support scores ranged from 49 to 96, with a mean score of 79.95, which indicates that majority of older adults perceived they had access if required to different forms of social support rather than a perception that their network was not able to provide a range of social support. The data sets for emotional loneliness and social loneliness included scores from the full range of possible scores (0-5 and 0-6, respectively). More people reported themselves as not emotionally lonely (33%) than emotionally lonely (18.6%). Likewise, more people reported themselves as not socially lonely (50.2%) than severely socially lonely (9.9%). There was more evidence of emotional loneliness than social loneliness in this cohort. Scores for the Locally Integrated Network type ranged from 0-8. The mean score of the Locally Integrated Network (M=3.77, SD=1.65) showed that, on average, participants in this study had some form of interaction with family, friends, or the wider community.

Overall the descriptive statistics indicated a population of older adults who were more likely to be high-functioning than not. The scores on the social isolation measures were all at the higher end providing support that this cohort are more likely to be socially

integrated with most believing they had adequate support available and low levels of loneliness.

Bivariate correlations.

The variables chosen for the bivariate correlations were the measures of social support, emotional and social loneliness, objective social isolation, and cognition. The bivariate correlations enabled the identification of significant relationships between the social isolation measures and cognition measures. Only social isolation measures that showed a relationship with either overall cognition or one of the cognitive subscales were included in the regression analyses, a process that has been employed by others (Ó Luanaigh & Lawlor, 2008; Wang et al., 2002). Control variables were not included in the bivariate analysis, in line with previous research on social isolation and cognition (Eisele et al., 2012; Ó Luanaigh & Lawlor, 2008; Yeh & Liu, 2003).

Table 3 describes the relationship between global cognition, cognitive domains and social isolation variables. Social isolation measures exhibited a range of patterns of significant correlations with global cognition and cognitive domains. However, all associations were regarded as weak (Cohen, 1988). Social loneliness was the only measure that had a significant relationship with all dependent variables. Social provision had significant relationships with global cognition, memory, fluency, and visuospatial domains. Emotional loneliness had a significant relationship with memory only. Locally integrated network had only one significant correlation with a dependent variable, that of fluency. These findings show that different indicators of social isolation (objective or perceived isolation) have different relationships with cognition in general and cognitive domains. It also provides evidence that measures of perceived social isolation have more significant correlations with cognitive measures than measures of objective social isolation.

Table 3. Bivariate Correlations (Pearson's *r*) for Measures of Cognition and Social Isolation

	ACE-R	Memory	Fluency	Language	Visuo-spatial	Emotional Loneliness	Social Loneliness	Social Support
Memory	.723**							
Fluency	.731**	.301**						
Language	.553**	.246	.273**					
Visuospatial	.428**	.135**	.217**	.201**				
Emotional Loneliness	-.051	-.090*	.012	.043	-.03			
Social Loneliness[1]	-.216**	-.115*	-.173**	-.152**	-.140**	.497**		
Social Support[2]	.134**	.085*	.114*	.108*	.108*	-.597**	-.540**	
Locally Integrated [3]	.002	-.027	.091*	-.049	.01	-.291	-.182**	.282**

**Correlation is significant at the .01 level (1 –tailed)

*Correlation is significant at the .05 level (1 – tailed)

[1] High levels of loneliness results in a higher score

[2] High levels of perceived social support results in a higher score

[3] High levels of local integration results in a higher score

Multivariate analyses.

The second part of the data analysis sought to determine if the relationship between the different types of social isolation and cognition was significant after controlling for socio-demographic, mental and physical health conditions, and lifestyle factors that have been empirically evaluated as having an association with cognitive performance. Multiple regression analysis was conducted to predict the overall variance in: a) the ACE-R measure of global cognition: and b) the ACE-R subscales of memory, language, fluency, and visuospatial. This is explained by social isolation measures that were identified in the bivariate analysis, discussed above.

Global cognition.

Hierarchical multiple regression was used to assess the ability of two social isolation measures (Social Loneliness and Social Provision) to predict cognitive performance (ACE-R), after controlling for the influence of age, education, gender, diabetes, heart trouble, stroke, smoking status, depressive symptomology, and physical health.

R was significantly different from zero at the end of each step. The results of this analysis are provided in Table 4. At step one, socio-demographic, medical and lifestyle variables alone explained 17.1% of variance (adjusted R^2) in ACE-R global cognition scores, F (9,347) = 9.165, p<.001. In step two, with social isolation measures entered (Social Loneliness and Social Provision), total variance explained in scores for ACE-R global cognition increased to 18.6% (adjusted R^2), F (11,345) = 8.415, p<.001. The R squared change for the model was significant after the addition of the social isolation measures, F change (2,345) = 4.264, p <.05. In step two, Social Loneliness was the only form of social isolation that was statistically significant predictor of ACE-R global cognition scores. The Social Loneliness variable accounted for 1.61% unique variance in ACE-R scores when controlling for socio-demographic variables.

Examination of the beta coefficients in the hierarchical multiple regression enabled the observation of the contribution each block of variables has on the DV and how each additional block of IVs may alter the effect of the preceding block of IVs on the DV. The

inclusion of the measure of Social Loneliness in step two reduced the significant effects of depression and gender (male) in step one.

Table 4. Hierarchical Multiple Regression Analyses of Socio-Demographics, Depressive Symptomology, Medical Factors and Social Isolation Measures on ACE-R Scores Showing Standardised Regression Coefficients, *R*, Total R^2, Adjusted R^2 and R^2 Change (N=357)

Variables	**Step 1**	**Step 2**
Socio-demographic		
Age	-.176***	-.177***
Education	.271***	.274***
Male	-.108	-.093
Diabetes	-.126*	-.127*
Heart trouble	.097	.094
Stroke	-.081	-.076
Non-smoker	-.005	-.007
CES-DMod	-.153**	-.084
SF12 Physical	.019	.022
Social Isolation Measures		
Social Loneliness		.160***
Social Provisions		.009
R	.438***	.460***
Total R^2	.192***	.212***
Adjusted R^2	.171***	.186***
R^2 Change	.192***	.019*

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

Memory.

Hierarchical multiple regression was used to assess the ability of three social isolation measures (Social Loneliness, Emotional Loneliness and Social Provision) to predict cognitive performance (Memory) after controlling for the influence of age, education, gender, diabetes, heart trouble, stroke, smoking status, depressive symptomology, and physical health.

The same procedure was followed for the memory score regression analysis as outlined previously. *R* was significantly different from zero at the end of each step. The results of this analysis are provided in Table 5.

Table 5. Hierarchical Multiple Regression Analyses of Socio-Demographics, Health Factors and Social Isolation on Memory Score Showing Standardised Regression Coefficients, *R*, Total R^2, Adjusted R^2 and R^2 Change (N=355).

Variables	**Step 1**	**Step 2**
Socio-demographic		
Age	-.117*	-.118*
Education	.153*	.158**
Male	-.142**	-.138*
Diabetes	-.117*	-.122*
Heart trouble	.116*	.114*
Stroke	-.043	-.041
Non-smoker	-.013	-.014
CES-DMod	-.158**	-.143**
SF12 Physical	.017	.017
Social Isolation Measures		
Social Loneliness		-.007***
Emotional Loneliness		-.035
Social Provisions		.004
R	.335***	.337***
Total R^2	.112***	.113***
Adjusted R^2	.089***	.082***
R^2 Change	.112***	.001

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

The socio-demographic, medical, depression and lifestyle variables, which were entered in for step one, explained 8.9% of variance (adjusted R^2) in Memory scores, F (9,345) = 4.851, p<.001. After entry of the social isolation measures the total variance explained in memory scores *decreased* to 8.2 % (adjusted R^2), F (12,342) = 3.646, p<.001.

The *R* squared change after the inclusion of the social isolation measures was not significant, F change (3,342) = .139, p = .936. Age, gender, education, depression, diabetes, and heart trouble were the significant variables to account for the variation in memory scores after social isolation measures had been included.

Fluency.

Hierarchical multiple regression was used to assess the ability of three social isolation measures (Social Loneliness, Social Provision and Local Integrated Network) to predict cognitive performance (Fluency), after controlling for the influence of age,

education, gender, diabetes, heart trouble, stroke, smoking status, depressive symptomology, and physical health. The same procedure was followed for fluency score regression analysis as outlined previously. *R* was significantly different from zero at the end of each step. The results of this analysis are provided in Table 6.

At step one, the socio-demographic, medical, depression and lifestyle variables explained 9.0% of variance (adjusted R^2), in fluency scores, F (9, 314) =4.562, p<.001. Social isolation measures included in step two increased total variance to 10.8% (adjusted R^2) of fluency scores, F (12,3110) = 4.215, p<.001. With the inclusion of social isolation measures the *R* squared change was significant, F change (3,311) = 2.922, p<.05. The Social Loneliness variable accounted for 1.56% unique variance in Fluency scores when controlling for socio-demographic variables and the inclusion of Local Integrated Network and Social Provision variables.

Table 6. Hierarchical Multiple Regression Analyses of Socio-Demographics, Health Factors and Social Isolation on Fluency Scores Showing Standardised Regression Coefficients, *R*, Total R^2, Adjusted R^2 and R^2 Change (N=324)

Variables	**Step 1**	**Step 2**
Socio-demographic		
Age	-.163**	-.170**
Education	.249***	.255***
Male	-.093	-.066
Diabetes	-.018	-.031
Heart trouble	.028	.019
Stroke	-.069	-.064
Non-smoker	.018	.018
CES-DMod	-.017	.052
SF12 Physical	.067	.067
Social Isolation Measures		
Social Loneliness		-.153*
Social Provisions		-.009
Locally Integrated Network		.068
R	.340***	.337***
Total R^2	.116***	.140***
Adjusted R^2	.090***	.107***
R^2 Change	.116***	.024*

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

Language.

Hierarchical multiple regression was used to assess the ability of one social isolation measure (Social Loneliness,) to predict cognitive performance (Language), after controlling for the influence of age, education, gender, diabetes, heart trouble, stroke, smoking status, depressive symptomology, and physical health. The same procedure was followed for language score regression analysis as outlined previously. *R* was significantly different from zero at the end of each step. The results of this analysis are provided in Table 7.

At step one, the socio-demographic, medical, depression and lifestyle variables explained 5.0% of variance (adjusted R^2), in fluency scores, F (9, 379) = 3.249, p<.01. The social isolation measure included in step two increased total variance to 6.3% (adjusted R^2) of fluency scores, F (10,378) = 3.607, p<.001. The *R* squared change after the inclusion of social isolation measures was significant, F (1,378) = 6.407, p<.05.

Table 7. Hierarchical Multiple Regression Analyses of Socio-Demographics, Health Factors and Social Isolation on Language Scores Showing Standardised Regression Coefficients, *R,* Total R^2, Adjusted R^2 and R^2 Change (N=389).

Variables	**Step 1**	**Step 2**
Socio-demographic		
Age	-.089	-.091
Education	.210***	.213***
Male	.003	.017
Diabetes	-.110*	-.109*
Heart trouble	.004	.003
Stroke	-.059	-.050
Non-smoker	.015	.013
CES-DMod	-.066	-.003
SF12 Physical	-.070	-.068
Social Isolation Measures		
Social Loneliness		-.140*
R	.268**	.295***
Total R^2	.072**	.087***
Adjusted R^2	.050**	.063***
R^2 Change	.072**	.015*

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

Visuospatial skills.

Hierarchical multiple regression was used to assess the ability of two social isolation measures (Social Loneliness and Social Provisions) to predict cognitive performance (Visuospatial) after controlling for the influence of age, education, gender, diabetes, heart trouble, stroke, smoking status, depressive symptomology, and physical health. The same procedure was followed for visuospatial regression analysis as outlined previously. *R* was significantly different from zero at the end of each step. The results of this analysis are provided in Table 8.

At step one, the socio-demographic, medical, depression, and lifestyle variables explained 6.8% of variance (adjusted R^2) in fluency scores, F (9, 348) =3.915, p<.001. Social isolation measures included in step two increased total variance to 8.4% (adjusted R^2) of fluency scores, F (11,346) =3.973, p<.001. The R squared change after the inclusion of social isolation measures was significant, F change (2,346) = 3.936, p<.05. The Social Loneliness variable accounted for 1.61% unique variance in visuospatial scores when controlling for socio-demographic variables.

Table 8. Hierarchical Multiple Regression Analyses of Socio-Demographics, Health Factors and Social Isolation on Visuospatial Score Showing Standardised Regression Coefficients, *R*, Total R^2, Adjusted R^2 and R^2 Change (N=358).

Variables	**Step 1**	**Step 2**
Socio-demographic		
Age	-.151**	-.152**
Education	.129*	.131*
Male	-.010	.005
Diabetes	.019	.019
Heart trouble	.052	.049
Stroke	-.019	-.013
Non-smoker	-.099	-.100
CES-DMod	-.042	.028
SF12 Physical	.137*	.142*
Social Isolation Measures		
Social Loneliness		-.158*
Social Provisions		.001
R	.303***	.335***
Total R^2	.092***	.112***
Adjusted R^2	.068***	.084***
R^2 Change	.092***	.020*

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

Conclusion

These results show that social loneliness was a predictor of cognitive performance in all areas of cognition except for memory. The effect was small but consistently accounted for 1.5% of the variance in all significant findings across global cognition, fluency, and language and visuospatial skills. This level was comparable to the effect of age, although smaller than the effect of education. Social loneliness had a greater influence than the well-studied mental health variable, depression, on all cognitive measures across the domains except for memory. None of the other social isolation measures had a significant effect after controlling for other covariates.

Chapter Seven: Discussion

Overview

The purpose of the present cross-sectional study was to examine the relationship between different types of social isolation and cognitive performance (both at a global level and for components of cognitive function) in the older adult. The questions examined in the current study were:

1) Do different types of social isolation exhibit different relationships with global cognition and specific cognitive abilities?

2) Which measures of social isolation have the strongest association with cognition?

The following section provides an overview of results. This is followed by a discussion of the findings for each social isolation measure as well as comparison with the existing literature, thereby providing an answer for question one. A consideration of question two follows, which explores possible explanations of the results.

Summary of Results

Initial findings at a bivariate level showed that the relationship between the measures of social isolation and cognition differed according to the type of social isolation. Measures such as social loneliness and social support produced more consistent patterns across the range of cognitive outcomes than emotional loneliness and locally integrated network type. Social loneliness had a negative relationship with all cognitive measures, whereas social support had a positive relationship with all cognitive measures other than language. Emotional loneliness and locally integrated network type each had only one association with cognition, memory and fluency respectively.

In the multivariate analysis, social loneliness was the only measure of social isolation that had an influence on cognitive performance after controlling for known covariates. Social loneliness influenced the scores for global cognitive performance and the domains of fluency, language, and visuospatial ability. The influence of social loneliness on memory was negligible, and not found to be an important predictor for memory performance in the older adult. A more detailed discussion of the findings for

each social isolation measure follows, along with a comparison of the findings in the present study to those presented in the literature.

Discussion of Results for Social and Emotional Loneliness

Social and emotional loneliness were operationalised as separate forms of perceived social isolation in the current study. The results for each type of loneliness are discussed individually. For comparison with previous research, the discussion incorporates the findings for both social loneliness and emotional loneliness. This is due to the lack of studies making the distinction between different types of loneliness and their effect on cognition.

The results for the influence of social loneliness on cognition (de Jong Gierveld Social Loneliness Subscale).

As noted above, social loneliness had a negative association with all cognition measures at the bivariate level. Compared to the other social isolation measures, social loneliness had the strongest relationship with both global cognition and cognitive subsets, notably fluency, and the weakest association with memory. The association between social loneliness and cognitive measures carried through in most of the multivariate regression analyses, its greatest influence once again being on global cognition. Memory was the only cognitive subset that was not significantly influenced by social loneliness. Overall, the patterns of association between social loneliness and cognition indicate that the majority of cognitive domains respond in a similar pattern to the influence of social loneliness.

Social loneliness was one of the three constant factors that influenced cognitive performance; the others being the covariates, education and age. For the cognitive domain visuospatial ability, social loneliness was the strongest predictor of performance. Other well-established covariates for cognitive performance, such as heart conditions, stroke, and smoking status, were not significant predictors of any measure of cognitive performance in the current study. Even depression, which has been well established as influencing cognitive ability, was only a significant predictor for memory.

These findings show that social loneliness as a measure of perceived social isolation has been unjustifiably overlooked as a potential risk factor for cognitive

performance. As previously mentioned, House et al. (1988) compared the impact of social isolation on health to that of smoking, obesity, and high blood pressure. The present study suggests that the consequences of social loneliness, as a type of social isolation, for cognitive performance in the older adult is not only comparable to the more well-researched risk factors associated with cognitive decline, but that it may even be *more* detrimental than other physical and mental health factors. The importance of social loneliness may surpass other forms of social isolation measures, such as social support and social network factors.

The results for emotional loneliness on cognition (de Jong Gierveld Emotional Loneliness Subscale).

Emotional loneliness did not show the same patterns of association as social loneliness in relation to cognitive measures. At a bivariate level there was a weak relationship between emotional loneliness and memory. This relationship was no longer of significance once covariates such as demographics, lifestyle and medical factors were accounted for in the multivariate analysis. No other associations for emotional loneliness and cognition were found in the bivariate analysis; therefore emotional loneliness was not assessed in the multivariate analyses.

Comparison of the present study's findings with previous research for social and emotional loneliness.

Lower scores in cognitive ability were reported in the present study for older adults who perceived their social network to have deficits, such as not having enough people they can count on, share their problems with, or just feel close to, than for others in their cohort who did not report social loneliness. These findings are consistent with previous research, which showed that *perceived* social isolation experienced through feelings of loneliness or expressions of dissatisfaction with social relationships influence cognitive performance in the older adult after controlling for covariates such as socio-demographics, depression, medical and lifestyle factors (Amieva et al., 2010; Cacioppo & Cacioppo, 2012; O'Luanaigh et al., 2011; Wilson et al., 2007).

As previously mentioned, there is no study that has specifically looked at social loneliness as a separate phenomenon and examined its relationship with cognition. Therefore, in comparing the present findings to the literature, comparisons will be made

with studies that have used a measure that assesses either global loneliness (that is, loneliness is a unidimensional construct) or studies that have viewed loneliness as a multidimensional construct and assessed emotional loneliness as a form of loneliness. It is worth mentioning that global loneliness is considered closer to the concept of emotional loneliness than social loneliness (van Baarsen et al, 2001). Therefore, the different measures of loneliness may contribute to the mixed findings found across existing studies.

Like the present study's findings that social loneliness influenced global cognition, similar findings have been reported that global loneliness predicts scores on global cognition tests (O'Luanaigh et al., 2011; Tilvis et al., 2004). Some of the findings of O'Luanaigh et al. (2011) were similar to those of the present study. Specifically, they revealed that different types of loneliness do not influence *verbal* memory but do have an association with *visual* memory (the measures of visual memory used by O'Luanaigh et al. (2011) are comparable to the measures used in the ACE-R as the cognitive component of visuospatial ability). Therefore, it is reasonable to suggest that both the O'Luanaigh et al. (2011) study and the present one found an association between a measure of loneliness and measures that capture visuospatial ability.

A study by Wilson et al. (2007), which examined the relationship between emotional loneliness and cognition, reported that emotional loneliness was associated with global cognition, episodic and semantic memory, processing speed, and visuospatial ability (Wilson et al., 2007). These findings contrast with the present study in that emotional loneliness did not have a significant relationship with any cognitive measures once potential covariates were controlled for. Yet what is interesting is that the cognitive domains reported by Wilson et al. (2007) were found to be influenced by emotional loneliness, such as global cognition and visuospatial ability, were influenced by social loneliness in the present study. Furthermore, tests used by Wilson et al. (2007) to capture semantic memory included verbal fluency tests and naming object tests. Both tests are used in the ACE-R, although they are categorised differently, as measures of the fluency subset and language subset, respectively. Both fluency and language in the current study were influenced by social loneliness. Hence in both Wilson et al. (2007) and the present study, it appears that there are similarities in that both emotional loneliness and social loneliness have been found to influence a broad range of cognitive processes such as fluency, language, visuospatial ability, and global cognition.

One of the greatest differences between the present study and Wilson et al. (2007) lies in the purported relationship between emotional loneliness and the cognitive domains. Although both studies use the de Jong Gierveld Loneliness Scale, Wilson et al. (2007) removed the social loneliness scale and made modifications to the emotional loneliness scale. This resulted in considerable changes to the scale's wording and format. Research on older adults and self-reporting has found that minor differences in question wording, format and order can have a significant influence on the results in representative sample surveys (Schwarz, 1998). With this in mind, it would be reasonable to assume that by not having the social loneliness items in the measure, socially lonely people may have either answered differently and/or used the emotional items to capture their social loneliness. For example, one emotional loneliness item is "I miss having people around". Hence, if you are socially lonely and the responses provided in the measure do not capture your experience of loneliness, it is conceivable that participants would answer "yes" to such a question, although it relates to emotional, not social loneliness. Therefore, the different results for emotional loneliness for the two the studies may be a consequence of Wilson et al. (2007) not measuring social loneliness, and making modifications to the emotional loneliness scale. Due to the lack of studies conceptualising loneliness as having different forms, it will only be through an accumulation of evidence from future studies that we can ascertain whether social or emotional loneliness, or both, will be identified as potential risk factors for cognitive performance in the ageing.

In reviewing the literature on loneliness and cognition, it becomes apparent that some of the inconsistencies across studies may relate not only to how loneliness is operationalised, but to the cognitive measures used. For example, the above section has illustrated that when comparison of measures used for cognition between studies is the focus, rather than comparison of cognitive domains assessed, there is more consistency across findings. Overall, it is reasonable to conclude that there is some consistency in the research on loneliness and cognition, including the present study. Loneliness, in some form, appears to have a negative influence on cognitive performance in the ageing across a variety of domains.

Discussion of Results for Perceived Social Support (The Social Provisions Scale)

Perceived social support, be it tangible or emotional, which assesses the potential ability to access support if needed, did not influence cognitive performance in the present

older adult cohort once covariates such as demographic, medical and lifestyle factors were included in the analysis. The associations between perceived social support and cognition at a bivariate level showed similar patterns to those of social loneliness and cognition. For example, perceived social support's strongest relationships were with global cognition and fluency, and weakest with memory, as was the case for social loneliness. However, there were two exceptions: the relationship between language and perceived social support was not significant; and overall the strength of the relationships between perceived social support and cognition were weaker than those reported for social loneliness. In the multivariate analysis, perceived social support no longer was a predictor of cognitive performance across any domains identified at the bivariate level, indicating that the relationship between perceived social support and measures of cognition is accounted for by other variables such as age, education and social loneliness.

Comparisons of the current study's findings with previous research on perceived social support and cognition.

Perceived social support was a measure in the current study that captured a variety of supportive functions available from a network. The results from the current study are comparable to others that used a broad measure of emotional and practical support, and did not show an association with social support and mental abilities such as reasoning, arithmetic, following directions, and analogies (Gow, Pattie, Whiteman, Whalley, & Deary, 2007). A lack of association between cognition and different forms of support such as information, instrumental and emotional support has also been reported (Bassuk et al., 1999; Conroy et al., 2010; Eisele et al., 2012; Hughes et al., 2008; Seeman et al., 2001). One study did report an association between perceived emotional support (such as feeling cared for and appreciated by family, and friends) and global cognition. It noted that significant findings only occurred after reducing the original multiple regression model and eliminating other social network factors such as social ties, groups, and support provided to others. However, the variance was very small at .6% (Seeman et al., 2001). Overall, there is an accumulation of evidence that perceived social support does not appear to be a predictor of cognitive performance in the older adult, which is consistent with my findings.

Discussion of Results for Objective Social Isolation (The PANT: Locally Integrated Network Type)

Objective social isolation, such as that the occurs when one is embedded in a small or restricted network, has a low frequency of social interactions, and a limited or lack of participation in religious, community, or social groups was not found to influence cognitive performance in older adults significantly. A weak but negative association with fluency did occur at a bivariate level, indicating that higher levels of social isolation resulted in a lower score for fluency. In the multiple regression analysis, this result was explained by demographic variables, age and education, and social loneliness.

Comparison of the current study's findings with previous research on objective social isolation and cognition.

The lack of relationship between a locally integrated network type and cognition concurs with the results by O'Luanaigh et al. (2011.) As the study by O'Luanaigh et al. (2011) was the only one located that reported the use of locally integrated network type (as a measure of objective social isolation) other comparable studies that focus on frequency of contacts with friends and family, as well as community involvement, were reviewed. The current results echo other studies showing no association between frequency of contact with family and friends, size of network, group participation, or a composite scale score of social integration with global cognitive performance or cognitive domains such as speed attention and memory (Green, Rebok, & Lyketsos, 2008; Hughes et al., 2008; Seeman et al., 2001). Those studies that did find a relationship between social networks and cognition often include measures to capture objective social isolation and perceived social isolation. For example, satisfaction with contacts (Fratiglioni et al., 2000) or size of perceived network (Crooks, Lubben, Petitti, Little, & Chiu, 2008) have been used in combination with objective indicators and reported findings were combined. Other studies do show a link between objective social isolation and fluency, which is in contrast to our findings. At baseline, Stoykova et al. (2011) reported a significant association between non-demented older adults' social network scores and the category fluency test. Similar results were found by Seeman et al. (2010); older adults who had a greater than average number of social contacts performed better on the category fluency test. This result still held after controlling for age, education, chronic medical conditions, depression, smoking status, activities of daily living ability, and level of physical activity.

Both Seeman et al. (2010) and Stoykova et al. (2011) used only a semantic verbal fluency test, whereas the present study differs in that the fluency score was the sum of phonemic and semantic verbal fluency tests. The use of two verbal fluency tests and combination of results, which occurs with the ACE-R, compared to the use of one fluency test, may have resulted in the different findings for fluency and objective social isolation. This may be due to a potential loss of sensitivity that occurs when using the semantic verbal fluency test alone. For example, Steenhis and Ostbye (1995) reported that semantic verbal fluency testing, such as the generation of animal names, had greater clinical utility for diagnosing dementia than did the phonemic fluency tests. This supports the conclusion by Zec (1993) who, after a review of the literature of pathological cognitive decline, commented that semantic fluency "may be considerably more useful than phonemic word fluency in the differential diagnosis of patients with Alzheimer's disease at all stages of dementia from normal elderly persons" (p. 43). A study that examined the clinical utility of phonemic and semantic verbal fluency tests found semantic verbal fluency tests far superior for diagnosing Alzheimer's disease and mild impairment compared to phonemic verbal fluency tests (Cerhan et al., 2002). A person scoring below the cut-off score for phonemic fluency was 2.1 times more likely to be diagnosed with dementia, whereas a person scoring below the cut-off score for semantic fluency was 24.5 times more likely to be diagnosed with dementia (Cerhan et al., 2002). A review of studies on phonemic and semantic verbal fluency tests found that semantic fluency was far superior in distinguishing between non-cognitively impaired and cognitively impaired older adults (Taler & Phillips, 2008). It was also reported by Taler and Phillips (2008) that many studies on phonemic fluency indicated that there are no differences between the results for non-cognitively impaired and cognitively impaired. In ACE-R fluency tests, scores are grouped and then points are given in ranked order. However, there is also a ceiling effect with all scores above a certain number given the top available mark. For example, if participants score above 17 words for semantic verbal fluency, they receive seven points. Therefore, a participant who obtains 30 words will receive the same score as one who obtains 18. The ceiling for phonemic verbal fluency is set at seven points for any results equal to or above 21 words. Then the points awarded for both semantic and phonemic verbal fluency are added together. In a non-clinical population, this combining of scores in the ACE-R may cause a loss of the power or sensitivity of the fluency test. The differences in how tests are used and scored may providing a possible explanation for the differences between the current study's findings and other studies on the association between objective social

isolation and fluency. Hughes et al. (2008) commented that the ability to find associations between measures of social resources and cognition might be reliant on the cognitive outcomes measures, and this may be a case in point.

Conclusion for Question One: Do Different Types of Social Isolation Have Different Relationships with Global Cognition and Cognitive Subsets?

Types of social isolation may be differentially important for cognitive ability – social loneliness influenced cognition, whereas other forms of social isolation did not. The influence of social loneliness on global cognition and the cognitive domains exhibited a fairly consistent pattern, with one anomaly that was found in the memory domain, which was not influenced by social loneliness. The pattern exhibited by all measures of social isolation in current study indicate that, if a form of social isolation influences cognition, it has a widespread effect on the cognitive ability of the older person rather than specific cognitive domains. The next section will focus on answering the second question of the study and provide where possible explanations on which measures of social isolation have the strongest association with cognition.

Question Two: Which Measures of Social Isolation have the Strongest Association with Cognition?

The second question asked in the present study is: Which measures of social isolation have the strongest association with cognition? The results indicate that social loneliness has the strongest negative association with cognition compared to other forms of social isolation. These findings provide evidence of the importance of measuring various types of social isolation in the same population to determine what component of social isolation is a potential risk factor for cognitive performance in the ageing. The findings also indicate that social loneliness did not have a blanket effect on cognition, influencing some cognitive processes more than others, which is illustrated by the lack of association between memory and social loneliness. A discussion follows in an attempt to determine why social loneliness may have a negative influence on cognition but not on memory, and why assessment of other forms of social isolation in the current study did not lead to significant findings.

Explanation of the Results: Why was Social Loneliness the Only Form of Social Isolation to Have a Negative Influence on Cognitive Performance?

Two speculative but plausible explanations can be offered to answer this question. First, social loneliness may result in less cognitive stimulation due lower levels of interactions and consequently may influence cognitive reserves. Secondly, social loneliness may be such a negative event that it places a drain on some cognitive processes such as executive functions. Two studies that analysed the relationship between neuropathology, social isolation, and cognitive performance provide the starting point for the present discussion.

Wilson et al. (2007) explored the association between loneliness, measures of cognitive ability and neuropathological measures. An analysis of the autopsy results of 90 adults who died during the longitudinal study showed that both loneliness and the neuropathological measures derived from the autopsies were inversely related to global cognition. Notably, loneliness was *not* related to neuropathological measures such as β-amyloid plaques, neurofibrillary tangles, or cerebral infarctions, which are the leading causes of dementia (Wilson et al., 2007). Wilson et al. (2007) concluded that the results suggest that loneliness is not a consequence of dementia, and that an alternative explanation is required to explain the association between loneliness and poorer performance on cognitive measures. The authors suggested that loneliness may have an influence on the neural systems that underpin cognition. That is, in lonely people the pre-existing neural systems underlying social behaviour may be less extensive or developed than in non-lonely people, causing a heightened susceptibility to the disruption of age-related neuropathology. Therefore, if lonely people have a 'less developed' neural system in the area of social cognition they will not have a compensatory networks available for use when other neural systems are weakened by neuropathology that comes with ageing.

Bennett et al. (2006), also assessed the relationship between a measure of social isolation, cognitive performance and neuropathology. Analysing the data from 89 older adults' autopsy results, Bennett et al. (2006) suggested that social network size modified the association between cognitive performance and brain pathology associated with Alzheimer's disease. For example, older adults who reported higher numbers of people they considered close, could talk to them at ease over private matters, and call upon for help, and whom they saw on a monthly basis, had better cognitive functioning, even at severe global levels of pathology, compared to those with a smaller number of close

people. Bennett et al. (2006) postulated that the aspects of cognitive processing that allow people to develop and maintain larger social networks may provide either a compensation system, or a cognitive reserve that offsets the increasing accumulation of Alzheimer's disease pathology, which consequently impairs cognition.

In review, both studies offer evidence that different types of social isolation may have some form of association with cognitive reserve (Stern, 2002, 2009). The cognitive reserve model describes experiences such as education, occupational attainment, leisure, and social activities throughout life as having an influence on the cognitive processing of tasks. Stern (2009) defines the physiological bases subsumed by cognitive reserve "at the level of variability in synaptic organisation, or in relative utilization of specific brain regions" (p. 2). This suggests that skill sets developed throughout life will result in anatomical inter-individual differences at the level of brain networks. It is plausible to conclude, based on the findings of the present study, that perceived social loneliness may be a type of social isolation that has a potential association with cognitive reserve. The following discussion sets out reasons for this.

The relationship between social loneliness, social cognition and cognitive reserve.

Social loneliness, a subjective measure, has been correlated with objective measures such as a lack of social contact, low integration and low frequency of interactions (Drennan et al., 2008; Heylen, 2010). Contact frequency directly affects social loneliness regardless of the perceived quality of the relationships (Heylen, 2010). The lack of interactions, and therefore lack of cognitive stimulation or engagement of cognitive processes, may reduce opportunities to increase or maintain cognitive reserve in socially lonely ageing adults. To illustrate, interacting with another person through conversation requires the use of many perceptual and cognitive systems such as vision, audition, attention, episodic memory (to retain the topic and contributions each have made), attribution of mental states and executive functions (for instance, decision-making about what is appropriate to discuss, and inhibiting irrelevant or inappropriate behaviour). Furthermore, social interactions are complex and involve knowledge about the self, perceptions of others, and interpersonal knowledge such as motivation, all of which are required for skilled social functioning (Adolphs, 2001; Amodio & Frith, 2006). This set of processes is broadly referred to as social cognition (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. In a study of younger adults, 10 minutes of involvement in a social interaction condition before assessment resulted in the participants outperforming the control group on measures of two cognitive functions, processing speed and working memory (Ybarra et al., 2008). Ybarra et al. (2008) suggested that the social interactions their participants engaged in included processes involved with executive functions such as planning and inference generation. Therefore, activation of cognitive resources such as executive functions in the social interaction condition was hypothesised to boost mental performance for the younger adults. In another study of the relationship between social interactions and cognitive performance, Ybarra et al. (2011) reported that 10 minutes of a basic 'get-to-know-you interaction' predicted scores on an executive function measure to the same extent as 10 minutes of performing intellectual activities (such as crossword puzzles, spatial rotation tasks and reading comprehension) known to maintain or boost cognitive reserve. Those participants who had no social or intellectual stimulation before being assigned a cognitive test were outperformed by both those in the social interactions group and those in intellectual activities group.

The findings from both studies by Ybarra et al. (2008, 2011) highlight the relationship between social and general cognition. Relating this to the findings from the

present study, there would appear to be support for the idea that social interactions can influence cognitive performance. In the present study, it was only the measure of social loneliness that predicted poorer performance on cognition. From a theoretical point of view, if social interactions provide the same boost to cognitive performance as intellectual stimulation or cognitive training, which studies report as promoting cognitive reserve in the older adult (La Rue, 2010), then by not interacting with others (that is, by experiencing social loneliness), the disuse or 'use it or lose it' hypothesis previously mentioned may apply (Salthouse, 1991; Salthouse, 2006). In other words, a decrease in social interaction may results in the atrophying of cognitive skills, while constant social interactions or novel social interactions may provide mental stimulation that consequently maintains and enhances cognitive reserve. There is merit in the claim that socially lonely people experience less social interaction than non-socially lonely people, and that lack of social interactions has a detrimental influence on cognition. The present study's findings, that social loneliness, but not emotional loneliness, predicts cognitive performance supports this proposed explanation. If both social loneliness and emotional loneliness had shown a relationship with cognition in the current study it would be less plausible that the pathway between loneliness and poorer cognitive performance is due to a lack of cognitive stimulation or reduced cognitive reserve due to less social interaction, as the source of emotional loneliness differs from the source of social loneliness. That is, the emotionally lonely person perceives themselves as lacking intimate attachment with another, rather than exhibiting an objective deficit in their broader network. Emotionally lonely people, for example widows, may find themselves surrounded by friends and family each day, or be involved in other activities that provide social interaction, yet miss the intimacy and closeness that comes with a partner. Therefore, emotionally lonely people may be getting a substantial amount of social stimulation, and the attendant benefit of promoting or maintain their cognitive reserve, but still yearn for a deeper attachment to a specific person. Likewise, a socially lonely person may have a close confident such as a spouse but lack a wider network to provide novel and challenging experiences. The findings however in the current study do provide some support that social loneliness has an influence on cognition, and the pathway for this relationship is possibly due to a lack of social interactions, which in turn results in a lack of cognitive stimulation.

Limitations of the proposed explanation that social loneliness influences cognitive reserve.

There are two issues that do weaken the support for the proposed explanation that socially lonely people, i.e. those with lower levels of social interaction have less opportunity to maintain or promote cognitive reserve that weaken the support. These are: (1) the nature of the social loneliness measure used in the present study; and (2) the findings regarding the relationship between the objective measure of social isolation and cognitive performance. First, the current study's measure of social loneliness was based on participants' perception of their social network, not on an objective measure of actual social interaction. It cannot be automatically assumed that older adults who report higher levels of perceived social loneliness in this sample have lower levels of social interaction than non-socially lonely older adults; some studies have found an association other have not (Havens et al., 2010; Tomaka et al, 2006; Victor et al., 2000). The research on the relationship between loneliness and objective measures of social isolation is far from conclusive. Cornell and Waite (2009a), for instance, have shown that the correlation between global measures of loneliness and actual social isolation is weak. Other studies found measures of objective social isolation to be a significant predictor of loneliness (Shankar et al., 2011; Shiovitz-Ezra & Leitsch, 2010). Studies that distinguish between various forms of loneliness have reported that social loneliness had a stronger association with objective measures of social isolation than emotional loneliness (Drennan et al., 2008; van Baarsen et al., 2001). The second issue to be raised concerns the objective social isolation measure used in the present study that had no association with cognitive performance. If, in the current study, the measure of objective social isolation had shown a significant association with cognitive performance, there would be more support for the relationship between social loneliness and cognition.

Future research requirements.

Further research examining the relationship between social loneliness and objective measures of isolation is needed to determine whether perception of the older person's network equates with the reality of the person's situation. The field would also benefit from longitudinal studies that investigate the association between perceived social loneliness and objective measures of actual social interactions and their influence on cognition. To investigate the social world of the older adult requires the use of a social loneliness measure, along with measures of actual social interactive engagement, while

controlling for non-social cognitive stimulating activities and other well-established confounding variables. The present study did not produce enough evidence to unequivocally support the notion that socially lonely people perform worse on cognitive tests due to a lack of socially stimulating interactions. Therefore, other explanations of why perceived social loneliness has the strongest relationship with cognition are possible. In addition, an explanation is needed for why social loneliness did not have a blanket effect across all domains, with memory, in particular, unaffected.

An alternative explanation of the way social loneliness influences cognition.

The following section endeavours to explain the anomaly of memory not influencing social loneliness, as well as provide a reason for the influence of perceived social loneliness cognition regardless of the actual reality of the older adults' social world.

Social exclusion and executive functions.

In the present study, memory, unlike the other cognitive domains, did not exhibit an association with social loneliness, a result which is consistent with O'Luanaigh et al. (2011) but inconsistent with Wilson et al. (2007). However, if socially lonely people have less opportunity to build or maintain cognitive reserve due to a lack of social interactions, it would be plausible that processes involved in memory may also be affected. Therefore, a different mechanism that explains how perceived social loneliness influences cognitive domains may be required in order to explain why not all cognitive processes are influenced in the same manner. A brief review of experimental studies by conducted by Baumeister et al., (2002) on social exclusion and cognitive performance follows. This provides a speculative, but nevertheless possible, explanation of why social loneliness had the strongest association with overall cognitive performance in the current study but did not influence memory.

Baumeister et al. (2002) employed manipulation of social exclusion (a future of aloneness) to determine if it influenced cognitive processes. The initial experimental study had participants complete a portion of the General Mental Abilities Test, which includes measures of verbal reasoning, mathematical ability and spatial ability (Janda, 1996). Before the participants completed the test they were given a personality inventory to complete. Participants received feedback on the personality test, explaining their scores

on extroversion. Straight after that, they were given bogus feedback about their future. Three sets of feedback were given: a high likelihood of ending up alone in life, a high likelihood of being surrounded by people who care for them, and a future of misfortunes such as being more accident prone in later life. The misfortune group was the control group, as it did not include any reference to social networks. After bogus feedback had been given, all participants were asked to fill out a one-item mood measure and to complete as many items as possible on an intelligence test within a six-minute timeframe. The participants pronounced alone in future performed worse for both speed and accuracy than either those with a future of belonging or a future of misfortune. Remarkably, regardless of the participants' actual social world, just the thought of social exclusion resulted in significant decrements in the ability to process information in an efficient and intelligent manner. Baumeister et al. (2002) noted that the results were impossible to explain by emotional distress or an increase in arousal from being informed of having a potential future alone. This indicated that those who are socially excluded may be trying to suppress their emotional state, and use cognitive resources to do. Moreover, Baumeister et al. (2002) hypothesised that, as suppressing emotion requires self-regulation, and self-regulation is an important form of executive control (Baumeister, 1998), it may be that only executive functions are impaired, whereas automatic processes such as the encoding of information would not be. To investigate this, Baumeister et al. (2002) researched the effects of social exclusion on learning and memory. Two verbal reading tasks were presented, one being a brief, relatively easy reading passage, the other being longer and more difficult. Questions were then asked about each passage, and were not timed. Findings from this experiment indicated that only the future alone (social exclusion) group was impaired in their ability to recall on a task that was deemed difficult but not on an easy test. Baumeister et al. (2002) conducted a final experiment to determine whether social exclusion affects complex cognitive tasks that require active thinking and deliberate conscious and controlled responses such as logical reasoning, rather than simple cognitive processes tasks that involve basic information processing such as encoding and retrieval of information in relatively easy rote memory tasks. The findings in this experiment showed that social exclusion did impair complex cognitive processes, but simple cognitive processes were not affected. Baumeister et al. (2002) concluded that social exclusion is regarded as such a threatening and unwanted event, and that in striving to suppress the attendant emotional distress, a drain is placed on executive functions, which results in an impairment of controlled processes.

Are socially lonely people regulating their emotion and consequently placing a drain on cognitive resources?

These findings of Baumeister et al. (2002), that social exclusion influences cognitive performance that involve complex cognitive processes, can be related to the present study as social loneliness has been characterised by feelings of social exclusion (Weiss, 1973). Social loneliness is also regarded as an indicator of social exclusion, reflecting the individual's subjective perception of their social participation (de Jong Gierveld et al., 2006; Gibson, 2001). Also, experimental studies have shown that when social loneliness is manipulated, through recall of a time when feeling isolated, not belonging, and lacking companionship, the individual becomes more anxious, has an increased fear of negative evaluations as well as more negative social impressions of others, and acts more cordially as a result, which in turn involves self-regulation (Cacioppo et al., 2006). Other studies have linked feelings of social loneliness with a reduction in capacity to self-regulate thoughts, feelings and behaviours (Baumeister, DeWall, Ciarocco, & Twenge, 2005). Another link between social loneliness and cognitive processes is that emotional regulation and control are thought to be associated with frontal lobe functions, as are executive functions (Jurado & Rosselli, 2007; Royall et al., 2002; Stuss & Alexander, 2000). It would be plausible to suggest from the above discussion that older, socially lonely adults may expend more of their cognitive resources on emotional regulation than those who are not socially lonely, and that less is available for tasks that require complex executive functions, which explains why social loneliness was a predictor of cognitive performance.

Furthermore, the explanation that socially lonely people have a drain on the cognitive resources due to emotional regulation, and thereby influencing the performance of complex cognitive tasks provides a possible answer to why all measures except memory were influenced by social loneliness in the current study. When examining the tests used in the ACE-R to assess the cognitive domains, the following domains (fluency, visuospatial, and language processing) all involved aspects of executive function. For example, fluency is a measure of executive functioning (Mioshi et al., 2006); language involves the use of semantic knowledge retrieval, which is associated with executive function processes (Raposo, Mendes, & Marques, 2012), as are visuospatial abilities (Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001); and in the ageing, declining scores on visuospatial tests are linked to a decline in executive function (Libon et al., 1994). Although the memory

component of the ACE-R would initially require some minimum level of executive processes in executing tasks such as attentional regulation and working memory, it does not involve the use of complex executive functions that fluency, language and visuospatial abilities do such as complex decision-making or problem-solving, and organisational skills. To illustrate, first the assessment of memory is a basic memory test. It involves the participant being given three trials in learning words and a physical address, with the instructions to remember them. The words and address are recalled after a time delay. The second part of the memory assessment is the asking of four general knowledge questions such as "Who is the current Prime Minister?". The repetition of the learning of three words and the address enables the information to be encoded into long-term memory due to the use of three trials in learning words. Repetition as used in the ACE-R memory component has been known to improve memory performance significantly in the normal ageing population (Rand-Giovannetti et al., 2006). The cognitive processes used in the memory test such as the formation of echoic memory, storage and recall are not as complex as those used in the verbal fluency test. These include inefficient organisation of verbal retrieval and recall, the need to self-monitor (keep track of responses already given), self-initiation, and inhibition of responses when required. Our findings, that social loneliness does not influence the memory domain which required the least use of executive functions, compared to the other cognitive domains in the ACE-R, provides support that social loneliness affects complex cognitive tasks but not easy tasks as suggested by Baumiester et al (2002).

Furthermore, the constant activation of cognitive processes involved in emotional regulation required to navigate through a world that is perceived as threatening and emotionally distressing, regardless of the reality of situation, potentially explains why social loneliness was not highly correlated with the locally integrated network measure used in the present study, and why the measure of objective social isolation was not a significant predictor in the multivariate analyses. Returning to the studies by Baumeister et al. (2002), for those in the 'future alone group', just the thought of having a future without others caused cognitive performance to decrease regardless of their actual social network situation at the time of the experiments. The reduction of executive function performance due to this emotional regulation may also provide evidence as to why emotional loneliness was not found to have a relationship with cognitive performance. Emotional loneliness can be distressing as it involves feelings regarding a lack of

attachment or intimacy with that 'special' person. However, it has not been associated with feelings of exclusion, or being marginalised, from the broader engaging social network, and it is the feeling of not being embedded within a network that research suggests invokes a state of being on high alert for threats or negative evaluations from those groups that a socially lonely person wants to interact with and be accepted by (Cacioppo et al., 2006; Drennan et al., 2008; Heylen, 2010). Hence, an individual who is emotionally lonely, but is feeling accepted and embedded within a social network, may not be as preoccupied by the constant need for emotional self-regulation and therefore is not draining their cognitive resources.

Future research requirements.

Further research examining why social loneliness is detrimental to cognition in the ageing would be beneficial. When assessing types of social isolation to enable testing of this proposed mechanism on older adults, it would be advisable to use a variety of cognitive measures, from those that require little expenditure of cognitive processes involved in executive function and memory, to those requiring more demanding tasks. The discussion now turns to the objective measure of social isolation and cognition findings in the present study between. The findings, or lack of, on objective social isolation show a link with the findings on social loneliness, as there does appear to be a potential connection between the two measures.

Objective Social Isolation

Expectations and satisfaction.

An explanation of the finding that objective social isolation does not appear to influence cognition in the older adult may be provided by socioemotional selective theory (Carstensen, Isaacowitz, & Charles, 1999). This theory suggests that, as people age, they selectively choose which relationships they want to invest in, value more, and get more pleasure out of, based on a desire for engagement that is emotionally meaningful and positive (Charles & Carstensen, 2010). This consequently determines the size of networks, as relationships that cause conflict or strain, or are not deemed important, will be discontinued (Carstensen et al., 1999). One study that examined socioemotional selective theory across three cohorts expanding four decades concluded that older adults become more satisfied with their social networks than younger adults, although they have less

frequency of contact with network members and smaller network sizes (Lansford, Sherman, & Antonucci, 1998). It was also reported that neither frequency of contact nor size of networks were found to predict satisfaction with the social network (Lansford et al., 1998). Similar findings have also been reported that as one ages expectations relating to social network change (Fung, Carstensen and Lang, 2001). Older people reported less network members but were more satisfied with the number of network members compared to young adults. Furthermore, having a network limited to very close social partners such as husband or close friend was unrelated to happiness. It was concluded by Fung et al. (2001), that unlike for younger cohorts, making contact with new people is not important for those in later life.

One way of making sense of the lack of influence of objective social isolation on cognition is that if ageing is associated with increased satisfaction with social networks, in the case of the older adult who reports dissatisfaction with their social network, this could be an indication of serious deficiencies within that network, which is not being captured with objective measures. That is, the use of objective measures such as frequency of contact or size of network will not capture deficiencies relating to the qualitative experiences of the network. These could include stressful and negative interactions with family or friends or even feelings of isolation. Hence, for the ageing population, size of network or frequency of contact is not necessarily an accurate marker of the support available or perceived, nor of the 'healthiness' of the social network. For older adults, perception of the quality of one's social network may be the best measure of social isolation, as it may better capture the emotional experiences of interacting with network members and the consequences of that experience. For example, the stress associated with negative interactions may reduce any benefit of the cognitive stimulation that occurs through being involved in social interactions or having large social networks. Research has reported that older adults who have higher than average social strain and conflict in their interactions performed poorer on tests of executive functioning, but not episodic memory (Seeman et al., 2010). Fratiglioni et al. found that over a three-year period, frequent contact with children that was not satisfying doubled the risk factor for cognitive decline compared to frequent contact that was satisfying (Fratiglioni et al., 2000). Likewise, with non-kin associations interactions that were not satisfying increased the risk of cognitive decline, although to a much lesser extent over the same period (Fratiglioni et al., 2000). As such, measures of objective social isolation that are based on the structure of the

network, such as frequency of contact, distance from family, and friends or size, do not allow the exploration of the benefit or type of interactions that occurs and the consequences of that. This further supports the findings in the current study, where the measure of perceived social loneliness influenced cognitive performance and the measure of objective social isolation did not, as the measure of social loneliness is capturing the older person's perception of the quality of their network.

However, if this is the case then we also need to explain why some studies *have* reported a relationship between objective factors of the social network, such as interaction with non-kin social ties and participation in social activities, and cognition (Conroy et al., 2010; Giles, Anstey, Walker, & Luszcz, 2012; Golden, Conroy, & Lawlor, 2009).

Objective social isolation indicators may have a differential influence on cognition.

In the present study scores on the PANT were not correlated with cognitive performance. The PANT uses a composite scale that includes a variety of indicators of social isolation such as interactions with family members, non-kin and participation in social activities. However, research is suggesting that different indicators of objective social isolation may have a stronger affect on cognition in the ageing than others. To illustrate, a 15-year longitudinal study of older persons, social network type and memory reported that older adults with a greater number of non-kin relationships had better memory performance than those with a greater number of kin relationships (Giles et al., 2012). Social networks were categorised into children, relatives, confidantes and friends. The friendship network type was the only one out of the four categories to predict memory performance. Giles et al. (2012) pointed out the importance of disaggregating kin and non-kin networks. Likewise, in a review of the literature on the social network of the older adult and cognition, Hertzog, Kramer, Wilson and Lindenberger (2009) noted that studies that have focused on social activity and participation as a separate measure of social network structure consistently yielded positive results. This was unlike studies that used combined indicators of social networks such as size, frequency of contact, activities or participation. The latter showed mixed results. This suggests that the combination of network data dilutes the effects of social engagement on cognition. As the PANT combines different indicators of the social network, the possible effect of social engagement on

cognition may be weakened. Furthermore, in a study examining the underlying dimensions of the PANT, Golden et al. (2009) found was that there were two network dimensions that the PANT captured: family (distance from and contact with relatives) and social engagement, which were uncorrelated. In regard to the PANT's locally integrated network type, better physical and mental health and cognitive performance, were related only to the social engagement component, regardless of the level of family support or family integration. Social engagement, not family integration or support, was identified as the "active ingredient" of network types in the PANT, be it attendance at social events or interactions with friends and neighbours. If a measure had been used in the present study to capture the various indicators as separate components, and if these were analysed, a different pattern of relationships may have been revealed. This may have provided more insight into the potential mechanisms of how objective social isolation may influence cognition.

Research signals that some aspects of the structural features of social networks, such as levels of social engagement or greater interactions with non-kin than kin, have greater potential for being a protective factor for cognition than others. However, the exact mechanisms are not yet well understood. Once again, a return to proposed explanations of social loneliness and a reassessment of the role of the cognitive reserve hypothesis as a mechanism may be useful. The cognitive reserve hypothesis holds that social activity, like education, presents complex cognitive challenges and leads to increased mental stimulation, which may preserve cognitive reserve, improve compensation in response to damaged areas of the brain through the likes of Alzheimer's pathology, and increase resilience in neuronal injury (Scarmeas & Stern, 2003). Older adults who are more socially engaged or involved with a diverse network than their peers may experience more variety, novelty and challenges in their daily interactions (Holtzman et al., 2004). This may arise from the activities themselves, or from the handling of information or interaction complexities that arise, such as the scheduling of dates, using different ways of communicating, and anticipation of how others will respond, thereby stimulating both social cognition and general cognition processes. Support for the benefit of social engagement comes 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 produces

structural and functional changes in the brain (Scarmeas & Stern, 2003; van Praag et al., 2000). However, it must be acknowledge that social engagement and specifically participation in social activities, such as playing chess or belonging to a book club, would possibly require a more broader level of cognitive activity than a social interaction between two people. At this stage it is still speculative of the role 'social interactions' have on brain plasticity. In general, there is a lack of studies that have looked at both social engagement and social interactions on brain plasticity, and there are key gaps in the research to be filled, such as comparing the relative stimulating properties of cognitive activities like regular social interactions, participating in a hobby, reading books on both the structural aspects of the brain and cognitive reserve.

Future research requirements.

Overall, the area of objective social isolation is still in flux, as studies that use specific indicators of objective social isolation find associations with cognition, whereas a study like the current one, which uses a combination of indicators, does not. However, the findings from the present study do contribute to the body of literature. For example the present study highlights the need for future research in the area of objective social isolation and cognition. Also brought to attention is the need to develop and use measures that offer opportunity to capture specific components/qualities of the social network. These are both the evaluative characteristics (e.g., satisfaction with interactions, perception of quality of interactions, or perceived healthiness of the network) and quantitative (e.g., frequency of contact, size of network, and participation in activities"). Future research that is designed to provide an understanding of all those components working together can ultimately clarify the relationships that types of social isolation have with cognition. It is not possible to conclude that only perceived social isolation influences cognition, nor can it be ruled out that objective measures of isolation do not play a part.

Perceived Social Support

Although no answers can be offered for the question of why a lack of perceived social support does not appear to influence cognition, this area is worthy of a discussion. The lack of association found between perceived social support and cognition, although consistent across studies (Eisele et al., 2012), is at odds with the theoretical literature on the possible relationship between a lack of social support and cognition. For example, it

was hypothesised that perceived social support buffers stress in anxiety-provoking situations, and thereby reduces the effect of stress on the activation of hypothalamic-pituitary-adrenal axis of the central nervous system and ultimately on cognition (Berkman et al., 2000; Fratiglioni et al., 2004). Research has shown that prolonged and repeated exposure to increased secretion of stress hormones, such as cortisol, can result in allostatic load (Heuser & Lammers, 2003). The pathophysiological consequences of allostatic load are increased blood pressure, increased risk of coronary heart disease and damage to the hippocampus (Lupien, McEwen, Gunnar, & Heim, 2009; McEwen, 2002; McEwen & Seeman, 1999). The hippocampus is involved in memory and learning processes (Pillai & Verghese, 2009). A four-year longitudinal study reported that older people who had a significant increase in cortisol levels over the years and high current basal cortisol levels were impaired on tasks measuring explicit memory and selective attention compared to aged control subjects presenting either decreasing cortisol levels with years or increasing cortisol levels with moderate current basal cortisol levels (Lupien et al., 1994).

The results in the current study do not support the hypothesis that low perceived social support influences cognition. It may be that the relationship between perceived social support and cognition is stronger for the oldest old adults, or for adults who have extremely limited social support and therefore lack a buffer for stress, or who have chronic stressful events in their life. Available research does not provide the answers to those questions yet, so future research will be crucial to understanding this relationship. What the literature does establish is that low levels of perceived social support have been linked to a lack of educational attainment, cardiovascular disease, depression, and changes to marital status (Everson-Rose & Lewis, 2005; Mickelson & Kubzansky, 2003; Prince, Harwood, Blizard, Thomas, & Mann, 1997; Uchino, 2006). For example, previous studies indicate that a lack of perceived social support is strongly linked to depression (Hawthorne, 2008; Prince et al., 1997). Controlling for depression might have mediated the relationship between perceived social support and cognition. In addition, since low social support has consistently been linked with both the development and progression of cardiovascular disease (Uchino et al., 1996), the inclusion of heart disease as a covariate may have reduced another possible mediated relationship between social support and cognition. Therefore, perceived social support relationships with cognition may be dependent on health and medical factors, unlike social loneliness, which still contributed

some variance to cognitive performance even after the other variables such as depression, heart disease and education were controlled for.

Another point to consider concerning the apparent lack of relationship between perceived social support and cognition is that in the present study the mean was a score of 79 out of the available 96 on the Social Provision Scale. This provides some evidence that the majority of the participants perceived they had the ability to access reasonable support. Furthermore, there was a higher proportion of tertiary educated adults and people in relationships than in the New Zealand general population, thus making it more likely that these participants had the potential ability and knowledge to access different forms of support than the general population. Also, New Zealand is fairly unique with regard to two factors regarding tangible support compared to other counties. First, the New Zealand government provides a superannuation payment to all those aged over 65 years, and secondly there is universal medical coverage for all citizens (Towers et al., 2012). This ability to have security of financial income in older age and low-cost health care may provide a form of social support that is not found in other countries.

Finally, using an encompassing measure of social support, which was the sum of all the scores of the six provisions, may have obscured any differences between the different provisions and their relationships with cognition. Although the findings from the current study suggest that perceived lack of social support is the one form of social isolation that appears to have a minimal influence on cognition, the fact that the relationship is firmly established in the literature suggests that it is too early to conclude that perceived social isolation does not influence cognition.

Summary of Question Two: Which Form of Social Isolation has the Strongest Influence on Cognition?

Social loneliness appears to have a negative influence on cognition in ageing. Potential explanations of the fact that social loneliness exhibited the strongest association with cognition of all of the forms of social isolation examined have been provided. One explanation drew on the concept of cognitive reserve and the idea that socially lonely people may not benefit from cognitive stimulation that results from social interaction. The other proposal investigated whether socially lonely people may 'drain' their cognitive resources in an effort to suppress or regulate the emotional experience of loneliness. Both

are speculative but nevertheless plausible. The fact that *emotional* loneliness did not influence cognition in the present study provided further support for both proposed ideas, as the source of emotional loneliness is not due to deficits in the wider social network, nor due to feelings of being social excluded or disconnected. Objective social isolation and perceived social support did not exhibit a relationship with cognition, a finding that was not surprising due to similar results in previous studies. A better understanding of how (or whether) objective social isolation and perceived social support may influence cognition requires further research – too many question regarding mediating and moderating relationships with other key variables remain unanswered. It is worth noting that in a discussion on objective measures of social isolation and loneliness and their influence on health, Waite, McClintock, Cornwell, Patterson, and Kim (2008) commented that although both objective and perceived social isolation are risk factors for poorer levels of health, they may affect health through different mechanisms. It was suggested that structural and functional aspects of social networks such as size, participation and support appear to affect health through modification of health-related behaviours, whereas loneliness operates through emotional and psychological mechanisms (Cornwell & Waite, 2009; Shankar et al., 2011). For cognitive health, existing research does not provide such a clear delineation of mechanisms. Cognitive performance may be dependent on some structural factors such as participation and engagement, or on emotional and psychological mechanisms, or a combination of the two. That is a question that the current study is unable to answer and thus a question for future research. What the current study *does* suggest is that for the older adult the feeling of social loneliness is of such strength that it can compromise cognitive performance regardless of the reality.

Limitations

Several limitations for the present thesis include issues that relate to the design of the study, measurements used, sample measurement issues, sample with the design of the study.

Design limitations.

Cross-sectional data were used in the present study, which precludes any analysis of direction of causation. Therefore, further research is required in order to discover if the associations between social isolation and cognition are causal. Furthermore, longitudinal

research would be beneficial to determine if there is a stable relationship between social isolation and cognitive performance in the ageing population or whether, as one ages, the influence of different forms of social isolation on cognition changes. Likewise, the current study was unable to capture whether recent perceptions of one's social network and interactions reflect a past pattern of social or emotional loneliness, or levels of integration of perceived support, or if the present situation was novel. The study captured a moment in time, and as such how the older adult perceived their social world around them at that present time. This study was unable to prove any attribution of causality either.

It is important to note that the directional associations in the analysis, that is, social isolation influences cognition may have reverse associations. The present study examined the influence of social isolation on cognition in older adults. Yet, the reverse may also be possible: a decline in cognitive ability influences perceptions of the social network. If cognitive impairment is found to increase the sense of social isolation, or even objective social isolation, the result would be significant in itself, given the already known detrimental effects of impaired cognitive performance on daily life.

Although many covariates were taken into consideration, it was impossible to control for all possible confounding variables, and unknown confounds may have obscured effects. For example, physical activity is regarded as a possible protective factor for cognitive performance in the ageing (Plassman et al., 2010). The current study had a measure of physical functioning, but not a control for the amount of exercise the participants were getting on a regular basis. The current study was unable to control for the possible influence of regular physical activity on cognition. Research has shown that people who are lonely participate less in physical activities and over time become more physically inactive than non-lonely people (Hawkley et al., 2009). Therefore, quantity of physical activity may have mediated the results between social loneliness and cognition. Personality traits form another area that would benefit from examination in future studies of social isolation and cognition. Do the people who perceive themselves as socially isolated, or who are objectively isolated, have traits that predispose them to neuroticism and thereby to evaluate themselves and their relationships in a more negative light? Or are they introverted? And does this alter or modify the association between forms of social loneliness and cognition?

Measurements.

As the current study relies on a self-report format questionnaire to assess social isolation, a potential problem is social desirability bias. Individuals may be unwilling or unable to report accurately on topics they deem sensitive such as a lack of social interactions, low levels of support from family and friends, and few or no close friends. This potential problem was minimised because the NZLSA study offered anonymity and confidentiality to those who partook in the study, thereby limiting the motives associated with socially desirable responses. In addition, the de Jong Gierveld Loneliness Scale is an indirect approach to measuring loneliness as it does not include the word lonely. Likewise the Social Provision Scale does not include direct questioning on 'social support'. However, although the problem of social desirability bias may be minimised by not including specific words of loneliness or social support, respondents' answers may still reflect a desire to appear more socially connected or supported than they are.

It is also important to acknowledge that the ACE-R was originally designed as a clinical screening test for dementia. The use of the ACE-R and its subscales as a measure of cognition differed from the majority of reported studies, which used extensive neuropsychological batteries of tests. For example in the studies by Wilson et al. (2007) and O'Luanaigh et al (2011), respectively, 20 and 16 different cognitive tests were administered covering a variety of domains. However, the ACE-R has proven itself as useful tool for both clinical and research work as documented by its use in over 150 clinical and research centres (Mioshi et al., 2006).

As with the ACE-R there are also limitations that are highlighted with the PANT. Although it is regarded as valid for assessing the older adult's social network, the objective measure of social network used in the current study, the PANT was limited in scope as it focuses only on friends within the neighbourhood. It does not allow for the inclusion of distance friendships that may provide support and companionship. With changes in the way we communicate through the use of technology, it may be of interest to include measures that evaluate these forms of contact with distanced friends.

Sample.

The current sample exhibited some demographic differences from general older population in New Zealand such as being relatively more educated, more likely to be in full-time employment, and to have a relationship which cautions against over-generalising the research findings. In addition, the population had a narrow age range (from 65-84) and consisted only of community dwellers. It therefore excluded older adults who were institutionalised or in residential care for the ageing, which may have tempered the results of all the social isolation measures.

Implications of the Study

The present study explored the relationship between different forms of social isolation and cognition. It extends the existing literature on social isolation and cognition in the ageing in two ways. First, the current study was novel in its approach to loneliness and cognition by using a measure of both emotional and social loneliness. By the inclusion of social loneliness as a separate form of social isolation, it highlighted that different forms of loneliness have differential patterns of association with cognition. This has important implications, as Masi, Chen, Hawkley and Cacioppo (2011) suggested that although loneliness can be categorised according to different factors (e.g., social and emotional loneliness) which overlap in relation to antecedents and consequence, it can be operationalised as a unidimensional construct due to high correlations between those factors. The results of the current study suggested that emotional and social loneliness are distinct concepts, and that they have different patterns of association with cognitive performance in the older adult. In turn, the current study established that it would be more appropriate to separate the different factors of loneliness, particularly in trying to identify and address risk factors for cognition. Also, the results support the general call for distinguishing various forms of perceived social isolation when studying loneliness in the older adult (Drennan et al., 2008; Heylen, 2010).

One other area the study highlighted was the fact that some cognitive tasks are taken to be useful measures of one cognitive domain by one set of researchers and a different cognitive domain by another research group. This was illustrated by the verbal fluency test which, in the study by Wilson et al. (2007), was considered to be a measure of semantic memory, whereas in the ACE-R it is a measure of executive function. Fluency tests were described by Estes (as cited in Lezak, 2004) as excellent measures to determine

how participants organise their thinking, enabling output in terms of clusters of meaningfully related words. Yet, they also involve short-term memory. Whether verbal fluency is a measure of executive function or semantic memory (or both) is beyond the scope of the present study. However, meaningful comparisons between studies on social isolation and cognition require the ability to compare the cognitive tests used in order to ensure they are indeed assessing the targeted cognitive functions. Similarly, literature on social isolation employs a variety of terms and indicators to operationalise the different forms of social isolation. For research to move forward consistency of measures is needed. In addition, a means of measuring specific components of the social network is required, such as social engagement or social loneliness, instead of adopting a coarser 'aggregation approach'. The examination of four different types of social isolation in the current study was an important starting point for future research, as it has raised awareness of the relationship between social isolation and cognition as dependent on the form of social isolation.

Summary of Explanations

In summary, since antiquity the need for humans to be socially connected has been of the utmost importance. Painful feelings of loneliness prompted our ancestors to recognise that their connections were weakening within the social group and to respond to this threat quickly (MacDonald & Leary, 2005). Although we live in modern times, the need to feel connected is as strong as ever and the implication of experiencing social loneliness appears to be detrimental to older adults' cognitive performance. The findings from the present study indicate that different forms of social isolation have a different relationship with cognition. The results also suggested that social isolation may influence some cognitive domains to a greater extent than others.

The present study's results are consistent with studies of satisfaction with network and perception of quality of support from networks and the older adult's social relationships (Amieva et al., 2010; Cacioppo & Hawkley, 2009; Conroy et al., 2010; O'Luanaigh et al., 2011). Yet, the different findings between emotional and social loneliness and cognition constitute the most important finding of the current study in contributing to the literature on social isolation and cognition. However, the mechanisms that underpin the social loneliness-cognition relationship were not identified the present study. Future research needs to closely examine the relationship between social

loneliness, the actual reality of the older adult's world and cognition. This could determine whether social loneliness is caused by a lack of social interactions and whether, in consequence, older adults lack the cognitive stimulation that can maintain their cognitive reserve. Alternatively, by providing support for the drain-on-cognitive-resources explanation, it may show that the perception and experience of feeling socially isolated is all that is needed to lower cognitive performance in the older adult. Overall, the current study's results suggest that aspects of the social environment may be a potential factor in the cognitive ageing process. In examining a selected range of those aspects, such as interactions with network members, how one perceives their network, and how they perceived the future availability of support, the present study highlights the importance of determining what type of social isolation is detrimental to cognition. These findings are especially important as loneliness, and other forms of social isolation, appear to increase during the ageing process (Dykstra et al., 2005; Jylha, 2004).

The present study's findings provide an opportunity for those working with older adults to pay close attention to social loneliness, and not just social isolation. To illustrate, many families may try to reduce a sense of isolation for the older relative by surrounding them with family or placing the older adult in a residential home. Actions like this may alter social isolation in an objective sense but may not reduce feelings of social loneliness if the older adult is unable to develop friendships and bond with their peers. Intervention for reduction of social loneliness in the ageing may need to focus more on skills and training that enable older adults to develop friendships with each other rather than just having older adults attend events, and assume friendships will always automatically develop. Thus, the present study's findings are useful for a wide variety of stakeholders involved with older people in that they highlight the negative effects social loneliness might have on the older adults' cognition. This provides us with the opportunity to target social loneliness effectively, not just in older people but throughout society. Prevention is likely to be a far more effective strategy than one aimed at 'curing' the negative cognitive effects of long-term social isolation.

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