Life-style Factors related to Working Memory Performance in Older Adults

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I, Mary Anne Sinovich, declare that this research report is my own work. It is being submitted for the degree of Masters of Arts by Research Dissertation at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Signed: MAS

On this, the 11 **day of** October**, 2019.**

Abstract

This study explored the relationship between the life-style choices of neurotypically healthy older adults and the effect this has on their working memory functionality. Life-style advantages for cognitive functioning have been comprehensibly discussed in the literature but little is known about which of the life-style factors extends to working memory capacity and functioning in older adults, or about the long- term effect of various life-style choices people make on their old age. With a sample of 50 cognitively healthy, older South African adults, this study used a cross-sectional, correlational design in which numerous of the life-style factors: socio-economic status, level of education, occupational status, stimulating leisure activities, sleep, diet, medical conditions and interventions, social interactions, physical exercise and bilingualism were examined for any relationship to working memory. Cognitive health was assessed using the MoCA and working memory was tested using the Weschler Digit Span, Arithmetic and Symbol Span tests. There were no significant relationships found between any of the life-style factors chosen for this study and working memory, other than being single/married and the Symbol Span test scores. The small sample size of only 50 participants meant that the study may have been statistically underpowered to achieve the anticipated outcomes and is acknowledged as a limitation of the study. In addition, a homogenous socio-economic status level among the participants weighed negatively against finding variations in the results and is a further limitation.

Keywords: cognitively healthy older adults, executive function, working memory, cognitive reserve, life-style factors

Dedication

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Introduction

The worlds' population is ageing and South Africa represents one of the most rapidly ageing countries in Africa. Data from UNECA indicates that the African over-sixty population group will increase from 50 million to 200 million by 2050, while South Africa's elderly population will double by 2050 (World Health Organisation, 2016), from 7.7 percent of the population to 15.4 percent. The societal importance of understanding the nature of developmental changes in later life, and how to mitigate against these, grows as the world's population undergoes this unprecedented age distribution, and increasing longevity results in growing challenges, such as a greater need for health care, for old-age support and for better pension schemes. This is exacerbated in South Africa by the HIV-Aids burden and cost of ARVs.

Old age is typically associated with chronic diseases, and especially with reduced cognitive health (Dall, Gallo & Churbarti, 2013) and, in recent decades, due somewhat to prolonged life expectancy, age related diseases, including those of the brain, have increased dramatically (Bherer, Erickson & Liu-Ambrose, 2013). Healthy cognitive functioning is integral to effective living and finding ways to mitigate against cognitive ageing and severe deterioration is imperative (Blazer, Yaffe & Liverman, 2015) as the effects of cognitive ageing not only have an impact on the individual, but also on his/her family, community, social services and health services. Firstly, it is important to examine what is already known about cognitive ageing and assess the validity of the existing research. It is then important to identify the workable elements of this research as this will enable societies to identify and promote actions that older adults themselves can employ to stay cognitively fit. It is imperative to identify interventions that are cost effective, accessible to the majority of people and offer a promise of neurological health to our elderly. To achieve this, it is necessary to uncover the causes of this decline in cognitive ability and consider factors that may contribute to healthy ageing.

This study concentrates on one aspect of this decline; namely that of working memory, an executive function. Executive functioning refers to the complex cognitive processes associated with the pre-frontal cortex and is responsible for the cognitive control of behaviour. It encompasses planning, inhibitory control, attentional flexibility and working memory, elements that underlie flexible, goal directed behaviour and that link to mentalization (Diamond, 2013). Decline in all of the executive functions in old age is well documented, with working memory showing the greatest sensitivity to age related decline (Armstrong, Gallant, Li & Wong, 2017). Working memory is the holding and manipulating of a small amount of information in mind for a few seconds, using primarily the dorsolateral pre-fontal cortex (Baddeley, 2000; Diamond, 2013; Hofmann, Schmeichel & Baddeley, 2012). It is a foundational cognitive function that underpins all other executive functions, emotional functions and social interactions (Alloway, 2013; Diamond, 2013). Therefore, any decline in working memory beyond what is typical for one's age has far-reaching implications on a person's life, and indeed on his/her family, who often become his/her carers.

To date, the plethora of research on the decline in working memory in older adults has focussed on the decline in the areas of processing speed, multi-tasking, focus and distraction, and fluid intelligence. These fall into the following two areas: the medical or physiological deterioration of the brain and neural networks themselves; and the social and psychological aspects caused by feelings of decline in usefulness after retirement and of feelings that one is not meaningfully contributing to society any longer. The focus of this research, however, was on investigating whether there is any relationship between life-style factors and working memory functioning in healthy adults over the age of 65, as there is mounting evidence to show that life-style choices have either a protective or detrimental role in how well people age, both physically and cognitively (Bherer, 2015). Consequently, this research investigated whether there is any relationship between selected demographic factors, such as level of education, occupation status, engagement in stimulating social and leisure activities, sleep patterns, bilingualism, physical exercise and diet, socio-economic status, medical conditions and medication regimes, and working memory functioning. Understanding these relationships could foster better social, medical and educational initiatives that in turn could ensure a healthier old age population of the future.

Theoretical Review

The breadth of evidence and majority of research into life-style factors and their detrimental or protective influences on cognitive ability in older adults has fallen into the sphere of the concept of cognitive reserve. Before discussing this research and relating it to the South African context, as well as to working memory, the focal outcome of this study, it is necessary to contextualise this study with a theoretical explanation and to provide a theoretical framework for the research. The variable of interest is working memory: how it relates to executive functioning and how it is positioned in the area of cognitive reserve. A lack of understanding of the relationships among psychological concepts can lead to misguided research questions, (Bennett & Hacker, 2003) and so care must be given to explanations of how the concepts relate to each other. This will be clarified in the following section.

Defining executive function, working memory and cognitive reserve

Working memory is the ability to store and process a small amount of verbal and visuo-spatial information in the short-term (Baddeley, 2000; Baddeley & Hitch, 1974) and is an integral component of executive functioning over a range of tasks (Alloway, 2013). It is a system of components that holds the above-mentioned limited information only temporarily, and in a heightened state of availability, for use in ongoing cognitive processes (Adams, Nguyen & Cowan, 2018). Research exploring working memory functioning therefore needs to be structured on a sound understanding of executive function. Executive function as a construct has received enormous attention in the past three decades (Alvarez & Emory, 2006). It is a broad attentional construct that is thought to be involved in goal directed, higher level cognitive functioning and has a domain-general, supervisory role, as well as being responsible for self-regulation. It is a neuropsychological construct that gives a description of higher- level cognition, but it can also be viewed at the level of dissociable executive processes and early theorists of cognitive psychology (Baddeley & Hitch, 1974; Miyake, Friedman, Witzki, Howerter & Wager, 2000) adapted the construct to models that were metaphors of attentional control, underlining executive function, or attention, as a foundational concept in cognition. The dissociable executive functioning processes identified by Miyake and Friedman (2012) thus refer to 1) cognitive inhibitory control, 2) cognitive flexibility and 3) working memory, and include tasks that measure these processes. These tasks include planning, problem solving and adaptive behaviour in response to any changes in the environment (Vaughan & Giovanello, 2010). When performing a complex task, it is the role of the executive functions to co-ordinate all the cognitive processes required to complete the task successfully and, traditionally, the range of tasks considered include inhibitory control, working memory, attentional control, switching or shifting between rules and sets, flexibility and monitoring, and conflict management (Miyake et al., 2000; Riggs, Shin, Unger, Spruijt-Metz & Pentz, 2014).

The construct of executive function arose from studies of patients with pre-frontal lobe damage who showed an inability to plan functional, goal-directed behaviours and, as a result, executive function is believed to depend on the optimal functioning of the cortical regions and networks in the prefrontal lobe. This posits the concept as an anatomical rather than a functional one and raises both philosophical and empirical concerns: philosophically it is difficult to identify one with the other and empirically, they are dissociable although closely related. Miyake et al. (2000) found such a schism, in that their research found prefrontal areas that were active during non-executive tasks and non-pre-frontal areas which were also active during executive functioning. There is also clear evidence of executive processes such as task switching (Verhaeghen & Cerella, 2002), attentional switching and updating (Vaughan & Giovanello, 2008) and processing speed (Nittrouer, Lowenstein, Wucinich & Moberly, 2016; Salthouse, 1996; Schneider, Daneman & Murphy, 2005) showing dissociation in older adults (Logie & Morris, 2015). This debate is also relevant as executive functioning is implicated in theories of ageing, largely because neuroimaging studies have shown that cognitive processes that are dependent on prefrontal cortex areas tend to be among the first to decline in old age, and this supports the anatomical theory of age-related decline in cognitive functioning (Nittrouer et al., 2016).

A critical debate between the differing theories of executive function is whether executive function has a single underlying mechanism or whether it should be conceptualised as separate components (Best & Miller, 2010; Miyake et al., 2000). Prominent among the theories responding to this debate is Miyake and Friedman's (2012) Unity and Diversity model of executive function in which the researchers made a much cited, and widely accepted, distinction between three related components of executive function, namely:

working memory/updating, inhibitory control, and shifting/cognitive flexibility; components chosen because of their tractability or potential to be measured by simple tasks, and because they were considered to be of a foundational nature. They proposed that all other executive functions would result from a combination of the three listed (Miyake et al., 2000). Updating is defined as the continuous monitoring of and addition to/deletion from working memory, while inhibitory control is defined as the capacity to override responses that are dominant in a situation, even automatic or prepotent responses where necessary. Shifting, or cognitive flexibility, is the ability to move between different tasks, sets of rules and mental states, sometimes called active inhibition in the literature. In recent years however, a fourth component has been added to this list. In studies of bilingual individuals, which will be discussed in detail later in this review, researchers found that some individuals are better than others at shifting or cognitive flexibility (Abutalebi & Green, 2008; Costa, Hernandez, Costa-Faidella & Sebastian-Galles, 2009; Teubner-Rhodes, Mishler, Corbette, Andreu, Sanz-Torrent, Trueswell & Novick, 2016). Teubner-Rhodes et al. (2016), described this ability as conflict-monitoring and resolution, and posit it as better conflict detection and the ability to make more flexible adjustments between conflict and non-conflict decisions. Conflict-monitoring and resolution is thus usually added as a fourth component to the Unity and Diversity model in recent literature (Logie & Cowan, 2015).

Fundamental to this theory is the idea that individual differences in executive functioning reflect a common underlying skill, which represents the unity aspect of the theory. However, there is also diversity of each component in that they can be separate measures, so aspects of the four executive functions are related, yet each remains a distinct entity as well (Miyake & Friedman, 2012).

Discussed above, the four dissociative processes of executive function are inhibitory control, shifting or cognitive flexibility, conflict monitoring and resolution, and updating or working memory, which places the concept of working memory within the executive function system. Because working memory is a holding mechanism within executive functioning that deals with the conscious mind and with all temporary memory functions outside of conscious awareness (Logie & Morris, 2015), it is essential for doing the work of cognition. It is needed for our understanding of problems and for the finding of their solutions and it is for this reason that it warrants individual attention in this study, separate from inhibitory control and cognitive flexibility. The many models of working memory, the focus of this research, now need to be understood in the broader context of executive function. Although inhibitory control has been well researched (Logie & Cowan, 2015; Miyake & Friedman, 2012; Adams et al., 2018), of the four components of this model, working memory (updating) has been the most researched (Logie & Cowan, 2015). As mentioned earlier, many theorists conceptualise working memory, a limited capacity system or holding mechanism that is responsible for briefly storing and processing a small amount of information for short term cognitive tasks, as an executive function. Together with cognitive flexibility and inhibitory control of automatized behaviours, working memory underpins the frontal-lobe controlled processes of reasoning, planning, attention, inhibition, decision making and social interaction (Alloway, 2013; Baddeley, 2000). Working memory also allows for the manipulation of stored information, that is, the organization of the memories and information we keep in our memory banks (Cowan, 2008). Memory issues form a large part of the challenges of the later stages of life (Bherer et al., 2013; Cooke & Ancoli-Isreal, 2012; Cotman, 2002), with processing speed, an element of working memory, among the first to decline in older adults (Hung, Ross, Boockvar & Sui, 2011). As such, an understanding of how working memory operates is essential.

Since the 1960s, numerous models have been put forward to describe how working memory functions, both from a cognitive and neuro-anatomical perspective. The term itself was first used by Miller (1956) when he described memory that is used in the planning for, and executing of, actions. The subsequent incorporation of working memory as a processing aspect of memory in models of executive function points to the close relationship between working memory and executive function. It is this processing aspect that is the distinguishing (and often controversial) feature, separating working memory from short-term memory, concepts which are often confused or used interchangeably. Our short – term memory passively stores small amounts of information for a short period of time. Working memory exists as a theoretically defined system which uses short-term memory to help it store information, but it is further capable of manipulating this information to aid learning, cognition and daily functioning (Baddeley, 2000). Different models of working memory conceptualise this relationship differently, and working memory's relation to long-term memory, and some of these models, is unpacked below.

The working memory model of Baddeley and Hitch (1974) was developed in response to the idea at the time that short term memory was a static store of phonological data. The original Baddeley and Hitch model comprised three components: namely, the central executive (responsible for co-ordinating the actions of the other two components and for allocating attention to differing tasks), the phonological loop, which stores and processes auditory information and which can be sub-divided into the phonological store and articulatory rehearsal system, and the visuo-spatial sketchpad, which is responsible for processing visual and spatial information fed directly through to it by perception or indirectly through a visual image. The central executive, therefore, controls and directs information between the other two 'slave systems', while working memory co-ordinates higher level cognitive processes (Baddeley, 2000).

Working with Baddeley, Logie (2015, 2016) further added to this model by questioning the relation between the visual and spatial components of working memory and dividing the visual sketchpad into the visual cache and the inner scribe. The visual cache was described as a passive storage component that is subject to decay and interference by new visual information and the inner scribe as an active rehearsal component that stores spatial codes and prevents both visual and spatial codes from decaying. This conceptualisation was in response to the question of the relationship between long-term memory and working memory which had previously been overlooked in favour of short-term memory. Logie proposed that incoming stimuli activate representatives in long-term memory and that the products of these activations are then transferred to the multiple components of working memory via a temporary visual buffer (the visual cache), via a buffer for retaining movement sequences (the inner scribe) as well as via the phonological loop. The buffers then work with the executive components of working memory, and with the activated long-term memory, to support task performance. (Other researchers have argued that working memory is not a separate system that interacts with long-term memory but is merely activated long-term memory (Cowan, 2008; Ericsson & Kintsch, 1995) and these contradictions will be discussed in the next sub-section).

In 2000, Baddeley himself added a fourth component to his model, that of the episodic buffer, a link between working memory and long-term memory that binds information into a unitary episodic representation (Baddeley, 2000). This hub also acts as a pathway along which short-term memories are moved to long-term memory. The latter component is relevant here from a theoretical point of view only: it was not measured in the current study as there is debate about its conceptualisation and measurement (Logie & Cowan, 2015).

Although Baddeley’s (2000) model has been generally well accepted by memory experts, it has acknowledged weaknesses. For example, the components of the model seem too simple and do not explain the full range of daily memory functions. The model does not tell us, for example, whether there is information that is prone to decay rather than to interference from other input, and vice versa. Also, the central executive is generally poorly understood and its exact components are not explained. It is not clear if it is the same as executive functioning or is a separate aspect. Evidence points to the fact that the central executive may not be one unitary construct (Miyake & Friedman, 2012). However, without knowing how it is subdivided, one cannot develop a hypothesis to test the model further. Lastly, researchers do not yet fully understand how the episodic buffer combines information from the other parts of the model or from short or long-term memory (Cowan, 2008; Logie & Cowan, 2015).

Despite these criticisms, the theory has remained widely accepted for a few fundamental reasons. Unlike most other models, Baddeley's (2000) working memory model explains both the storage and the processing of both verbal and visuospatial information; it highlights separate functions and subsystems, so new predictions can be outlined for research; there is neuroscience/biological evidence to support the model, even though it was developed as a purely cognitive model with no links to neurobiology, it is able to account for the memory performance of brain-damaged patients (Cowan, Rouder, Blume & Saults, 2012; Li, Christ, & Cowan, 2014; Rose, LaRocque, Riggall, Gosseries, Starrett, Meyering & Postle, 2016) and the model integrates many research findings (Adams et al., 2018; Friedman & Miyake, 2017; Logie & Cowan, 2015). For example, most models place importance on verbal rehearsal for transferring information into long-term memory, but the evidence from our day-to-day lives does not back this up (Adams et al., 2018). In Baddeley's (2000) working memory model, verbal rehearsal is noted as only one way to encode and store information. It points to other routes (such as the visuo-spatial sketchpad and the episodic buffer) to encoding and is therefore more realistic (Adams et al., 2018; Cowan, 2008; Logie & Morris, 2015).

It is important to recognise that in addition to Baddeley’s working memory model, there are other alternative, feasible models of working memory. For example, Cowan (1988; 2008) disagreed with Baddeley’s conceptualisation of working memory and proposed that working memory is not separate from either short or long- term memory; he developed the idea of working memory as activated long-term memory. Cowan’s (2002) model stresses the importance of attention and its role in working memory processes. He divided memory into two embedded levels: the first level comprises long-term representations and there is no limit to how many of these can be activated at any given time. The second level refers to the focus of attention and is central to the theory. The focus here is limited and can hold up to only four of the activated representations or chunks of the information at a time (Cowan, 2008).

Cowan (2008) cited substantial evidence for his notion of a focus of attention that supports a temporary memory for these four items at any one time, but Logie (2016) points out that there is no clear indication of what precisely controls this focus of attention in Cowan’s model, the homunculus question that remains a recurring critique of this theory. He states that although Cowan originally argued for a unitary view of memory, rather than a view that working memory is separate from long-term memory, he altered his model to admit peripheral systems (notably the phonological loop) that appeared to aid verbal rehearsal without drawing on the focus of attention (Cowan, Saults & Blume, 2014). Logie (2016) states that although Cowan sees the focus of attention as the core of working memory function, his peripheral systems are completely compatible with the phonological loop in Baddeley’s model.

Oberauer (2002) added a third component to Cowan’s (2002) model. This is an even narrower focus of attention that forms part of the four-element focus described by Cowan (2008) but which is capable of holding only one chunk of information at a time. When a complicated activity is required, the attentional component selects only one part of the process, completes this chunk, then shifts the attentional focus to the next part of the process, continuing until all the parts of the activity have been processed (Oberauer, 2002). Both of these models were challenged by other theorists who believe that the observed capacity is in fact a fluid resource that can be spread thinly over all items in a series (Ma, Husain & Bays, 2014). Current researchers suggest that after three items, the fluid resource would become so thin that it would be of no use, and this remains a critique of this model.

A different model of working memory was proposed by Ericsson and Kintsch (1995) who argued that the five- plus- or- minus- two working capacity notion, proposed by Miller (1956) was inadequate and that everyday tasks, such as reading, require a very skilled memory that would reach its capacity within a few seconds if it could only hold, on average, seven chunks of information. They consequently also suggested a long-term working memory model in which they proposed that experts in various domains (for example chess players) are able to encode information into long-term memory far more rapidly than was proposed by traditional models, including the chunking method. The core of their long-term working memory theory is that encoding occurs through a retrieval structure or through knowledge-based associations connecting items to other long-term patterns and schemas. One stores information in long-term memory through two mechanisms: elaboration of long-term memory patterns and schemas, and the use of retrieval structures (Gobet, 2000). This model proposes that people need to keep very little in their working memory because they store most of what they read in their long-term memory and then link current reading and processing with these memories through a system of retrieval structures. The few chunks of memory in working memory are used only as cues to activate these retrieval structures (Ericsson & Kintsch, 1995). Distinguishing it from most other theories is that it proposes that experts develop, through practice and study, retrieval structures for each task domain and that these are then generalisable across a wide variety of tasks. This generalisation is refuted by evidence however and empirical support for the theory as a whole is much weaker than proposed by the Ericsson and Kintsch and are major critiques of this model (Gobet, 2000).

A further model conceives of working memory as the intersection of attention and memory (Shipstead, Harrison & Engle, 2015). In 1999, Engle and his colleagues developed and implemented working memory span tests and their results led them to conclude that these instruments were not only a measure of memory but also of the capacity to control attention, when memory is required, along with controlling distraction and interference. From this they developed the concept of executive attention, or working memory capacity (Engle, 2002), and this is similar to the models of executive function proposed by Miyake (2000) and Cowan (2002) in that it is domain-general and limited in capacity. However, Engle (2002) posits working memory as a continuous construct, not one composed of distinct and differing components. His model, unlike those of Baddeley (2000) and Miyake et al. (2012), is a clear departure from the others in that it is meant to include executive function as an independent system. The critique of this model is that it is based on memory span tests and while these are considered successful in predicting performance of a wide range of metal tasks, there is mounting evidence that these tests are not good measures of working memory (Logie H. , 2016). Rather they measure the ability to inhibit the impact of distraction and to avoid its impact on memory which relates more to Baddeley's (2000) sense of executive functioning. Engle and his colleagues (1999) view the memory measure in these tests as activated long-term memory, and it is feared they are measuring this rather than working memory itself.

The approaches to working memory are even more varied and bountiful than those few represented in this brief review. While influential and not without value, these models have not gained the traction that Baddeley's (2000) component model achieved. His theory, which has a large body of empirical data supporting it, has been cited almost 10 000 times in scientific literature and is still vigorously debated (Logie & Cowan, 2015). It remains one of the most comprehensive models as it includes all the different stimuli (verbal, visual- spatial) and all the different types of processing skills (maintenance, storage, manipulation) required to understand working memory and its application in cognitive psychology.

Measurements of working memory need to incorporate at least two aspects: a short-term memory component, as participants need to store some information in their minds, and a processing component that compels the participant to manipulate information in some form while preventing the participant from rehearsing or refreshing information already in memory. Most take the form of verbal or visuospatial tasks. For example, in the former, participants may be asked to recall five words in the correct sequence and in the latter, participants are involved in some judgement based on visual information, all in a timed scenario. Measures of working memory based on tasks of this sort have been found to correlate well with intellectual aptitude and fluid intelligence (Cowan, 2008) and have significance for this study as fluid intelligence is one of the factors that declines in older age (Nittrouer et al., 2016).

The working memory theories referenced above demonstrate that executive function processes are involved in working memory functioning (Alloway, 2013; Miyake & Friedman, 2012; Nittrouer et al., 2016; Logie & Cowan, 2015; Vaughan & Giovanello, 2010; Verhaeghen & Cerella, 2002). However, the debate about the unity or diversity of executive function has an implication for our understanding of working memory as, if a unified executive function model is followed, then working memory is not seen as a distinct component and would need to be viewed as the outcome of general executive processes acting on short term memory stores. Conversely, if a diverse conception of executive function is accepted, then working memory would be included as a component of executive function, as do Miyake et al. (2000). This latter understanding is complicated by the fact that some of the working memory models have components which are almost identical to components of executive function in other models, seen as the central executive in Baddeley and Hitch's (1974) model and as the executive system in Miyake et al.'s (2000) model. This speaks to the danger of accepting a simple hierarchical understanding of the two concepts of working memory and executive function and it is necessary to clarify whether theorists consider their working memory model a subsystem of executive function or as a stand- alone system which employs assistance from certain processes in the independent executive function system. It is clear that Baddeley's (2000) working memory model is not independent of executive function (Baddeley, 2000) but it is not clear whether it is a subsystem of the broader system. This is one of the critiques of Baddeley's model. Since this study is based on the assumption that working memory is separable from the other executive functions, Miyake and Friedman's (2000) model has been chosen to underpin this investigation.

This debate on the unity or diversity of executive function and the placement of working memory within this system, is further exacerbated by the theoretical concept of cognitive reserve, an understanding of which is essential to an understanding of cognitive functioning in healthy aging. Before defining cognitive reserve, it is important to establish a baseline for healthy aging and to understand that mild declines in memory, psychomotor ability, speed of processing, and concentration are part of normal aging (Bherer et al., 2013). Vance and Crowe (2006) highlight three theories of normal cognitive aging, which differ according to the resource that is believed to be most essential for maintaining healthy cognitive functioning in old age. These are the Processing Speed Hypothesis (Salthouse, 1996), the Executive Functioning Hypothesis (West, 1996) and the Common Cause Hypothesis (Baltes & Lindenberger, 1997). In the first, Salthouse suggested that the speed at which the central nervous system processes information could influence not only the quantity but also the quality of memory performance. The speed at which cognitive functions are processed slows with age, due to central nervous system decline, and cognitive efficiency therefore declines accordingly. Also, because cognitive speed is slowed, processed information has more time to decay and this affects the quality of the information being transmitted between the cognitive processes. In the Executive Functioning model, it is the deterioration of the prefrontal lobes that accounts for the decline in cognitive ability in older individuals and, as these regions control executive tasks such as planning and goal- directed behaviours, cognitive efficiency and functioning in daily life are especially affected. The third model, the Common Cause hypothesis model, relates to the age-related changes that occur in the physiological integrity of the brain itself, physical health, and that of the nervous system as a whole. In this model, it is posited that declines in mental functioning are related to declines in physical, motor and sensory functioning. This association supports the theory that general physiological integrity impacts all neuro-dependent functioning, despite differences of function in the unique components making up the nervous system (Olderbak, Hildebrandt & Wilhelm, 2015).

Understanding neuro-typical aging as outlined by the theories discussed above does not explain the variances in the effects of these declines found across the spectrum of older adults and cognitive reserve is the hypothetical construct employed in the field to obtain further information about diverse patterns of cognitive aging. Therefore, in order to link the theories of normal cognitive aging to my investigation of how life-style factors relate to healthy aging, an understanding of cognitive reserve is necessary.

Cognitive reserve describes the capacity of the adult brain to mitigate and cope with the effects of neurodegenerative processes and to minimise the clinical symptoms of dementia (Sobral, Pestana & Paul, 2014). The concept arose from the realisation of brain reserve: the earliest reference to this concept was by Katzman in 1988 (Katzman, Terry, De Teresa, Brown, Davies, Fuld et al., 1988). In a seminal study, the researchers noted that individuals with high levels of post-mortem Alzheimer’s disease pathology had not behaved in ways that demonstrated this level of the disease in their everyday life. Investigating this, they found almost double the number of large pyramidal neurons in the neocortex of the deceased, in comparison with individuals who showed clinical symptoms of Alzheimer’s Disease. They concluded that people who, at the outset of the disease, had larger brains with more neurons and synapses, had a greater reserve and that this gave these sufferers a genetically endowed advantage against showing the signs of Alzheimer’s Disease (Katzman et al., 1988). This was the first conception of cognitive reserve and has become known as the passive model as it depends on genetic architecture.

A number of challenges to operationalizing this model arose. Firstly, intracranial volume and head circumferences, used as proxies for brain volume, proved unsuccessful as no association with incidence of dementia was shown. Secondly, the neurocentric proposition implies that brain reserve is non-modifiable and becomes fixed after the onset of adulthood. Epidemiological and clinical evidence suggested the opposite however and again, measurement issues came to the fore (Valenzuela, 2008). From this need for a methodology to retrospectively estimate an older individual’s neuronal numbers came an alternative conceptualization of brain reserve, moving from the hard, mechanical version of brain reserve to one that emphasized the way in which we use our brains in old age that mitigates cognitive processing. A notion closer to neurocomputational flexibility was considered, looking at how individuals develop a range of cognitive strategies to overcome brain pathology (Valenzuela, 2008) and the second model of cognitive reserve was born. This model is often called the active model, or the behavioural brain reserve model, and, in contrast to the first model that focuses on brain morphology, the active model of cognitive reserve focused on the role of experiences such as level of education, occupational status, and participation in cognitively stimulating leisure activities. These experiences were argued to build cognitive reserve, and thus to offer a defence against the effects of brain pathology, allowing the affected individual to cope by enlisting compensatory processes (Opdebeeck, Martyr & Clare, 2016).

Yaakov Stern has been the most prominent exponent of the concept of cognitive reserve over the last three decades, which he defines as “the ability to optimise or maximise performance through differential recruitment of brain networks” (Stern, 2002, p.451). It is the ability of an individual to make flexible and efficient use of their available brain reserve when performing cognitive tasks, resulting in those with higher cognitive reserve having better clinical outcomes for any level of pathology or brain reserve (Steffener & Stern, 2011). This explains why some individuals, who displayed considerable post-mortem brain damage, did not have observable symptoms of cognitive decline while alive (Opdebeeck et al., 2016). Importantly, he later noted that cognitive reserve is not only relevant to the onset of dementia, but that it is also relevant to normal aging, as it seems to enable individuals to cope more effectively with the typical age-related brain changes (Steffener & Stern, 2011). Researchers believe this result is developed out of a greater proliferation and connection of neurons in the brain, in a sense having more ‘hardware’, which provides a protection against the attacks of cognitive decline, and that these are acquired from a lifetime of exposure to education and cognitively stimulating experiences (Opdebeeck et al, 2016; Stern, Zarahn, Habeck, Holtzer, Rakitin, Kumar, Flynn, Steffener & Brown, 2013; Vance & Crowe, 2006). When cognitive decline occurs, the greater proliferation and connection of neurons compensate by using alternative connections and problem-solving strategies, thus delaying symptoms of dementia (Stern, 2002; Vance & Crowe, 2006). This can be compared to having refined ‘software’ underpinning the hardware’s ability to function effectively and points to an interdependence of the passive and active models.

Neuroplasticity has been suggested as the mechanism through which the concept of cognitive reserve functions (Vance & Crowe, 2006). Even when cognitive function has begun to decline, the brain retains some plasticity (Calero, Navorro-Gonzalez & Munoz-Manzano, 2007). “Neuroplasticity refers to the potential for morphological changes in the brain to occur as an organism is exposed to stimuli that promote learning or challenge existing neuronal connection to adapt” (Vance & Crowe, 2006, p.64). It is the relationship between this challenge to existing cognitive structures and the resultant adaption, that points to the potential role of neuroplasticity in cognitive reserve (Vance & Crowe, 2006). In order to understand this, Vance and Crowe (2006) looked to the results from a research project conducted by Rosenzweig, Bennett and Diamond (1964 - 1972). These researchers conducted a series of 16 rat experiments, over a ten-year period, to address the effect of experience on the brain and to investigate the effects on rats’ brain growth and chemistry when placed in an extremely stimulating and socially exciting environment, compared to the effects from an impoverished environment. Great variations in brain structure were found: the cerebral cortex, the part of the brain that responds to experience and which is responsible for learning, memory and movement, as well as all sensory input of the enriched rats was significantly thicker and heavier than that of the impoverished rats. While there was no difference found in the number of brain neurons in the two groups of rats, the enriched rats produced much larger neurons, and the synapses in the enriched rats’ brains were 50% larger than those in the impoverished rats. From this, the researchers extrapolated that if humans were engaged in intellectually stimulating and novel experiences, then at least cognitive maintenance, if not cognitive improvement, would occur (Vance & Crowe, 2006).

Vance and Crowe (2006) then suggested a four- level model of neuroplasticity and cognitive reserve to explain how cognitive reserve growth, or shrinkage, is achieved through neuroplasticity. The aim of this model was to show the links between physiological health, morphological changes, cognitive reserve, mitigating factors and neuroplasticity, with the assumption being that cognitive reserve can be increased through modifying factors that influence the process of neuroplasticity and morphological change advantageously and that everyday functioning can thus be maintained for longer periods in later life (Vance & Crowe, 2006). The first level in this model represents the mitigating factors that mediate cognitive reserve, such as modifiable health factors, education, social support, positive affect, stimulating activities and novel experiences and cognitive training; the second level represents the connection between physiological health and neuroplasticity (poor health is correlated with poor neuroplasticity); the third level speaks to the connection between morphological changes and neuroplasticity; and the last level refers to the connection between morphological changes and cognitive reserve, where a positive morphological change is related to an increase in cognitive reserve. The model stresses the permeability between each level, where a change in one level exerts a change upon another. For example, if physiological health improves, the other levels have a greater propensity to expand and, conversely, if neuroplasticity decreases, then the potential for morphological changes also decreases (Vance & Crowe, 2006). It is the synergy of combining all the levels that is needed to promote cognitive health well into older adulthood.

Conceptually then, Vance and Crowe (2006) hypothesized that cognitive reserve and performance are dynamic and can be altered. Secondly, they proposed that it is easier to increase cognitive reserve in individuals with good neuroplasticity, and lastly, that there are a variety of mitigating factors travelling along six different paths that determine the maintenance of cognitive reserve (Vance & Crowe, 2006). The six paths are: 1. Modifiable health factors; 2. Education; 3. Social support; 4. Positive affect; 5. Stimulating activities and novel experiences; and 6; Cognitive training. These pathways and factors will be elucidated in the next sub-section.

As a concept, cognitive reserve is important as it is not only relevant to the onset of dementia but also to natural brain changes occurring as people age (Opdebeeck et al., 2016).

However, it is also a concept that cannot be measured directly. Experiences that are believed to increase cognitive reserve are thus used as proxies to measure its effect on cognitive ageing (Lenehan, Summers & Saunders, 2016; Opdebeeck et al., 2016) and this is not without issue in the literature. Using only one proxy measure of cognitive reserve does not produce a holistic picture as cognitive reserve is a fluid construct that results from a combination of many, varied activities and experiences over an individual's life and it is doubtful that any one proxy alone can ever constitute a complete measure (Nucci, Mapelli & Mondini, 2012; Sanchez Rodriguez, Torrellas, Vallejo & Mellado, 2011). Additionally, because an augmentation of experiences is needed to find any sort of score, it is difficult to assess cognitive reserve in young people and this research is more salient with older adults.

Although there are measures such as the Life Effectiveness Questionnaire (LEQ) (Valenzuela & Sachdev, 2007) and the Cognitive Reserve Index questionnaire (CRIq) (Nucci et al., 2011) which combine factors to reach a standardized index of an older individual's overall score, there are debates about which factors should be included; for example, whether verbal IQ should be included in the indexes or whether this is a measure of cognition rather than reserve (Opdebeeck et al., 2016). Many cross-sectional studies have assessed proxy measures of cognitive reserve however, mostly using the proxies of educational level, occupational status and cognitively stimulating leisure activities, with mixed results (Bartres-Faz, Catteneo, Solana, Tormos & Pascual-Leone, 2018; Boller, Mellah, Ducharme-Laliberte & Belleville, 2017; Leneham et al., 2015; Rzezak, Squqrzoni, Duran et al., 2015; Valenzuela & Sachdev, 2006; Zahodne, Stern & Manly, 2015). Discrepances in results have hindered consensus and this is mainly with regard to the patterns of association between the different cognitive domains, making it unclear how the proxy measures relate to the different domains of cognition in non-clinical samples. This challenge will be explored later in this report when the proxies of education, occupation status and stimulating activities are discussed in detail.

Life-style factors associated with cognitive functioning in older adults

Using Vance and Crowe's (2006) four level model of neuroplasticity and cognitive reserve as a framework for discussion, it is necessary to link the concept of cognitive reserve to the life-style factors that are at the centre of this investigation. To begin with, it is important to establish a developmental progression of cognitive functioning in older adults in order to build an accurate picture of age- related cognitive decline, as much of the research discussed here investigates whether this age-related decline can be moderated by certain life-style factors. Generally, in healthy adults, memory begins to decline in the late fifties (Bherer et al., 2013). A person's ability to find the right word, referred to as anomia, and their speed in processing information, are often the first to deteriorate, due to a loss of white matter integrity, especially after 70 years of age (Cooke & Ancoli-Isreal, 2012). Next, working memory, the ability to maintain and consciously manipulate information, becomes sensitive to the aging process. Much of this is due to the fact that the structural and functional brain mechanisms, ie., internal factors, change: for example, brain volume decreases after 50, there is neuron death and a reduction in the number of synaptic spines and functional synapses, and the volume of the hippocampus, implicated in memory and learning, decreases (Bherer et al., 2013). Added to this, cerebral metabolism alters with age and there is a reduced metabolic rate for glucose, oxygen and blood flow (Bherer et al., 2013). A 37% reduction in the size of the thalamus, which is involved with sensory integration and the sleep-wake cycle, also occurs in normal aging (Junior & de Almondes, 2016). These aspects of decline are considered neurotypical and the appropriate use of norms for older adults when measuring working memory will indicate whether or not a participant's functioning is typical for their age or not. In summary, even early in the aging process, the global changes of cerebral atrophy, ventricular enlargement and hippocampal atrophy are evident in most, but not all, individuals. Underlying this are the pathological causes of cognitive decline, in that there is loss of synapses, neurons, neurochemicals, and neuro-networks. Importantly though, although this age-related neurological and functional decline has been defined and accepted as the norm, impairment to quality of life is not inevitable. There are many examples of elderly individuals who do not display any impairments at all and the belief that cognitive decline is inevitable has been dispelled by the many who maintain intact intellectual levels and avoid dementia.

There is a prevailing idea that working memory ability may be a key process in maintaining intellectual levels and healthy cognitive functioning in older age and that it may be that older individuals with a strong working memory are the ones who avoid impairment or dementia (Adams, Nguyen & Cowan, 2018; Baltes & Lindenberger, 1997; Bherer et al., 2015). The question remains, however, about what builds and maintains a healthy working memory in adults over sixty and if it is life-style choices rather than genetics that achieves this solid base. Having discussed the various models of executive function, working memory and cognitive reserve, and the theoretical links between them, in the previous sub-section, the remainder of this chapter will review the relevant empirical evidence surrounding the life-style factors that may moderate, protect or be detrimental to cognitive health in neurotypical older adults, in the hope of shedding some light on the question above. The first section will review the research of the factors traditionally considered pertinent, that of the roles of education, occupation and stimulating social and leisure activities in maintaining non-demented cognitive status. These are linked to the first level of Vance and Crowes' (2006) four level model of neuroplasticity. Other demographic factors such as age, gender, marital status and socio-economic status will also be briefly considered in this section. Two further sections will focus on studies that review the other factors now thought to influence cognition, namely, sleep; diet and nutrition; physical activity; medical conditions and medication regimes; the bilingual advantage; and stereotypes and ageism. In order to establish the necessary body of knowledge, evidence for the effects of each factor is presented and reviewed independently but this in no way contradicts the conclusion established previously that all factors are inter-related and that the effects are realistically the result of combinations of factors. In each section, the effects of these factors on executive function and cognitive reserve is considered, with special attention paid, where possible, to the effect on working memory, the focal outcome of this study.

Education, occupation and stimulating leisure and social activities.

The first level of Vance and Crowe's (2006) model of neuroplasticity is mitigating factors that mediate cognitive reserve, and the six paths they highlight are 1. modifiable health factors, 2. Education, 3. Social support; 4. Positive affect, 5. Stimulating activities and novel experiences and 6. Cognitive training. Largely influenced by the cognitive reserve theorists, research on factors influencing the differences in cognitive and brain function in older adults has been dominated by the study of education, occupation, and social and leisure activities (Bartres-Faz et al., 2018) and the literature on these factors will be reviewed first. Recently, however, the field has expanded and the new umbrella terms of resilience and life-style have entered the field (Bartres-Faz et al., 2018). These conceptual terms acknowledge further cognitive components as relevant to this type of research and factors such as bilingualism, physical activity, sleep and diet and nutrition, have become factors of interest, along with certain mental and physical practices, such as meditation and dance, and how these interact with an individual's genetic make-up and the modifiable risk factors he/she practises (Bartres-Faz et al., 2018). These factors will be discussed in the following sub-sections. Psychological factors such as personality traits, coping strategies and attitude towards life are also included under this new umbrella and several studies have considered the impact of the psychological aspects of these experiences on healthy cognitive aging (Bartres-Faz et al., 2018). There is solid evidence for their part in cognitive reserve/debt but they are beyond the scope of this study and have been thus been excluded from this report. Only a brief review of the stereotype threat effect and ageism is included later in this section as it pertains to qualitative observations made during the assessment phase of this project.

In the current study, education was investigated as a fundamental factor in the study of age-related cognitive decline and it is probably the single most important predictor of cognitive viability in old age (Rzezak et al., 2015). Educational attainment is defined as the acquisition and constant exercising of higher order cognitive processes such as executive function, language, memory and attention (Rzezak et al., 2015). It is proposed that individual differences in brain capacity, flexibility and efficiency underpin task performance in these specific cognitive domains and that education is the vehicle for the achievement of such.

Between 1985 and 2006, there was robust evidence that adults with higher levels of educational attainment showed better performance on cognitive testing and were at lower risk of dementia or age-related cognitive loss. That is, they performed better across the range of cognitive tasks needed in daily living. This concept, that education could be a protective factor against the cognitive aging processes, was first posited in the dementia literature, where, as discussed in the subsection on cognitive reserve, it was found that patients with Alzheimer's Disease with higher levels of education attainment, and with similar cognitive symptomatology, endured more brain pathology than their counterparts with lower education attainments (Rzezak et al., 2015). Cognitive reserve theory states that this is due to the individuals involved possessing a finer ability to recruit and utilise specific brain regions and so to cope with more brain pathology before clinical signs become observable, and not that the pathology is not present. Education appears to increase or improve cognitive functioning by fostering the development of new cognitive strategies (Leneham et al., 2015) even though the rate of decline is not decreased and is similar in both the higher and lower groups of educational attainment. This supports the passive model of cognitive reserve (Valenzuela & Sachdev, 2006).

In 2006, in a review of previous research, Valenzuela and Sachdev (2006), found that older people, with a high level of education, had as much as a 47% decrease in the likelihood of suffering dementia than those with low levels of education. Brayne, Ince and Keage (2010), in their review, confirmed that education had a dose-related effect on reducing the risk of dementia and found that lower levels of education were associated with a more rapid decline in measures of processing speed and verbal memory. However, many discrepancies found their way into the evidence, and it was necessary to consider the potential roles of universally improved educational systems, cohort differences, baseline cognitive differences, methodological issues and data analysis on these findings. Modern, sophisticated techniques could perhaps better cope with cohort variances, missing data and unevenly spaced assessment time points that beleaguer longitudinal research into ageing. Leneham et al., (2015), set out to investigate the association between the level of education and cognitive performance, and whether it could be stated categorically that education moderates the trajectory of age-related cognitive decline. Out of the 358 studies considered, they found ten studies that met the criteria to best answer these questions and their conclusion was that education did not, in fact, moderate age-associated cognitive decline. Their conclusions were that the studies which found this had poor methodologies and that only evidence supporting the passive theory of cognitive reserve was evident. They found that most research had been conducted on the highly educated and results for the lower levels of education were extrapolated from this. Consequently, further investigation is needed to gauge if lower levels of education are associated with greater rates of age-associated cognitive decline. People who have had a good education simply continue to perform at a higher level than those less educated and thus, education merely delays the onset of impairment. In this sense, education is beneficial, but there is no clear evidence of a decrease in the rate of decline over time that can be directly attributed to levels of education, possibly because education is tied to so many other factors such as socio-economic status; decision-making processes; health care; social interactions and leisure activities. Lastly, they suggest that a cohort effect may also help explain the lack of association: the groups researched in most cases shared common characteristics, as do most groups of the same age, and had mostly faced similar historical and social events, as in the same kind of educational system. Shared temporal experience or common life experience is often responsible for muddied outcomes (Leneham et al., 2015).

In light of this growing debate, Zahodne et al. (2015), looked at whether early-life educational experiences affect later life cognitive functioning but widened the sample to a racially, ethnically and educationally diverse population. They used nine years of education as their baseline and found that individuals with this level of education were associated with higher cognitive levels and slower cognitive decline in older age and that education had a positive effect in this group. However, in individuals who had more than nine years of education, the slower cognitive decline was fully mediated by income rather than education itself. They concluded that early education, up to eight years, promoted areas of development (such as language) during a sensitive period of childhood and that these skills would protect against cognitive decline in later life, independent of income. However, education beyond nine years was associated with earning potential and that this factor influenced late-life cognitive health through many, non-mutually exclusive pathways, such as access to health care, good nutrition, a healthy habitat and better employment opportunities.

The move away from the education effect found in the majority of earlier research could be due to the more advanced statistical and analytic techniques of this decade but the advent of magnetic resonance imaging (MRI) and functional MRI techniques (fMRI) could add a further dimension to the debate and again swing the thinking. In a recent study directly related to this research project, Boller et al. (2017) examined the relationship between educational attainment, regional grey matter volume and functional working memory related brain activation in older adults. They found a positive correlation between years of education and cortical grey matter volume in the frontal and parietal lobes and that volume loss related to age was larger in the low-education group than in the high-education group. The education by age interaction was also significant for working memory task related activity in the left superior, middle and medial frontal gyri and fMRI activation increased with age in those with a higher education. However, no significant correlation was found between regions that are structurally related to education and those that are functionally related to education and age. They concluded that education has a protective effect on cortical volume and that brain regions involved in working memory show more activation in individuals with a higher education attainment than in lower educated groups (Boller et al., 2017). Results of this kind point to the importance of further measurement and investigation into the potential relationship between education and working memory and for this reason, it was included as a factor in this study.

Another path on level one of Vance and Crowe's (2006) model is that of occupational activity. This factor was investigated in the current study as, like education, it is a commonly used proxy for measuring cognitive reserve (Smart, Gow & Deary, 2014). Research in this area strongly suggests that a more stimulating life-style, one which includes a more complex work environment, is associated with better cognitive outcomes in older age (Smart et al., 2014). The direct influence of the environment and activities on the brain, like the effect of education, remains a controversial topic, in particular with regard to the nature of the causal relationship. Because there is a lack of temporal depth of cross-sectional studies on this aspect, the issue of causal directionality persists. For example, does participation in stimulating occupational and leisure activities promote better cognitive performance or is it that more cognitively capable individuals tend to participate in more social, physical and intellectual activities? Findings from animal experiments suggest that rats raised in enriched environments have greater dendrite density in the hippocampus than those raised in poorer environments (Diamond, 2013). Winocur (2013) showed that the brain modifications found in these rats also affected their cognitive abilities in that they performed better on memory tests than those from the deprived environments. Human studies echo these results and show positive associations between participation in social, intellectual, occupational and physical activities and positive performances on cognitive tasks. Conversely, people in low-complexity occupations have been shown to be at risk for age-related cognitive decline and social isolation and an unstimulating life-style seems to accelerate the decline (Berkman, Glass, Brissette & Seeman, 2000). It appears to be a circular influence, in that professional activity increases social interaction and a sense of self-efficacy, which in turn contributes to the maintenance of cognitive reserve. However, education and socio-economic status play a role here too: d'Orsi, Xavier, Steptoe, de Oliviera, Ramos, Ornel, Demakakos & Marmot (2014), investigated whether socio-economic, demographic and life-style factors could predict impairments in daily living activities. Daily living activities include activities such as shopping, managing money, taking medications, making phonecalls and sending messages and are related to executive functions such as planning, working memory, problem solving, inhibition, multi-tasking, verbal reasoning and mental flexibility. These researchers found that those with a higher socio-economic status, a better quality of life, paid work, digital literacy and increased physical activity had significantly lower risk of daily living task impairment and that these were modifiable factors. Low socio-economic status, on the other hand, was a predictor of incidences of daily living task impairment (d'Orsi et al., 2014).

Smart et al. (2014) examined the association between the complexity of main lifetime occupation and cognitive performance in later life and found results that indicated that it was complexity of work, with both people and data, that was associated with better cognitive performance at age 70. Their study controlled for early -life cognitive ability, years of education and deprivation and found that individuals who had complex and stimulating occupations, inclusive of social interaction, benefitted in later life cognitive performance, independently of lifelong stability of cognitive ability. They infer reciprocal effects between level of ability and occupational complexity but stop short of inferring causation as this is not possible. Their findings, however, stress the importance of social interaction and the protective effect of stimulating environments and activities on cognitive ability. In the plethora of recent research into the assocaition between social engagement and cognitive aging, it has been postulated that greater levels of both social engagement and support are associated with a lower risk of cognitive impairment in old age (Crooks, Lubben, Petitti & Chiu, 2008; Derksen, Duff, Weldon, Zhang, Zamba, Tranel & Denberg, 2015).

Path six of Vance and Crowe's model (2006), that of social support, is also indicated in cognitive health and relates closely to occupational activity. Derksen et al. (2015) examined whether a learning situation that emphasized collaborative social interaction would help older persons overcome age-related learning and memory problems and enable them to perform similarly to younger people. Memory tests were administered prior to playing a game and, as expected, the older group showed poorer memory abilities relative to the younger group. Old and young worked together in the game and while the older group initially performed less well than their younger team mates, the performance of the older group improved and became statistically equal to that of the younger group as the game progressed. The researchers inferred that a learning environment of collaborative social interaction may attenuate the typical memory impairments associated with old age (Derksen et al., 2015). In interactions that mimic real -life communications, where there is interaction with familiar people over a period of time, free-flowing conversation, facial expressions and gestures, older people are encouraged to engage in goal-directed tasks and to problem solve collaboratively. This allows flexibility to enter the interactions, and this has a positive effect on memory. This can be linked to complexity of occupation, where constant interaction and collaboration takes place, and points to a reciprocal relationship between cognitive functioning and occupational activity (Derksen et al., 2015).

The results of the previous study also indicate how difficult, if not impossible, it is to separate out the effects of education, occupation and social economic status when reviewing the effects of these factors on cognitive health and aging. Eloborating on this, a 2013 study of 25 000 older Europeans set out to investigate the relationship between the concept of general mental and physical activity, both professional and leisure, and cognitive functioning. The researchers collected data using SHARE (Survey on Health, Aging And Retirement in Europe) which anaylses several dimensions simultaneously, including both mental health activity and physical activity (Adam, Bonsang, Grotz & Perelman, 2013). They included the variables of age and level of educational attainment as well as several indicators of activity. These included professional activity that was represented by different categories such as being active (employed), inactive for 0-4 years/ more than 15 years, never worked, retired but working part-time. They also included variables of non-professional activities such as helping friends/family, doing voluntary charity work, taking care of others, going to sports or social clubs, attending training courses, or taking part in church or political organisations. Physical activity was divided into variables that described the frequency of the activity and the vigorousness of the tasks. The researchers also controlled for health status. Their analysis revealed that all types of activities are positively related to cognitive functioning in older people, in varying degrees. There was a positive association with education and they found most types of occupational activity to be associated with cognitive reserve, with those individuals who continue to work into old age showing better cognitive performance. There was a significant positive relationship between cognitive performance and engagement in new and stimulating activities, like attending training courses, and a moderate association between cognitive functioning and some non-professional activities like going to clubs, participating in religious or political organizations or doing charity work. The study highlights a significant positive relationship with both moderate and vigorous physical activity. Living alone, a variable associated with less engaged activity as there is no one to cook/shop/watch television/play games with, and which is associated with loneliness, was negatively associated with cognitive functioning. This underscores the importance of social interaction and affiliation for the elderly and points to social isolation and social disengagement as risk factors for cognitive decline and impairment. For example, Alzheimeir disease is more likely to occur if one leads a lonely life (Cacioppo & Capitanio, 2014; Wilson, Krueger, Arnold, Schneider, Kelly, Barnes et al., 2007). It was presumed that the participants selected for the current study would be predominately retirement community dwellers and that the majority of them would live alone, so the factors of marital status and living independently or in a retirement village were included in the investigation. Finding pertinent evidence in the literature as to the effects of these conditions was therefore deemed essential.

While the results in the previous study confirm the relationship between activity and cognitive functioning, it does not address the question of whether a decrease in cognitive functioning is the consequence of a reduction in activity or vice versa and this is a common limitation of any research into factors that influence cognitive reserve.

The value of Adam et al.'s (2013) study is the emphasis on the relationship between cognitive functioning and retirement, which brings great change to an individual's life-style. The study found, as would be expected, that if a person engaged in more cognitively stimulating activities and interactions during his/her professional life compared with after retirement age, there would be a decline in cognitive functioning after retirement. Cognitive scores in the elderly are better in countries where retirement age is higher (as in Sweden where individuals are eligible for retirement benefits at 65 years) as opposed to countries where the retirement age is 60 (for example, France), suggesting that retirement decreases cognitive functioning and points to a significant negative causal impact (Adam et al., 2013).

Consequently, the associations between traditionally used proxy measures of cognitive reserve and cognition in the elderly are reasonably well researched and documented. However, the strength of the associations between these measures varies across studies and cognitive domains, and there is some discrepancy with regard to the patterns of association with different cognitive domains. Opdebeeck et al. (2016) conducted a meta-analysis to assess the relationship between cognitive reserve and multiple cognitive domains (memory, executive function, visuospatial ability and language) in healthy older people. Specifically, they set out to assess how the different proxy measures of cognitive reserve were used by different researchers. They questioned whether these researchers used only a single proxy measure, or a combination of proxy measures, in their studies, and what similarities, if any, there were between the proxies and their associations with cognitive functioning in older adults. They chose the three most utilized proxies, namely level of education, occupational level and engagement in stimulating activities ie., those that involve cognitive effort like reading, attending classes, doing crosswords and Sudoku and playing games like bridge, and found that all three proxy measures had modest positive associations with cognitive functioning in healthy older adults, but that their relationships with the different cognitive domains varied. For example, Opdebeeck et al. (2016) found that there is a strong correlation between level of education and memory (Angel, Fay, Bouazzaoui, Baudouin & Isingrini, 2010; Lee, Lee & Yang 2012) and a moderate correlation between level of education and executive function was found in other studies (Jefferson, Gibbons, Rentz, Carvalho, Manly, Bennet & Jones, 2011; Lee et al., 2012; Mueller, Raymond & Yochin, 2013). The main difficulty with using education as a proxy is that the nature, intensity and content of educational systems differ across nationality and social groups. Occupational status and cognitive function yielded a weak correlation with memory (Leung et al., 2010) to a moderate correlation with executive function (Foubert-Samier, Catheline, Amieva, Dilharreguy, Helmer, Allard & Dartigues, 2012) suggesting that the relationship of this proxy measure with cognitive function also varies according to the domain been tapped into. The proxy of cognitively stimulating activities provided discrepancies as well in relation to the different domains of cognitive functioning: for example, there were non-significant correlations between engagement in cognitively stimulating activities and memory (Lin, Friedman, Quinn, Chen & Mapstone, 2012) but moderately significant correlations between this proxy measure and executive function (Eskes, Longman, Brown, McMorris, Langdon, Hogan & Poulin, 2010; Lin et al., 2012). Occupational and cognitive activities displayed the most variation across the different cognitive domains. These conclusions suggest that one cannot use only one proxy measure to provide an accurate picture of cognitive reserve as it is a fluid construct resulting from a combination of experiences and activities over the course of one's life. Rather, the typically used proxy measures of cognitive reserve seem to share an underlying process, while each may additionally provide a unique contribution to cognitive reserve.

Cognitive training is path six of level one of Vance and Crowe's (2006) model of neuroplasticity. In the same way that other stimulating intellectual and social activities contribute to cognitive reserve, bilingualism is considered a cognitively demanding condition and enriching activity and an advantage to cognitive health in older age, as well as a contributing factor to cognitive reserve (Craik, Bialystok & Freedman, 2010). In a country where people are predominately multilingual, this factor should be considered when looking for factors that could delay or prevent cognitive decline.

For a long time, it was believed that bilingualism had negative consequences for the developing mind but an extensive body of literature has falsified this and there is growing evidence that bilinguals demonstrate better executive control than monolinguals matched on different demographic factors (Guzman-Velez & Tranel, 2015). The positive effects of exposure to more than one language on cognitive functioning across the lifespan is well documented (Baum & Titone, 2014; Bialystok, 2009: Craik et al., 2010; Hitchley & Klein, 2011; Valian, 2015) and lifelong bilingualism is evidenced as strongly associated with the delayed diagnosis of dementia and Alzheimer disease (Craik et al., 2010; Gobet, 2000; Guzman-Velez & Tranel, 2015) and is believed to exert a positive effect on the executive control system (Bialystok, 2009). The executive functions of monitoring and task-switching, attention, anticipation, inhibitory control and conflict management all seem to be positively affected by being bi-or multilingual and higher levels of cognitive control are found in bilinguals (Guzman-Velez & Tranel, 2015; Luk, Bialystok, Craik & Grady, 2011). This improved executive control is known as the bilingual advantage and most of the studies referenced here suggest that the skills employed by bilinguals when managing language generalise to other non-verbal domains and there is evidence that the bilingual advantage exists for working memory itself (Calvo, Ibanez & Garcia, 2016; Engel de Abrau, 2011; Morales, Calvo & Bialystok, 2013; Wodniecka, Craik, Luo & Bialystok, 2010). The bilingual advantage is observed in all age groups, from children to old adults, suggesting that this enhanced executive control is present throughout the life span, even after controlling for confounding variables and disadvantaged environments and upbringings (Bialystok, Craik, Klein & Viswanathan, 2004). Further, there is evidence that knowing and using more than two languages is particularly protective against the onset of cognitive decline.

Several reasons have been put forward for the bilingual advantage and neuroplasticity is posited as the most probable (Guzman-Velez & Tranel, 2015). The brain is flexible and sensitive to experience, and influences in the environment can modify its physical structure and functional organization. The brain adapts itself to the environment cognitively (by developing new task-related pathways) and neuronally (by synapse strengthening, synaptogenesis and neurogenesis) and these changes are due to developmental processes, learning and experience. Learning a second or new language, and using at least two languages daily, is cognitively demanding and this leaves a trace on the brain. It is reasoned that the continuous mental activity in which bilinguals engage builds both brain and cognitive reserve, and this protects against some of the detrimental effects of cognitive disease and ageing (Bialystok et al., 2004; Craik, Bialystok & Freedman, 2010; Guzman-Velez & Tranel, 2015). As intimated to above, task switching and inhibition are two processes that have been extensively studied with regard to bilingualism. Because bilinguals have to switch from one language to another, depending on context, task-switching processes are both developed and well-practised; and the inhibition control model put forward to explain how both languages are controlled by the bilingual individual proposes that both languages are activated simultaneously in bilinguals, which necessitates the speaker to attend to one language while inhibiting the other. Added to this, available literature suggests that a bilingual speaker's neural networks are more flexible and less susceptible to disruption than his counterpart (Gold, Kim, Johnson, Kryscio & Smith, 2013). Bilinguals have been shown to have enhanced performance in non-verbal tasks that require these skills and they usually perform better than monolinguals in any tasks that require attention, anticipation, task-switching and inhibition (Bialystok et al., 2012). Overall, the literature seems to point to the fact that lifelong bilinguals can make more efficient use of the brain's resources and that they have a greater critical threshold, and that this is why they maintain cognitive functioning even in the presense of brain pathology.

The claims that bilingualism fosters cognitive reserve and delays the onset of demetia are not uncontroversial; there are many criticisms about the methodologies employed in this research; there are many studies that have failed to replicate the results discussed above; and it is difficult to say for certain that the brain differences between bilingulas and monolinguals directly imply increased cognitive reserve (Calvo, Garcia, Manoiloff & Ibanez, 2015). However it may be that not all the claims are valid, this is an important factor in any investigation of this kind and needs to be considered in this project.

Other life-style factors mitigating cognitive health.

While level of educational attainment, occupational status and participation in cognitively stimulating activities have traditionally been used as the proxies for measuring cognitive reserve, other factors are now also taken into account when considering good predictors of cognitive health in older age. The second level of Vance and Crowe's (2006) four level model of neuroplasticity represents the connection between physiological health and neuroplasticity and these factors were included in the investigation as they are were considered important indicators of cognitive health. Medical professionals warn us that a healthy body leads to a healthy mind and that healthy diets, regular exercise, good sleep and control of typical mid-life health issue like diabetes and cholesterol should be started early in life to guard against dementia in later life. There is no known cure for ageing: but there are many cases of successful aging, both cognitive and physical, and the need to find the perfect life-style that would protect an individual against cognitive decline is essential. This sub-section will look to the literature for empirical evidence of the effects of the above factors on healthy cognitive ageing.

Sleep was included in this study as it is known to be important for memory consolidation. Advanced technology and the use of polysomnography have shown that there are typical age-related, normal changes that occur in both sleep architecture and patterns, but these are also accompanied by a variety of sleep complaints and disorders in the aged. Significant changes in sleep are a normal part of aging (Cooke & Ancoli-Isreal, 2012). Poor quality of sleep, fragmented and lighter with more arousals and awakenings, is a typical complaint in old age and the amount of restorative sleep gained from sleep stages three and four (slow wave sleep) decreases with age (Junior & de Almondes, 2016). A compensatory increase in the stage one and two lighter stages of sleep occurs and there is a decrease in rapid-eye movement sleep which leads to a decrease of total sleep time. Sleep efficiency is also reduced with age as there are more sleep stage shifts and the circadian organisation of the elderly shifts. Older people get sleepy in the evenings and have a propensity towards an earlier sleep onset but then tend to wake earlier. This is complicated by social pressure which tends to frown on day-time napping, even though circumstances of the retired allow this. This works against their internal sleep rhythms and all the factors mentioned here, when combined with life-style factors such as medication usage, emotional issues, diet and lack of exercise lead to poor quality or sleep deprivation (Junior & de Almondes, 2016). Neuro-typical structural changes that occur with aging also exacerbate the effects of sleep deprivation, especially in the areas of attention and postural control, and this results in, amongst other things, falls and significant injuries (Cooke & Ancoli-Isreal, 2012; Stern, 2002). Thus, the elderly may spend more time in bed but have a deterioration of both quality and quantity of sleep, all of which leads to excessive daytime sleepiness and then difficulty falling asleep at night (Cooke & Ancoli-Isreal, 2012). This decreased ability to sleep is often reported as insomnia, the inability to initiate or maintain sleep, resulting in daytime consequences. Medications typically taken by older people, for example, hypertension treatments, also often lead to insomnia. The risk factors for this are varied but a significant factor is depression, often the result of the loss of a loved one, and this is highly indicated in this group (Cole & Dendukuri, 2003; Fava, 2004).

Good, restorative sleep is fundamental for effective cognition and any sleep disorder in the elderly has been shown to negatively affect their cognition (Cooke & Ancoli-Isreal, 2012; Stern, 2002). It is already known that there is cognitive decline and changes in cognitive functioning as one ages and that sleep components also undergo alterations in healthy aging and it must be presumed that there are associations between the two as the impact of the ultradian (changes in slow wave and rapid eye movement sleep), circadian (earlier sleep onset) and homeostatic (sleep efficiency) sleep changes occur in the prefrontal circuits and these are the circuits that underlie working memory and executive functions generally.

A systematic review of evidence for the interaction between sleep and executive functioning in healthy aging showed that the many sleep parameters differ in the way that they benefit or impair executive functioning (Junior & de Almondes, 2016). Circadian rhythm disturbances, increased wake after sleep onset, and lower restorative sleep levels, showed consistent results: they were found to be correlated with worsening executive functioning. A clear finding of the study was that sleep quality in the elderly is less about the pathology and due more to life-style factors such as daytime napping, alcohol consumption, diet and medication side-effects, all of which detract from restorative nocturnal sleep. In addition, they found that higher levels of physical activity can protect against the negative effects of poor sleep on executive functioning (Junior & de Almondes, 2016).

In light of the above finding, it was necessary in this study to investigate diet and nutrition among the elderly as evidence, especially in the medical literature, suggests neuroprotective benefits and findings from animal research support this claim (Marseglia et al., 2018). Although it is known that dietary patterns are related to cognitive functioning at all ages, associations of dietary patterns with cognitive function are not yet fully understood and there are often covarying and contradicting variables at play (Yin, et al., 2018). An example of this is from a meta -analysis concluded in 2017, which found that there is a protective cognitive effect of a diet rich in fruit and vegetables (Jiang, Song & Wei, 2017; Riggs, Shin, Unger, Spruijt-Metz & Pentz, 2014). This study concluded that there may be an approximate 13% reduction in risk of cognitive impairment with each increment of 100g per day of fruit and vegetables, due largely to the rich antioxidant nutrient content and anti-inflammatory properties of fruit and vegetables. The caveat here is that this diet may be accompanied by a higher risk of diabetes and hypertension, especially in cultures where sugar is added to fruit or where excessive salting of vegetables occurs. It needs then to be decided if, since it is known that diet influences cognition through more than one pathway, the positive effect of this pattern for cognitive function outweighs its negative effect. The animal-food dietary pattern (meat-fish -seasoning) is also controversial with varied results: most western studies find negative associations between this pattern and cognitive functioning (Granic et al., 2016; Staubo et al., 2017); but the eastern countries like Japan and China find the opposite, perhaps because their diet contains more fish than red meat. Inconsistencies could also arise because of the differing intakes of energy (calorie intake and portion size) (Yin et al., 2018). This lack of consistency in results should warn against cultural and socio-economic bias and differences when interpreting these findings.

Overall however, Smith, Blumenthal and Hoffman (2016) have summarised the findings and emphasize the importance of the following dietary factors for cognitive health: reduced saturated and trans fats, foods with antioxidant qualities, increased fruit and vegetable consumption, a controlled calorie intake diet and a dietary intake of vitamins E and

B12. These are all associated with a lower incidence of cognitive decline, stroke and dementia in the majority of studies. For example, in individuals where there is more folic acid (B9), pyridoxine (B6) and cobalamin (B12) in their blood streams, a lower likelihood of cognitive decline is noted. But the study also finds that it is not only the impact of these specific nutrients that are important: dietary patterns are important for cognitive health. It is the whole food matrix effect on the biological systems in the body that counts more as it is known that cognitive decline is influenced by multiple factors at the same time.

Additionally, it is known that diets that are high in fat impair cognitive performance and that obesity at any age is associated with poor cognition, especially in executive function, independently of any associated medical conditions that an individual may have (Smith, Hay, Campbell, & Troller, 2011). In animal studies, obese rats are found to perform worse in memory and learning tasks compared to rats of normal weight and rats fed diets high in fats are found to be more cognitively impaired than rats fed normal feed (Winocur & Greenwood, 2005). In their review of the literature, Smith, Hay, Campbell and Troller (2011), found high fat diets impaired processing speed, attention and general cognitive function in sedentary older people. They also found that weight loss in the elderly improved working memory scores but not overall executive function scores. They further discuss whether obesity in the elderly is a cause or consequence of these cognitive deficits and acknowledge a likely bidirectional relationship. It is a common problem of older people, especially those living alone and who may be depressed, grieving the loss of a loved one or dealing with chronic health issues, that they do not eat properly and have poor dietary patterns such as snacking rather than eating three meals a day. This could exacerbate cognitive decline, or be the result of poor decision making because of a decline in other executive functioning.

In addition to healthy sleep habits and good nutrition, there are at least three other life-style factors that play a significant role in healthy aging, namely, a socially integrated network, cognitively enriching leisure activities and regular physical activity (Baker et al, 2010; Cotman, 2002; Dall et al., 2013: Kirk-Sanchez & McGough, 2014; Smith et al., 2010; Opdebeeck et al., 2016) and these were all investigated in this study. These factors cross the first two levels of Vance and Crowe's (2006) model of neuroplasticity and although already touched on in the previous sub-section, they deserve more discussion.

Socially enriched leisure activities, where social interaction takes place and serotonin, the feel- good drug, is produced, are very important at any age but especially in older age, and these were discussed in some detail in the previous sub-section. There is correlational evidence in the literature that points to the fact that individuals who engage in life long socially enriched activities (or at least in middle and late adulthood) fare better cognitively than less active individuals (Adam, Bonsang, Grotz & Perlman, 2013; Park, et al., 2014; Wilson et al., 2002) and it would seem that these activities are key to defending against cognitive decline. As important to cognitive health, however, are cognitive leisure activities: keeping the mind active with cognitive exercises like puzzles, crosswords and Suduku, arts and crafts, board and card games, playing with children, reading and watching television and movies, visiting museums, writing letters and keeping journals, are all suggested to be important to healthy aging and keeping the brain fit (Park et al., 2014; Stern, 2002). Sustainability in these activities is the key here: individuals need to participate in as many of these as possible and as often as possible. However, physical activity, especially if it includes a social interaction component, seems to have an even greater impact on cognitive functioning in older age (Bherer et al., 2013) and needs emphasising.

Physical exercise, defined as intentional physical activity for the improvement of health and fitness, appears to influence the risk factors and neuroprotective mechanisms associated with cognitive decline (Bherer et al., 2013; Kirk-Sanchez & McGough, 2014). The programmes that are structured, individualised, highly intensified, of longer duration and which are multi-component (aerobic, cardio-vascular, resistance and weight bearing exercise) show the most promise for preserving positive cognitive performance in adults (Kirk-Sanchez & McGough, 2014). A meta-analysis of 29 randomised controlled trials concluded that older adults who performed aerobic exercise at least three times a week, showed improved attention, processing speed, executive functioning, and working memory capabilities (Smith, 2010) but a combination of all exercise types, especially cardio and resistance training, seems to be the best, with light exercise showing no significant results. In support of this, Sofi, Valecchi and Bacci (2011) compiled the results of 15 studies, including more than 30 000 participants worldwide, and found a decreased risk factor of dementia of up to 38% for those individuals who engaged in vigorous exercise more than three times a week.

Cotman (2002) suggests that exercise has neuroprotective effects that reduce risk for disease; physiologic mechanisms (eg., increased glucose sensitivity) are mediated by exercise, thus playing a role in neuroprotection, and exercise may then lead to brain plasticity via neurogenesis. It also increases blood flow and oxygen to the brain and keeps the blood vessels working effectively. Physical exercise is thus a non-pharmacological approach to slowing age related decline and reducing disease-related cognitive impairment in normally aging adults (Kirk-Sanchez & McGough, 2014). Bherer et al. (2015) reviewed the studies that assessed if cognitive training and physical activity improved cognitive performance in older adults and he found that physical exercise studies found significant and large improvements in physical capacity, in some cognitive domains, and in overall quality of life. The results are aggravated by the same question facing cognitive training interventions however: namely, if training stops, can the benefits be maintained? This is still to be empirically confirmed but it seems not, for either intervention (Melby-Lervag, 2013; Park et al., 2014). He thus hypothesised that a combined intervention of physical exercise training and cognitive training would further boost brain function in older adults but found this not to be the case, and suggested research into exercise interventions that naturally involve cognitive stimulation.

Two such exercises are dance and yoga. Of all the forms of physical exercise, the most effective on the brain appears to be dance training and dance movement therapy, as these activities combine physical, cognitive and social engagement (Burzynska et al., 2017). Dance results in all the physical and metabolic improvements of other physical exercise types, but also requires complex mental co-ordination to achieve success. Synchronizing music and movement activates the sensory and motor circuits in the brain, promotes the production of serotonin (which helps develop new neural connections, especially in the regions responsible for executive functions, memory and spatial recognition) and provides the participant with pleasure, thus stimulating the brain's reward systems. As dance improves mood, decision making, cognitive skill and visual recognition, it is an important element to investigate with regard to working memory support (Burzynska et al, 2017).

Vigorous exercise has benefits at two levels: indirectly, it improves health conditions like sleep and stress levels, it reduces chronic diseases and it impacts neurocognitive functioning; and directly, it shows induced changes in brain structure through neurogenesis and synaptogenesis (Sofi et al., 2011). This is important as older adults often suffer from multiple medical conditions or chronic diseases and as a consequence of this, take multiple medications. The relationship of these illnesses and medications to cognitive functioning was investigated in this study as a reduced physical well-being is an ever-present fact of old age.

In a South African study involving 104 elderly respondents, it was found that most suffered from at least two of the following diseases: hypertension, joint disease, heart disease, cancer and psychological disorders, and study results concluded that these diseases resulted in pain and affected mobility and cognition (Gerber, Botes, Mostert, Vorster & Buskens, 2016). Two other diseases are also highly prevalent in our sample population group: high-cholesterol and type-2 diabetes. All of these diseases and disorders bring with them pain, discomfort, fear and pharmaceutical interventions, and much negative effect. Cognitive effects are also evident. Nevado-Holgado, Kim, Winchester, Gallacher & Lovestone (2016), using a very large UK population cohort, performed a systematic investigation into the use of medications commonly prescribed to patients and their association with cognitive function. They used three cognitive tests (verbal-numerical reasoning, memory and reaction time, domains known to be sensitive to change in old age and performance) and results were regressed on each medication, adjusting for other medications and diagnoses. They found that all drugs used for the nervous system were associated with poorer cognitive performance, especially in memory and reasoning. Drugs used for non-nervous system ailments also showed significant negative associations with cognitive scores on the three skills: both anti-diabetics like insulin, and antihypertensives, affected all three test scores negatively; and asthma pump inhibitors and laxatives showed strong negative effects. Only anti-inflammatory agents, like ibrufen, showed a positive effect on cognitive function. Some of these associations could reflect the underlying disease for which the medications were prescribed, in spite of the researchers controlling for this. Cancer medications are also negatively associated with cognitive function, with cognitive impairment due to chemotherapy been reported in 17-75% of patients where a considerable decline in level of function was found (Muniyandi, Ganesan, Meenakshisundaram & Palanichamy, 2018). Recovery of function after chemotherapy is unreported.

In summary, the polypharmacy regimes used to treat the multiple medical problems commonly found in older adults negatively affect the cognitive functioning of this cohort. Additionally, the beta-blockers, bronchodilators, corticosteroids, decongestants, diuretics, cardiovascular, neurologic, psychiatric and gastrointestinal medications that are prescribed to counteract the conditions of this group cause disruptions in sleep, and this has an effect on daytime functioning and attention and concentration. If sedating medication is then prescribed to help with sleep, the situation is further exacerbated (Cooke & Ancoli-Isreal, 2012). Following from this is the probability that if the individual is feeling unwell and is sleep deprived, he/she might eat less, not exercise and not participate in social and cognitive leisure activities, and the negative effects of this on cognition have already been outlined.

It is clear from the literature reviewed above that the life-style factors under investigation in this study all have, either individually or in combination, an effect on cognitive functioning in older adults. Also evident is that the field of cognitive reserve and neuroplasticity has expanded over the past 30 years to include many more factors than originally considered. Psychological factors, especially the attitude- towards- life of the individuals involved, cannot be overlooked when investigating a very personally challenging construct of this sort. There is solid evidence for the part psychological factors play in building cognitive reserve and resilience (Bartres-Faz et al., 2018) but investigation of these was beyond the scope of this study. However, it was anticipated that the assessment phase of the project might be undermined by stereotypical, self-fulfilling behaviour and thoughts and that gender-role and age stereotyping would affect the findings in this study. Qualitative observations were recorded throughout the process to see if this was the case and a brief review of the literature on these concepts follows.

Stereotype threat and ageism factors affecting cognitive health

Stigmatisation related to age, or ageism, is a widespread phenomenon in modern industrial societies where older people are seen as cognitively incompetent (Marquet, Missotten, & Adam, 2016). It is described as the discrimination against individuals based on their age and exhibited through negative stereotypes and prejudice (Ayalon & Tesh-Romer, 2017; Malta & Doyle, 2016) and can be directed towards people of any age, but worldwide, it mainly occurs in relation to older adults (Ayalon & Tesh-Romer, 2017). Old age is seen as a negative life stage during which one deteriorates, becomes weak and senile, forgets things, is anxious and often sickly and where one is generally cognitively incompetent. Younger individuals in society internalise predominately adverse societal views of older people, often based along gender lines, and these negatively influence their perceptions of the elderly (Ayalon & Tesh-Romer, 2017; Kotter-Gruhn & Hess, 2012). The elderly also internalise these stereotypical views and this negatively impacts their health and functioning (Palmore, 2015). The main concern, however, is that ageism has been found to be ingrained in our culture and that most people do not even realise that they hold these stereotypical views of the elderly or themselves (Nelson, 2016; Palmore, 2015; WHO, 2016). Furthermore, older individuals also hold negative perceptions regarding old age and tend to view those older than themselves in a negative light (Ayalon & Tesh-Romer, 2017): thus ageism is a universal phenomenon that negatively influences the majority of people (Palmore, 2015).

Research has shown that exposure to negative age-based stereotypes, known as the stereotype threat effect, can undermine older adults' memory performance (Armstrong, Gallant, Li, Patel & Wong, 2017) and may have a detrimental influence on older adults' cognitive performance (Marquet et al., 2016). Armstrong et al. (2017) conducted a meta-analysis of this research to examine the reliability and magnitude of the stereotpe threat effects on older adults' episodic and working memory performance during testing. Using 38 samples, and allowing for potential moderators of age, type of threat, type and timing of memory task and education level, they revealed a reliable effect of stereotype threat on both older adults' episodic and working memory performances. Neither age nor education level moderated these effects. These results highlight the vulnerability of older adults during a testing process and the importance of not exposing older adults to the common stereotypes about ageing and memory.

Conclusion

The present study explored the contribution of various life-style factors believed to contribute towards cognitive reserve and their relationship to working memory. Working memory was the focus of the study as it is a foundational process that underpins efficient cognitive functioning (Alloway, 2013; Baddeley, 2000; Diamond, 2013).

From the review of the literature above, it was hypothesised that certain life-style factors were likely to promote good working memory in old age. This study therefore set out to discover if there was a significant difference in three aspects of working memory performance between males and females, between participants who work or are retired, between participants with different levels of education, socio-economic status or marital status, and between those that live in retirement or communal villages or who live independently. The study presumed there would be differences in working memory functioning between participants with different activity levels: mental activities, exercise levels, interaction with family and grandchildren, as well as social interactions Lastly, significant differences were anticipated between those participants who had better nutrition and diet, between those on medication and with medical conditions and those who were not, between those who spoke more than one language or only one, and between participants with different sleep habits. Therefore, it was hypothesised that the demographic factors included in this study would relate either positively or negatively to both working memory as well as to general cognitive functioning and, although the review of the literature indicated clearly that all the life-style factors considered are closely intertwined and that, in reality, it is difficult to determine the individual effects of each on working memory, it was considered important enough to attempt this analysis.

Chapter Two

Methods

Research Design

The aim of this research was to collect data pertaining to the life-style choices and demographic backgrounds of older South African adults and to investigate if these were related to their working memory ability. A non-experimental design was deemed suitable as there was no researcher manipulation of any independent variable. A cross-sectional, correlational design was thus employed as data was collected at a single point in time and the purpose of this study was to understand whether any life-style or demographic variables were related to working memory functioning in older adults. The study was exploratory as the nature of the variables involved, including that of working memory, were all conceptually complex and their definitions often contentious.

Consequently, the focus of this research was on working memory in neurotypical, healthy adults over 65 years of age. In a correlational design, two or more variables are measured in relation to one another, rather than manipulating various independent variables and then measuring the dependent variable. Data, relationships and distributions of variables are studied and not manipulated; they are merely identified and studied as they happen in a natural setting (Babbie & Mouton, 2014). Additionally in this study, notice was taken throughout the process of any qualitative observations made to be included in the discussion.

Having established the variables to be analysed and chosen the design for analysis, the method of measurement first needed to be justified. In this study, quantitative measures were used to represent the psychological constructs in a correlational analysis and traditionally, this falls into the sphere of the positivist, epistemological paradigm. The positivists believe that no claim is valid unless based on sensory data as nothing can exist in the mind without first being in the senses (Zammito, 2004), a claim relating to direct access of theory- neutral observation. In this approach, the role of the researcher is limited to the accurate collection of empirical data and the analysis and interpretation and the research findings; conclusions are observable and quantifiable (Babbie& Mouton, 2014). The researcher uses a systematic, scientific approach; observing and recording events, data and phenomena in a systematic way and then using statistical analyses to uncover the underlying principles of why these have occurred (Babbie & Mouton, 2014). While events may exist neutrally before perception, during the process of perception itself, they are assimilated into existing conceptual constructs and are naturally affected by the researcher's perception and theories of mind (Schumacher & Gortner, 1992). Post – positivism, conscious of this criticism, states that no observation is independent of the beliefs of the researcher and that these beliefs determine what counts as an observation and how it is interpreted. The post-positivists reject the concept of there being only one method of conducting objective science and posit it that there are many ways to justify a scientific claim and that there are many socio-cultural and psychological aspects besides the researcher's belief system that are important when justifying a claim (Zammito, 2004). It is in this post-positivist paradigm that this study falls.

This type of research design has some limitations. For example, the reduction of complex behaviours to discrete measurements often leads to very small units of behaviour being studied, such as memory, sleep, education, diet, medical interventions, without considering how all these units work together and affect each other. Further, the use of structured questionnaires may elicit only superficial information that does not delve deeply enough to get a true measure of the complicated relationships under scrutiny. It is important to note that cause and effect relationships cannot be determined with a correlational research design (and this was never an objective). Most importantly, there could be other variables mediating the relationships that are uncovered. Attention thus needs to be paid to mitigating this by improving validity with careful sampling, appropriate, valid and reliable instruments and the correct usage of appropriate statistical methods. Lastly, this method requires the researcher's strict objectivity, but it is difficult to remain completely objective when dealing with human behaviours and humans themselves (Babbie & Mouton, 2014). Self -reflection and bias checks were needed to counter this.

Sample and sampling

This study was based on a convenience sample of 50 neurotypically healthy adults over the age of 65 years. Seventy-five participants were initially recruited and assessed, but 25 did not meet the inclusion criteria and were thus excluded from the final sample. Three participants who had to be excluded had severe eyesight issues and could not complete sections of the tests; six were found to be under 65; and 16 participants completed the procedure but were found to have cognitive difficulties beyond what would be expected for their age, based on them not meeting the MoCA cut off score of 23.

The study aimed for a sample with substantial variation in SES to reflect the reality of South Africa, one of the most unequal countries in the world, but the final sample was a very homogenous group, and the lifestyle variables examined were found to be similar across the whole sample. Forty-six of the 75 participants recruited were community-dwelling older adults from retirement villages in the more affluent areas of Johannesburg and Pretoria, while 29 were older adults who still lived independently in their own homes or with their children (two). They were originally recruited by convenience from three retirement villages, but snow-balling recruitment also occurred. Descriptive statistics of the participants will be presented in Chapter Three.

Instruments

To implement the design of this study and correctly describe the sample, instruments were used to collect information about: 1) participants' cognitive health; 2) participants' demographic characteristics and socio-economic status and background; and 3) participants' working memory capacities and abilities via a series of brief verbal and visuo-spatial memory tests. The following section presents an overview of the measures that were used in this study. The psychometric properties of each measure are outlined, along with indicators of reliability and validity where applicable.

Demographic questionnaire.

Each participant completed a demographic questionnaire (see Appendix A) to elicit information on their life-style choices and living conditions. Demographic variables included those of age, gender, marital status, languages spoken, education levels, career and work, sleep patterns, medical conditions and medications, diet and exercise routines, cognitive activities and contact with children. The actual information pertaining to these items was obtained and captured for descriptive and analytic purposes. Added to this questionnaire were selected questions taken from the self-report Language Experience and Proficiency Questionnaire (LEAP – Q; Marian et al.,2007). In particular, participants were asked to rate their reading, writing and speaking comprehension proficiency in each of their languages on a scale of 0 (none) to 10 (excellent). Information regarding the age of acquisition of each language was also collected. There is a lack of "uniform assessment instruments" (Marian et al., 2007, p. 941) in multilingual research. The LEAP-Q (Marian et al., 2007) was developed as an alternative to other self-report questionnaires of language proficiency that appear in the literature. Based on its ability to predict a range of standardised behavioural measures of language, it has been shown to have good internal and criterion-based validity. It has not been standardised for the South African context but, as it is not being used for diagnostic or norm-setting purposes, this was not considered a grave issue.

The second part of the questionnaire was a section tapping the socioeconomic status of the participants. This was adapted from the Living Standards Measure (LSM) (South African Audience Research Foundation – SAARF-, 2001) commonly used to assess this variable. Participants marked either true or false to 29 presented statements assessing living standard, degree of urbanisation, and ownership of a motor vehicle and major appliances. Scoring of the LSM is done manually using a weighting system; each question is weighted differently according to economic trends in South Africa in any given year. Each weighted score reflects a final LSM score that places participants in one of 10 groups. Individuals can attain a score of 1 to 10, with higher scores indicating a higher living standard, and a higher SES.

The final section of the questionnaire was the Epworth Sleepiness Scale (M. W. Johns, 1990-1997). This scale, a good indicator of sleep hygiene and the presence of serious underlying sleep problems (Sharwood et al., 2012) was used to determine the participants' self-reported level of daytime sleepiness. It comprises eight scenarios and participants are asked to rate the number of falling asleep/dozing off episodes in each of the scenarios. It is scored using a 4- point Likert scale. The maximum score is 24 which indicates severe sleepiness but any score over 10 is considered pathologically sleepy.

The cognitive testing section of the study followed the completion of the questionnaire. In this section of the interview, participants were individually assessed in a quiet room for one session of between 30 and 60 minutes. Measures were administered in a fixed order and the tests were all administered in English. This section comprised the following sections:

The Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005).

The MoCA was administered to control for possible differences in cognitive abilities between participants and to exclude participants with cognitive difficulties. It is a brief, one -page cognitive screening instrument, developed to differentiate healthy ageing from Mild Cognitive Impairment. The test was originally validated for many disorders, including dementia and Alzheimers Disease, and it covers a wide range of cognitive functions such as short-term memory, executive functions, visuospatial abilities, concentration, working memory, attention, language and spatial and temporal orientation. It includes a one-page test that requires on average ten to fifteen minutes to administer and has a copy-righted manual that gives the instructions for administration and defines the scoring system. A MoCA score is obtained by summarising the points gained in each task, in a range of 0 to 30, and any score under 26/30 was originally deemed to show cognitive impairment of some sort. However, validation studies conducted on the MoCA in a variety of clinical populations indicated that the suggested cut-off of 26/30 led to an inflated rate of false positives, especially for older and less educated participants. Carson, Leach and Murphy (2018) conducted a systematic review and meta-analysis of the literature to determine the diagnostic accuracy of the MoCA for differentiating healthy aging for Mild Cognitive Impairment and found that a cut-off score of 23/30 yielded the best diagnostic accuracy across a range of parameters and lowers the false positive rate. This cut-off score of 23/30 was adopted for this study. See Appendix B for a copy of the test.

Wechsler Adult International scale, - Fourth Edition (WAIS-IV; Weschler, 2008) - verbal working memory subtests (Hartman, 2009).

The WAIS-IV is a standardised, verbal pen- and- paper based battery, developed by David Wechsler in 1997 and revised in 2008, and is used to determine cognitive ability in adults. It is the most widely used IQ test globally and was appropriate for the sample population of the current study as it evaluates aspects of working memory and includes norms of older adults. The WAIS-IV, which has been normed on South Africans, comprises 10 core subtests which result in scores for the following indices: Verbal Comprehension (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index, which together represent the major elements of intelligence.

In this study, only two subtests from the Working Memory Index from the WAIS-IV were used, namely the Digit Span and Arithmetic subtests. Both these tests are verbal in format. The supplementary subtest in this group, the Letter-Sequencing subtest, which is also part of the WMI, was omitted because it is not recommended for people over 70. The Digit Span subtest comprises three parts: Digit Span Forwards, Digit Span Backwards and Digit Span Sequencing. For the Digit Span Forward test, the participant is read a sequence of numbers and is asked to recall the numbers in the same order. For the Digit Span Backwards test, the participants need to recall the numbers in reverse order and for Digit Span Sequencing, they recall the numbers in ascending order. In terms of scoring, correct responses are listed on the Record Form provided. The examiner records the examinees' responses verbatim and gives one or two points for every correct response given. The item score is the sum of the trial scores for that item and the Digit Span total raw score is obtained by adding the Forwards, Backwards and Sequencing scores.

In the Arithmetic subtest, participants mentally solve a series of arithmetic problems within a time limit. This subtest measures mental manipulation, concentration, attention, short-term memory, numerical reasoning ability and mental alertness. In terms of scoring, correct responses are listed on the Record Form provided. The examiner records the examinees' responses verbatim and gives one point for every correct response given within

30 seconds. The item score is the sum of the trial scores for that item and a standardised score is then calculated from tables provided.

The Wechsler Memory Scale (WMS-IV; Weschler, 2008) – visuo-spatial working memory subtests.

One non-verbal, visuo-spatial test from the Wechsler Memory Scale – IV (WMS-IV) was administered, namely the Symbol Span sub-test. In the Symbol Span subtest, participants are shown cards with one to four pictures in a row. They are asked to remember the design(s) in the left to right sequence of the design. Participants are then asked to choose corresponding design foils and choose them in the correct sequence. In terms of the scoring, examinees are scored 1 for correct answers and 0 for incorrect answers. Additional points are allocated on some of the 26 items. To obtain the Symbol Span Total Raw Score, the scores for the 26 items are summed. The maximum score is 50 points.

This battery of tests provided a measure of different components of working memory, namely, the phonological loop, the visuo-spatial sketchpad and the central executive, aligning it with Baddeley's (2002) theory. All three components were used as the dependent variable in the correlation tests conducted.

Procedure

Before the assessment process began, it was anticipated that the individual assessment on working memory, including both the questionnaire and interview sections outlined above, would take 30 – 40 minutes in total. Because it was not actually known how long the testing would take, and in order to test whether the procedure was an appropriate one, the researcher piloted the questionnaire and working memory tests with five participants living independently in Johannesburg. This was considered necessary to test the different levels of the instruments, whether the questions were clearly phrased and comprehensible, and whether the time allocated to each section was adequate. It was found that at least an hour was necessary to complete the procedure, and that it often took longer, but no changes to the instruments were deemed necessary following the pilot study. However, it was realised during this phase that it was extremely difficult for one person to handle the interviewing and the group's questions alone and permission was granted by the University to train three research assistants to help with future group sessions. This proved to be extremely useful: the assistants helped by administering the MoCA and helping the participants with the demographic questionnaires while the researcher did the memory tests privately and without being disturbed.

Once the process had been refined and the participants recruited, the interviews and tests were conducted by the researcher and the three assistants trained by her. To guard against interviewer effects, the order of the tasks and the exact instructions were standardised in these training sessions.

On assessment days, the participants were organised into groups of 8 – 12 at a time; they all arrived together and were given an information sheet to read and a consent form to complete. Once questions had been dealt with and consent forms signed, the Demographic Questionnaire was handed to the participants to complete. Individuals were called out one by one for the MoCA and working memory tests; all the interviews were conducted in private rooms and the standardised nature of the instruments allowed for the interview and data collection process to be similar among all interviewees. Tea breaks were factored into the event to avoid the effects of fatigue on responses. The full written Demographic Questionnaire took about 45 minutes to complete and assistance was given to anyone who struggled to do it independently. This was usually completed in group situations and discussion and sharing of information was common. Some participants asked to complete it privately in their own space and in these cases, questionnaires were collected when completed.

Ethical Considerations

This study was approved by the Humanities Research Ethics Committee (HREC Non-Medical) at the researcher's academic institution and granted the Ethics Protocol No.: H17/11/53 (See Appendix C).

Once ethics clearance had been obtained from the above institution, an email was sent to the managers or matrons of eight homes identified for the research in the Johannesburg and Pretoria areas, asking permission to interview the community dwellers in the homes (Appendix D). This letter stressed that consideration would be given to the fact that this is a vulnerable population and that the researcher would ensure confidentiality and anonymity of both the institution and the participants once the data was collected. An incentive in the form of a talk on memory and sleep was offered to all residents of the villages, including those who did not participate in the study. This would be provided on completion of the study. It was also stated that a discussion would take place about procedure if a participant was identified with a severe cognitive impairment or severe working memory decline. It would be established if the home/s had inhouse doctors or psychologists and what referral procedures were in place. Once permission had been obtained, invitation letters calling for participants would be given to as many residents as possible (Appendix E).

The letter made clear that a cover letter would also be provided for participants when they attended the session and before they completed the questionnaire (Appendix F). This letter would fully inform them of the study's requirements (and this information would be verbally reiterated prior to administrating the questionnaires). Participants would be told that the research was aimed at exploring Working Memory in the elderly and how life-style and other factors impact this. They would be informed of approximately how long the questionnaire would take to complete and would also be informed of the voluntary nature of participation, and of their freedom to withdraw at any point without repercussions. Anonymity could not be assured during testing, but after the assessment, all data would be anonymised with a participant code. Anonymity could be ensured as participants would not be required to provide the researcher with any personal identifying information. Confidentiality would also be assured as only the researcher/supervisors would have access to the data collected. This data would be securely stored in a locked cupboard at the university and on password protected laptops so there would be no access by unauthorised persons, ensuring confidentiality be further maintained. Data would be anonymised in the final write up and questionnaires would be destroyed once there was no compelling reason to retain them.

Participants' verbal and written consent (Appendix G) would be required but participants would also be made aware that returning the completed questionnaires would indicate that they had given their permission for their data to be used for analysis and reporting and, possibly, for publication or presentation at conferences.

The letter covered the issue of possible negative repercussions by ensuring that should any participant experience distress during testing, they would be referred on to the medical staff of their institution but would also be given the details of the Emthonjeni Community Psychology Clinic, which offers free counselling. Participants were told they could contact the researcher with any queries they had: they could receive general feedback on the results of the study at a specific point in time, but that, in order to retain confidentiality, no individual feedback would be available. All University Masters research reports are stored in the main library and are made available on the internet and might thus be accessed.

Initial contact was made with the managers/matrons/social workers of four homes in the Johannesburg and Pretoria areas, asking for the homes' participation. This was achieved through the email described above. Only one home in Johannesburg responded favourably; the others all explained that permission was needed from governing/management committees and this was never granted.

At the home that agreed to participate, a follow up meeting was arranged with the social worker in charge to explain in detail the procedure for the interviews. The Matron was also informed of what participants would be asked to do and consent was given to set up three days of interviews. Once permission had been granted, and once the individual meetings with the social worker had taken place, an advertisement was posted in the communal areas of the villages, calling for participants (Appendix E) and 35 residents replied favourably to the request. Letters were sent to all interested parties (Appendix F) and meeting times in some cases, and testing sessions in others, were arranged. At these meetings, participants were again informed of the procedures and their rights and then asked to complete a consent form (Appendix G). Up to 12 participants at a time were scheduled over three days of interviews but some did not turn up for the procedure and eventually 22 participants were processed over a 10-day period. The researcher was assisted by three trained assistants in this process.

As no other homes gave formal permission to set up interviews in the homes, the researcher relied on snowballing recruiting and found someone in each of four more retirement villages who would give the introduction letters to other village dwellers and host the assessment session in their homes. Twenty- seven assessments were completed this way. An HR department in an electronics production company also allowed the researcher to interview 10 of their employees in the workplace and 17 individuals, who were not village residents but who lived independently, were also recruited and assessed privately in their homes or workplaces. The same procedures followed in the first village were adhered to in all other sessions.

In summary, participants were all over 65 years of age and signed a consent form prior to participation. They were assured of the ability to withdraw without prejudice, and anonymity and confidentiality of results was assured. Participants were given information on free counselling services in case of any distress being experienced but fortunately this did occur. The researcher’s details were also given so that participants could contact her at any time with queries.

Once the interviews were completed, data from these instruments were captured, and the data analysed using appropriate statistical procedures. The analysis from these procedures is discussed in the following chapter.

Chapter Three

Results

Introduction

The aim of this study was to examine whether various life-style variables were related to working memory functioning in neuro-typical older adults. In chapter one, the difficulties with the measurement of these variables was highlighted and the use of proxies to evaluate life-style variables was discussed. The research design chosen, and outlined in chapter two, revolved around examining the effect of these groups of variables on three different components of working memory, namely the two verbal working memory components of Digit Span and Arithmetic, and the visuo-spatial working memory component of Symbol Span. First, the potential correlations between the three working memory measures was assessed, and then the sample was divided into groups, based on the various demographic variables under consideration, and these groups' working memory abilities were compared.

In this chapter, the steps taken to carry out these analyses are described: the first step covers descriptive statistics for all the variables deemed essential in interpreting the correlations and the second contains the results of the inferential analysis of the correlations undertaken. At each step, the results of the statistical analyses are presented in tables and significant findings, if any, are discussed.

The statistical analyses are divided into three sub-sections, each describing the characteristics of a different group of variables used in the study. The first deals with the demographic variables which provide crucial background information; the second covers the life-style factors that are assumed to be related to working memory; and the third describes the three working memory components. In each subsection, the variables generated by the instruments chosen, and the process by which study variables were derived from these, are described. Later, in the preliminary analysis section, the properties and validity of these variables are explored.

Data from 50 adults aged 65 year or older, who had passed the MOCA screening test with a score of 23 or more, was collected. This data related to the following variables:

The demographic variables of age, gender, location (living in a retirement village or independently), nationality, relationship status, highest level of education, working status, pets and socio-economic status

Number of children and grandchildren, frequency of contact with grandchildren, number of mental activities, exercise and frequency, number of meals per day, meals per day with protein, portions of vegetables per day, portions of fruit per day, medical conditions, number of medications, mother tongue and daily use of two languages, age of acquisition of first and subsequent languages and self-rated proficiency of language one in speaking, reading and writing, self-rated sleep scores

MOCA score and working memory measures: namely Digit Span Total Scaled Score, Arithmetic Scaled Score, and Symbol Span Scaled Score.

Overview of Data

As a first step, the data were structured and cleaned in an excel spreadsheet. Sample size estimation was based on the key research question to be answered, in this case, the comparison of the outcomes between selected variables (all categorical or categorised for the purposes of analysis). This required the use of the independent samples t-test in most instances. For the detection of a small, medium or large effect size (d=0.2, 0.5 and 0.8 respectively) with 80% power at the 5% significance level, sample sizes of 788, 128 and 52, respectively, are required. Typically, the detection of at least a medium effect size should exist; thus, a sample size of at least 128 would have been recommended. This, however, was not feasible, given the one-on-one testing required and time frame of the study. The actual sample size of 50 used in this study only allowed for the detection of large effect sizes, should they exist. This is acknowledged as a limitation of the study. The sample size calculations were carried out in G*Power (Faul, Erdfelder, Lang & Buchner, 2007).

Descriptive analysis of the data was carried out as follows: categorical variables were summarised by frequency and percentage tabulation, and illustrated by bar charts. Continuous variables were summarised by the mean, standard deviation, median and interquartile range, and their distribution illustrated by histograms. The correlation between each pair of working memory measures was measured by the Pearson's correlation coefficient. Demographic variables were used to split the sample into two groups eg., working or not working, and working memory performance of each of these groups was compared with independent sample t-tests. Where the data did not meet the assumptions of these tests, a non-parametric alternative, the Wilcoxon rank sum test was used. The strength of the associations was measured by the Cohen's d for parametric tests and the r-value for the non-parametric tests. The following scale of interpretation was used:

0.80 and above	large effect
0.50 to 0.79	moderate effect
0.20 to 0.49	small effect
below 0.20	near zero effect

Data analysis was carried out using SAS (SAS Institute Inc., 2002-2012) and the 5% significance level was used.

Descriptive analysis of study variables

The descriptive statistics for all the study variables are shown in the histograms below.

Age.

The mean age of the participants was 77.3y (SD 5.4y; range 65.1-89.3y). The distribution of the data is shown below.

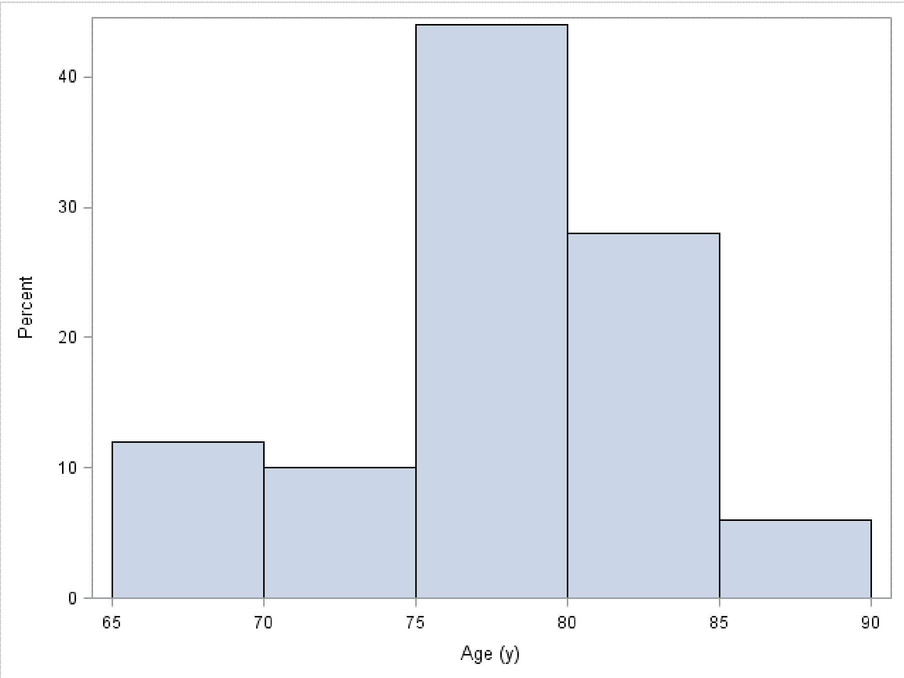

Figure 1. Histogram showing data distribution for age (n=50)

For further analysis, age was categorised as younger than or equal to 75y(n=16; 32%) versus 76 years or older (n=34; 68%).

Gender.

Participants were predominantly female (n=42; 82%).

Place of residence.

Sixty percent (n=30) of the participants were living in a retirement community.

Nationality.

Participants were predominantly South African (n=42; 92%). In addition, two were Croatian, one had dual South African/British nationality and one was Mozambican.

Relationship status.

Participants were predominantly widowed (n=22; 44%) or married (n=21; 42%). For further analysis, categories were grouped as single (56%) versus in a relationship (44%).

Highest level of education (HLOE).

Participants predominantly had post-matric qualifications (n= 40; 80%). For further analysis, categories were grouped as matric or less (n=10; 20%) versus post-matric (n=40; 80%).

Working status.

Participants were predominantly not working (n=41; 82%).

Number of children.

Most participants predominantly had two or three children (n=36; 72%).

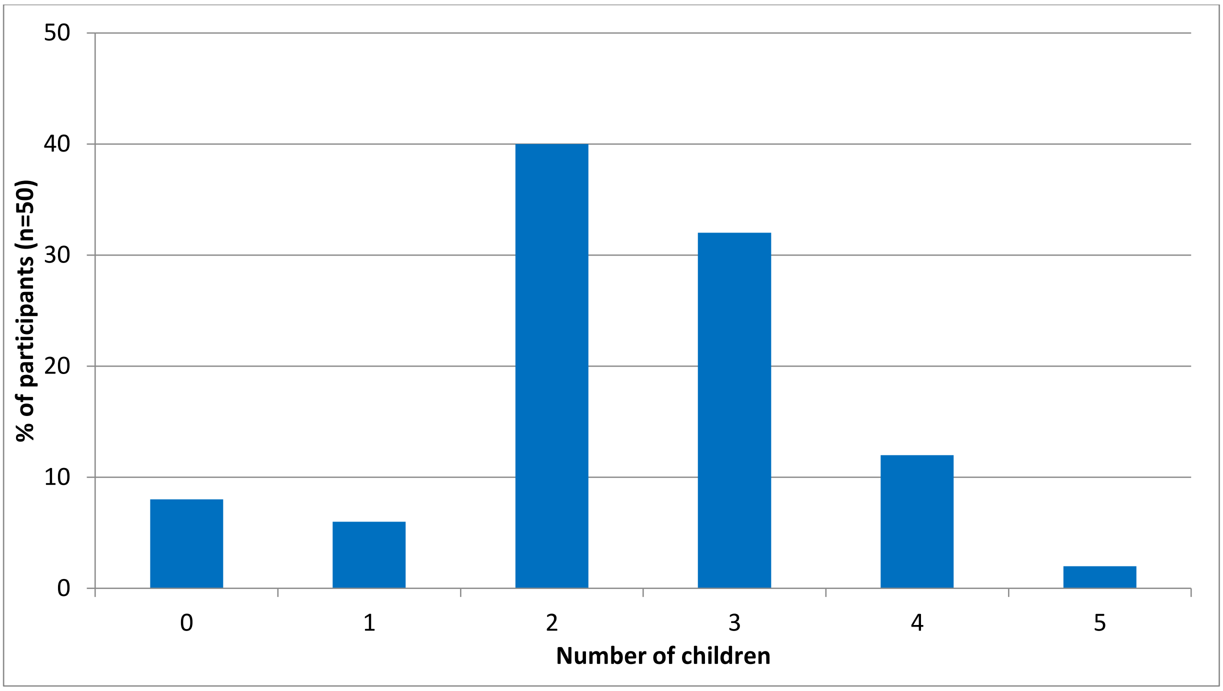

Figure 2. Histogram showing number of children per participant (n=50).

Number of grandchildren.

Sixteen percent (n=8) of the participants had no grandchildren, while 46% (n=23) had between four and six grandchildren.

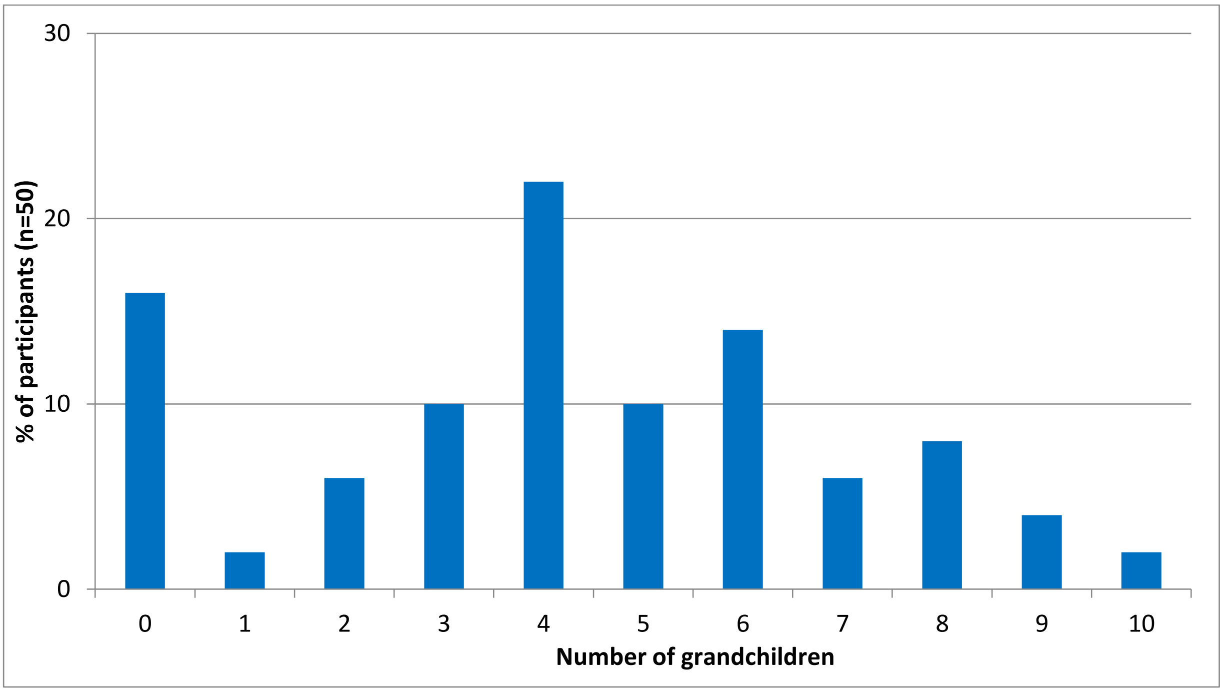

Figure 3. Histogram showing the number of grandchildren per participant.

Frequency of contact with grandchildren.

The data were grouped as either ‘at least weekly’ (n= 30; 60%) versus ‘less often than weekly’ (n= 20; 40%). This included those with no grandchildren. These categories were problematic for the analysis and more specific categories (like once a week/twice a week) should have been used to capture this information.

Number of meals per day.

Sixty-eight percent (n= 34) of the participants ate three meals per day; the rest ate two meals per day (n=16).

Meals per day with protein.

Participants predominantly ate one (n= 20; 40%) or two (n=24; 48%) meals with protein per day. For further analysis, this was grouped as one meal (n=20; 40%) versus two or three meals (n=30; 60%).

Portions of fruit/vegetable per day.

0ver 90% of the participants had at least two fruits and two vegetables per day.

Number of medical conditions.

Seventy percent (n=35) of the participants had two or three medical conditions.

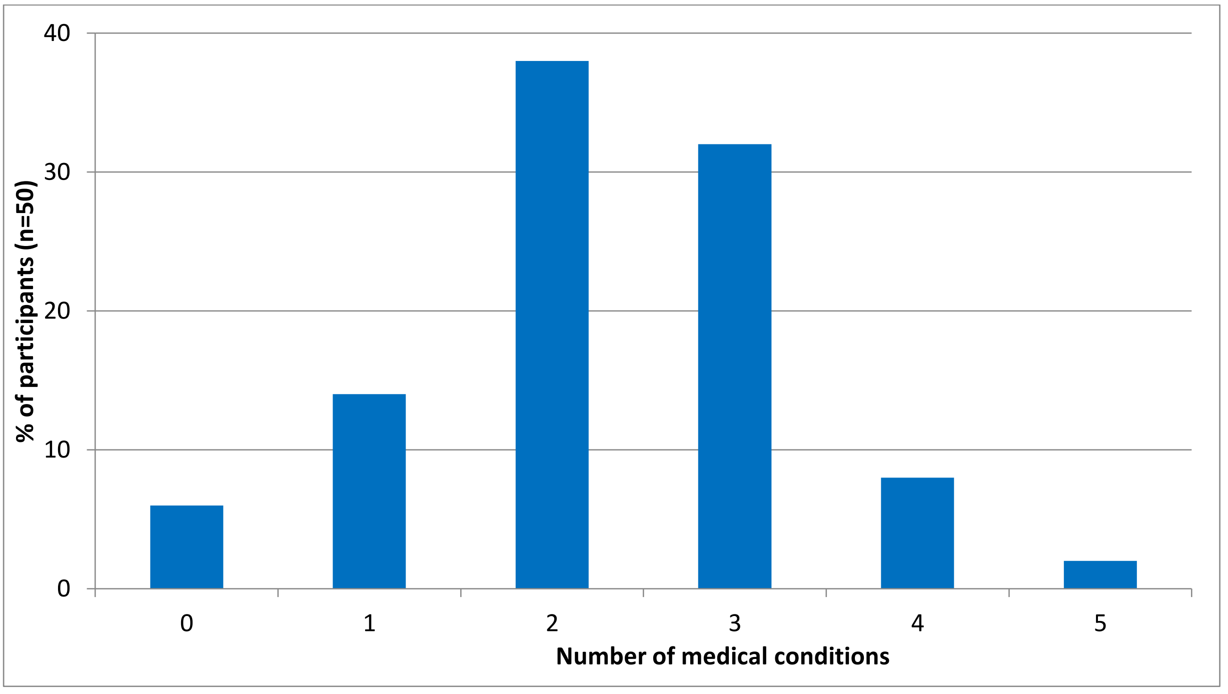

Figure 4. Histogram showing data distribution for medical conditions (n=50).

For further analysis, this was grouped as zero to two conditions (n=29; 58%) versus three or more conditions (n=21; 42%).

Number of medications.

Sixty percent (n=30) of the participants took two to four medications per day.

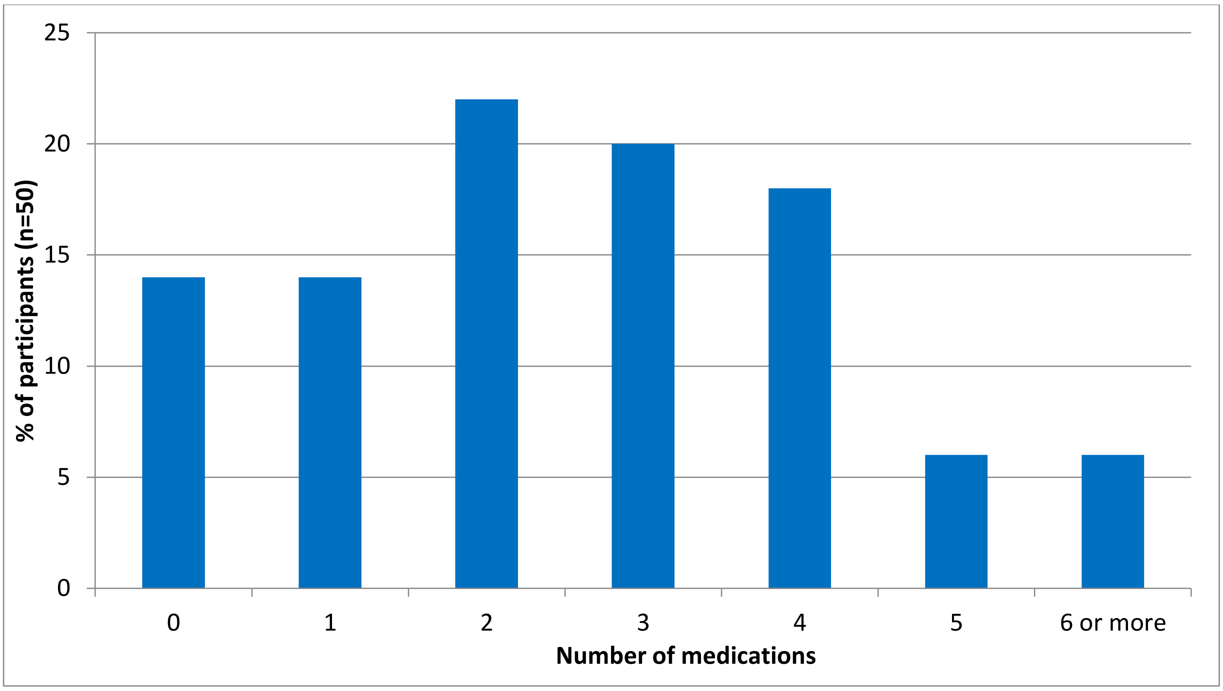

Figure 5. Histogram showing data distribution for number of medications taken (n=50).

For further analysis, this was grouped as zero to two conditions (n= 29; 58%) versus three or more conditions (n=21;42%).

Mental activities.

Of the six mental activities questioned, the predominant activities were watching television, followed by reading novels, newspapers and magazines.

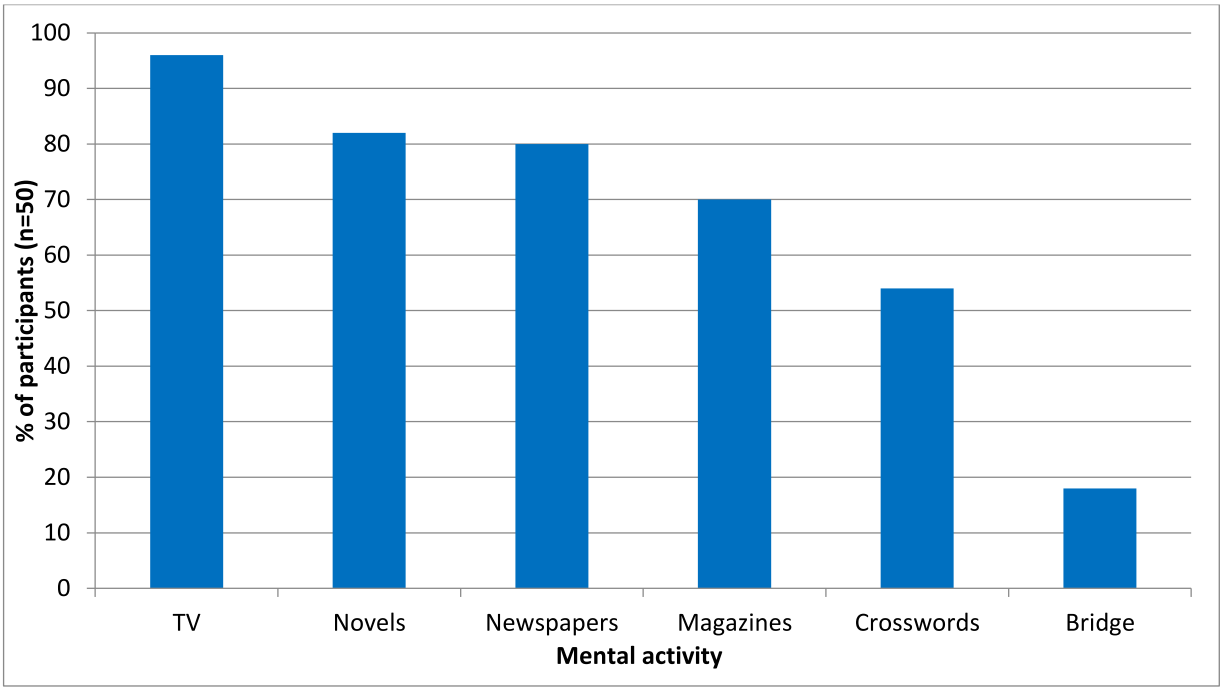

Figure 6. Histogram showing data distribution for the types of mental activity engaged in by participants (n=50).

Number of mental activities.

Seventy-two percent (n=36) of the participants participated in four or five of the six mental activities asked about in a typical week.

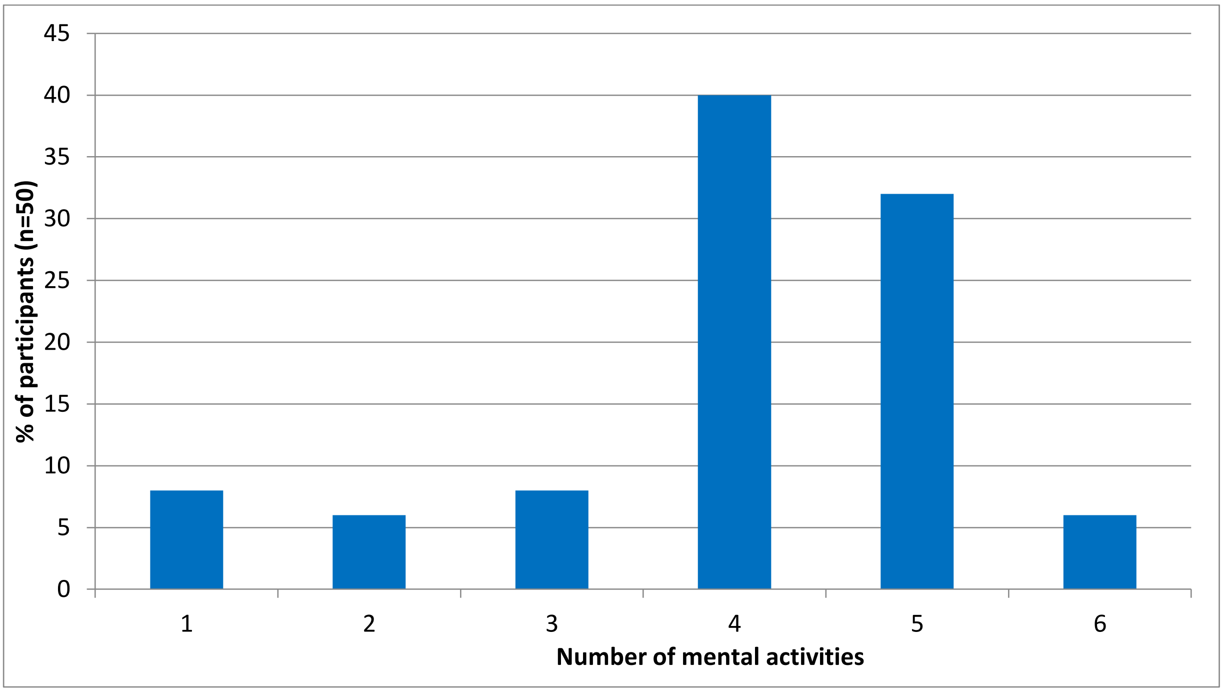

Figure 7. Histogram showing the number of mental activities done in a typical week (n=50).

For further analysis, this was grouped as one to three activities in a typical week (n=11; 22%) versus four to six activities (n=39; 78%).

Exercise.

One participant did not answer this question. Ninety percent (n=45) of the participants claimed that they exercised. The data were grouped as three times per week or more (61%) versus less than three times per week (39%). These categories were problematic for the analysis and more specific categories (like once a week/twice a week) should have been used to capture this information.

Pets.

Only 26% (n=13) of the participants had pets. This low number was a reflection of the rules of the villages that disallow pets.

Mother tongue.

Participants' mother tongue was predominantly English (n=39; 78%).

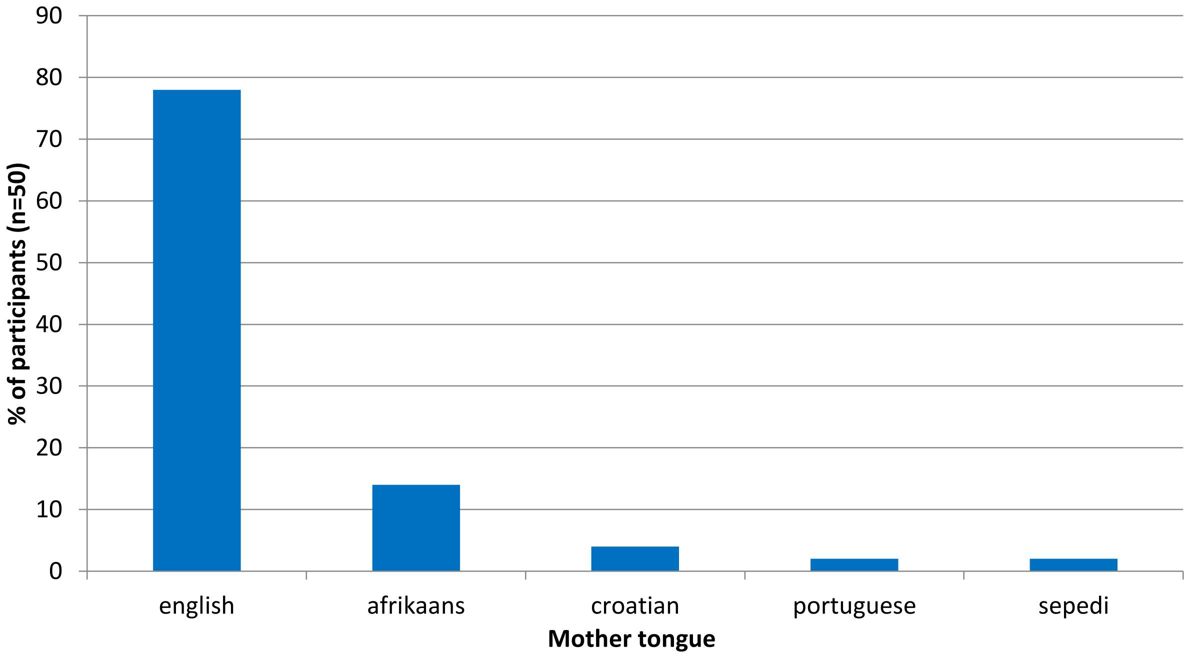

Figure 8. Histogram showing the breakdown of participants' mother tongues (n=50).

Two or more languages spoken.

Ninety-six percent (n=48) of the participants spoke at least a second language.

Age of acquisition of first and subsequent languages.

The first language was acquired at birth in all cases. Most participants spoke a second language (n=48) but data was sketchy. Pre-specified categories should have been used in the questionnaire to capture this data.

Self-rated proficiency of first language – speaking, writing, reading.

Approximately 70% (n=35) of the participants rated their proficiency in each area as 'excellent'.

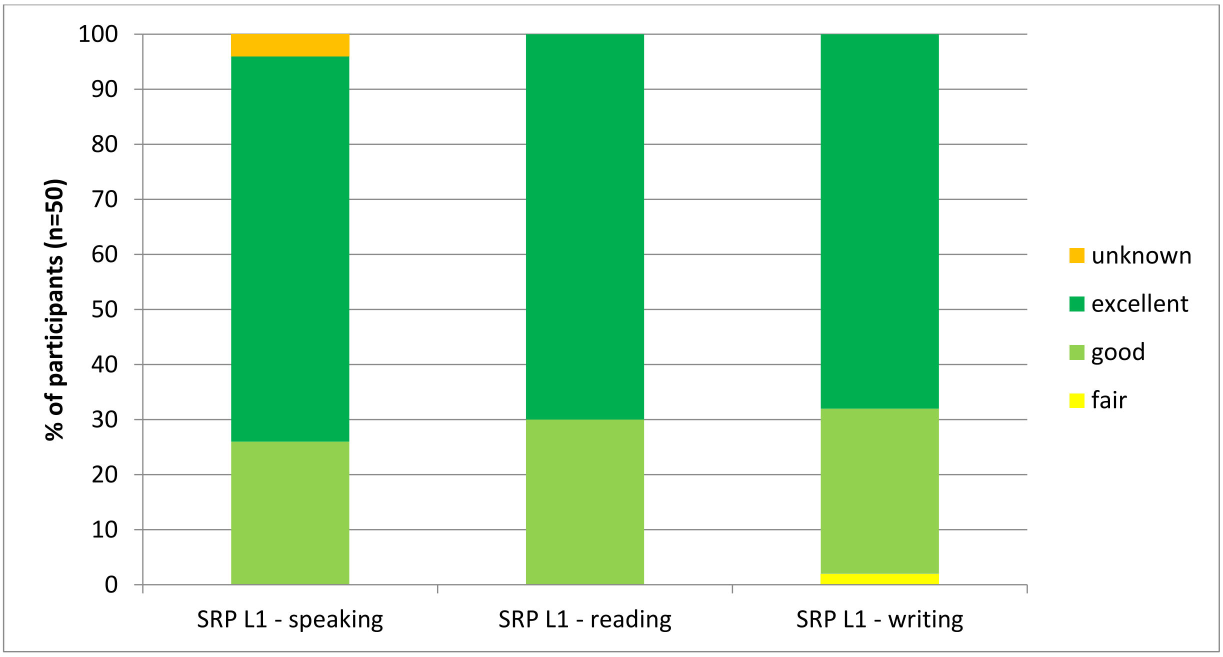

Figure 9. Histogram showing proficiency in speaking, reading and writing of participants' first language.

Daily use of two or more languages.

Thirty-six percent (n=18) of the participants reported daily use of two or more languages.

Socio-economic status (SES)/ Life-style measurement.

All participants were categorised as 10H (ie., high SES) on the Life-style measure or SES Questionnaire and were thus a homogenous group. This lack of variation of SES among the participants is a limitation of the study and will be discussed in the next chapter.

Montreal Cognitive Assessment (MoCA) score.

The mean MOCA score was 25.3 (SD 1.7; range 23-29). The distribution of the scores is shown in the histogram below. Participants with MoCA scores of below 23 were excluded from the analyses, following the reasoning given in the methods section.

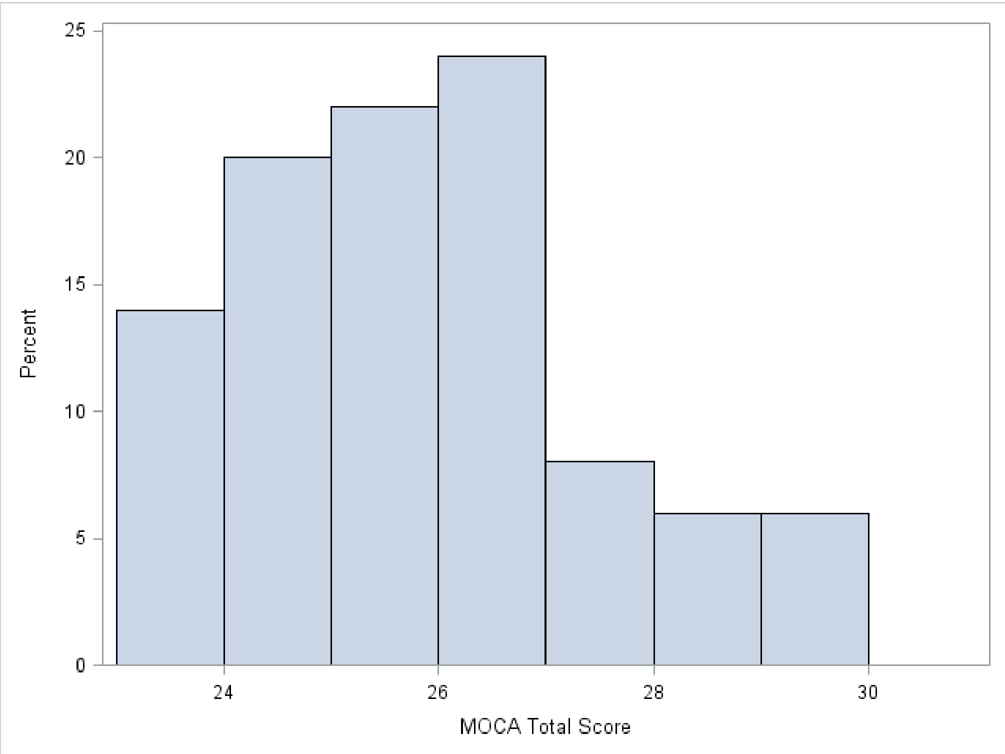

Figure 10. Histogram showing results of the MoCA assessment (n=50).

This table reflects participants who scored 23/30 and above. Twenty-five participants were excluded from the original sample because they scored below this number.

Epworth Sleepiness Scale Score (ESS).

The median ESS score was four (IQR 2-7; range 0-15). The standard scale used to score this questionnaire is as follows:

1 – 6 points: Normal sleep

7 – 8 points: Average sleepiness

9 – 24 points: Abnormal (possible pathological) sleepiness

As there were only five participants with scores above nine, categorisation of the data as below 9 versus above 9 was inadequate. Instead, a cut- off point of 0-6 points (70%) versus seven or more points (30%) was used.

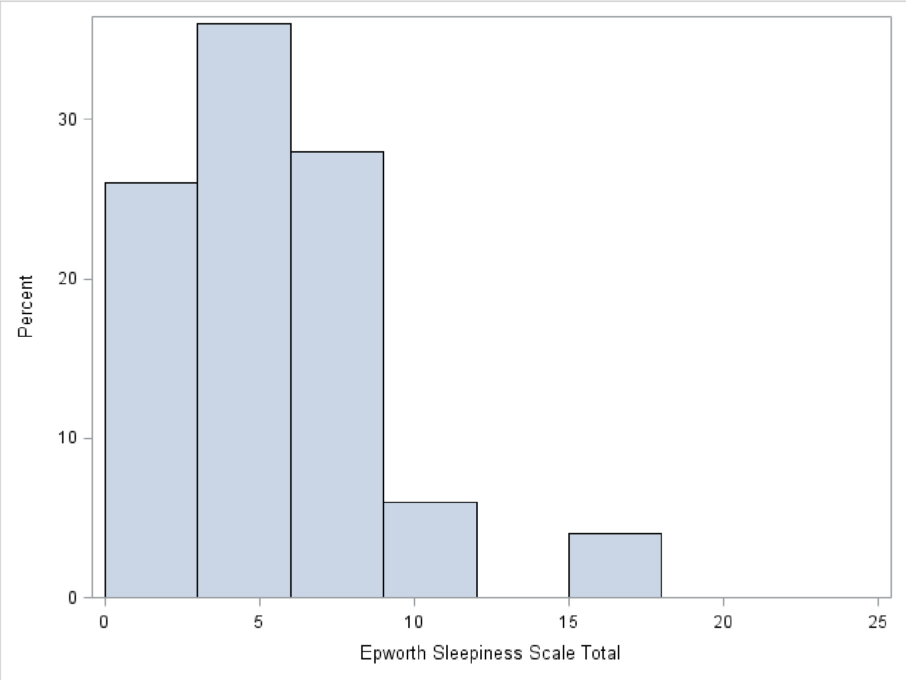

Figure 11. Histogram showing results of the sleepiness self-report assessment (n=50).

This histogram is skewed to the left, signifying that most participants exhibit 'normal' sleep.

Working memory was measured using three Working Memory tests, namely Digit Span, Arithmetic and Symbol Span. The information below refers to the results of these three tests.

Digit Span Total Scaled Score.

The mean scaled score of this normally distributed graph was 10.2 (SD 2.2; range 5-16). The distribution of the scores is shown below. Since the mean score on this test is 10 (SD: 3) (Hartman, 2009), this reflects a generally average performance in the sample.

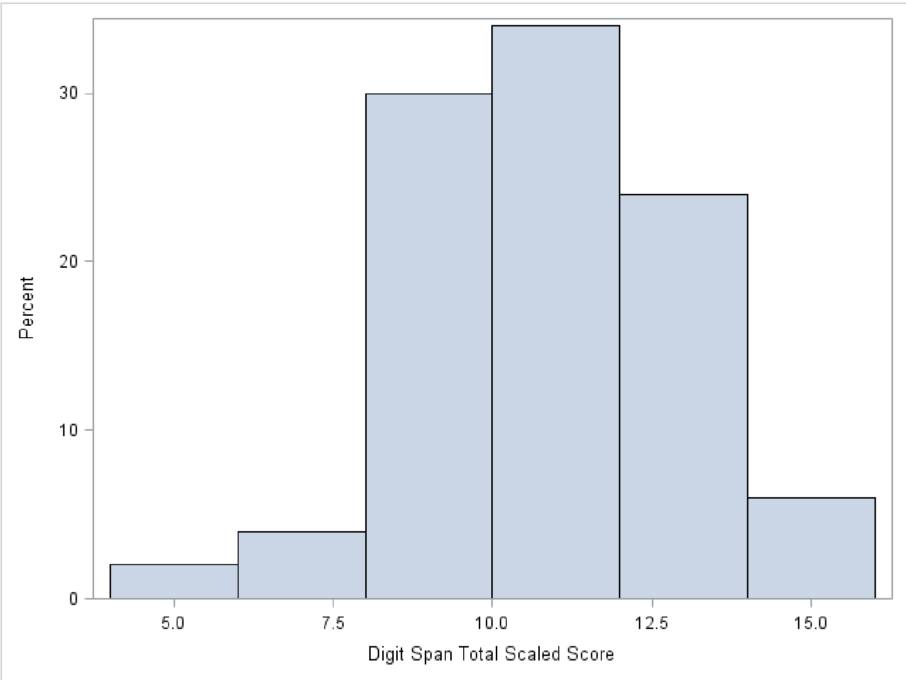

Figure 12. Histogram showing the Total Scaled Score achieved on the Digit Span test.

Arithmetic Scaled Score.

The mean score was 9.7 (SD 2.7; range 3-18). The distribution of the scores is shown below. The graph is normally distributed and as the mean score on this test is 10 (SD: 3), (Hartman, 2009). This reflects a generally average performance in the sample.

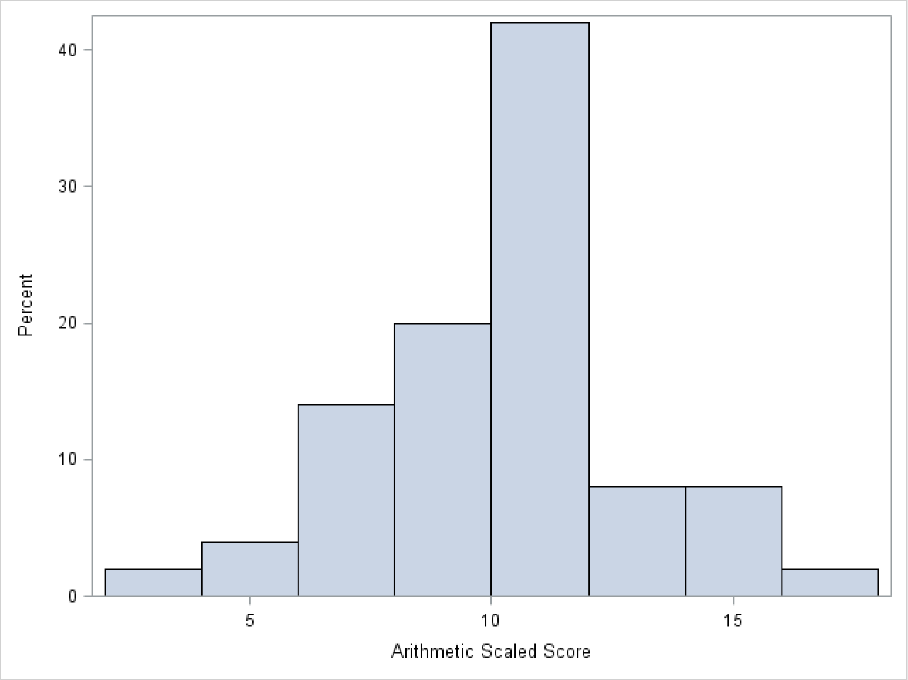

Figure 13. Histogram showing the Total Scaled Score achieved on the Arithmetic test.

Symbol Span Scaled Score.

The mean score was 9.1 (SD 2.6; range 2-14) which was within the average range for this subtest (Hartman, 2009). One participant refused to complete this section of the test and his score had to be excluded. Therefore the total sample for this subtest was forty-nine. The distribution of the scores is shown below. The graph is very slightly skewed to the right, possibly due to one outlier who scored over twelve on the test.

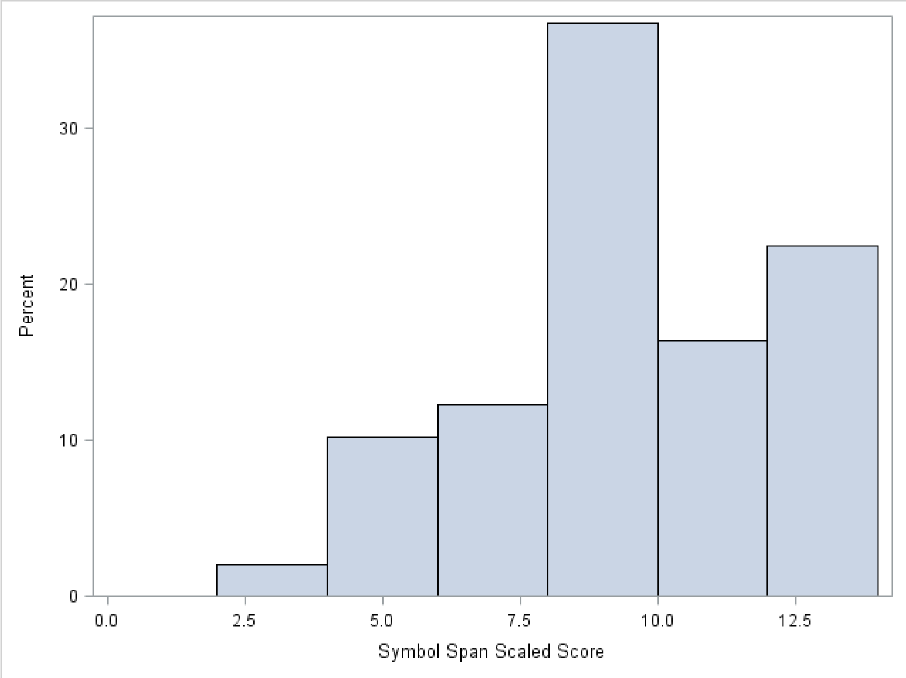

Figure 14. Histogram showing the Total Scaled Score achieved on the Symbol Span test.

Inferential analysis of the study variables

Given that working memory has many components, it was important to assess if the three working memory tests administered in this study tapped into the same construct. To achieve this, correlations between the three working memory measures, namely Digit Span, Arithmetic and Symbol Span were run. The correlation coefficients are given in the table below.

The following table shows the intercorrelations between working memory measures.

Table 1: Intercorrelations between the working memory measures (n=50)

Working Memory Tests	Digit_Span	Arithmetic	Symbol Span
Digit_Span	1.00	.26	.004
Arithmetic	.26	1.00	.075
Symbol Span	.004	.075	1.00

As can be seen in Table 1, none of the correlations between the working memory measures was statically significant at p<.05, which suggests that these tests were tapping unrelated skills.

Comparisons of each working memory measure with regard to the study variables

In order to investigate whether there were any differences in working memory ability related to the life-style variables, t-tests were run between each of the variables of interest. The life-style variables were divided into two groups as shown in Tables 2-4, and these groups' performance was compared on each working memory measure. Categories smaller than 10 were not included in the analyses as it is not possible to make inferences based on so few cases. Hence, the following variables were not analysed: gender, working status, exercise and having pets. The results are given in the tables below and comment on all three tables given below table 4.

Table 2: *Independent sample t-tests comparing demographic groupings on Digit Span scores*

Variable	***n***	***M***	***SD***	***SE***	**Min.**	**Max.**	**Mean Difference**	**95% CI for Mean Difference**		***df***	***t***	***p***
Age												
<=75 years	16	10	2,19	0,55	6	14	-0,29	-1,66	1,07	48	-0,43	0,67
=>76 years	34	10,29	2,26	0,39	5	16						
Location												
RC	30	10,4	2,47	0,45	5	16	0,5	-0,80	1,80	48	0,78	0,44
Not RC	20	9,9	1,8	0,4	8	13						
Relationship status												
In relationship	22	10,32	2,3	0,49	6	15	0,21	-1,07	1,50	48	0,33	0,74
Single	28	10,11	2,2	0,42	5	16						
HLOE												
Matric or less	10	10,9	2,08	0,66	8	14	0,88	-0,70	2,45	48	1,12	0,27
Post Matric	40	10,03	2,25	0,36	5	16						
Contact with grandchildren												
At least weekly	30	10	2,42	0,44	5	16	-0,33	-1,95	1,28	40	0,42	0,68
Less than weekly	12	10,33	2,1	0,61	6	14						
Meals with protein												
1 meal	20	10,5	2,24	0,5	6	16	0,5	-0,80	1,80	48	0,78	0,44
2 or 3 meals	30	10	2,29	0,41	5	15						
Number of medical conditions												
0-2 conditions	29	10,52	2,4	0,45	5	16	0,76	-0,52	2,03	48	1,19	0,24
3 or more conditions	21	9,76	1,92	0,42	6	13						
Number of medications												
0-2 medications	25	10,24	2,26	0,45	5	15	0,08	-1,20	1,36	48	0,13	0,90
3 or more medications	25	10,16	2,23	0,45	6	16						

Number of medications

Variable	***n***	***M***	***SD***	***SE***	**Min.**	**Max.**	**Mean Difference**	**95% CI for Mean Difference**		***df***	***t***	***p***
0-2 medications	25	9,52	2,68	0,54	3	14	-0,36	-1,89	1,17	48	-0,47	0,64
3 or more medications	25	9,88	2,7	0,54	5	18						
Exercise frequency												
3x week or more	30	10,17	2,41	0,44	5	16	-0,2	-1,53	1,12	47	-0,31	0,76
less than 3x week	19	10,37	1,95	0,45	6	14						
Daily use of 2 languages												
No	32	10,47	1,97	0,35	8	16	0,75	-0,57	2,06	48	1,14	0,26
Yes	18	9,72	2,61	0,61	5	14						
ESS Total												
0-6 points	35	10,49	2,39	0,4	5	16	0,95	-0,41	2,32	48	1,4	0,17
7 or more points	15	9,53	1,64	0,42	6	12						

Note. N=50; *n* = sample size in group; *M* = mean; *SD* = standard deviation; Min. = minimum; Max. = maximum; CI = confidence interval; *df* = Degrees of freedom; *t* = *t*-test statistic; *p* = probability; RC – Retirement Community, HLOE = Higher level of Education, ESS = Epworth Sleepiness Scale

* $p < .05$

Table 3: *Independent sample t-tests comparing demographic groupings on Arithmetic scores*

Variable	***n***	***M***	***SD***	***SE***	**Min.**	**Max.**	**Mean Difference**	**95% CI for Mean Difference**		***Df***	***t***	***p***
Age												
<=75 years	16	8,94	1,53	0,38	7	12	-1,12[a]	-2,41[a]	0,17[a]	47,64[a]	-1,75[a]	0,09[a]
=>76 years	34	10,06	3,01	0,52	3	18						
Location												
RC	30	10,10	3,08	0,56	3	18	1,00[a]	-0,39[a]	2,39[a]	47,38[a]	1,45[a]	0,15[a]
Not RC	20	9,10	1,80	0,40	6	14						
Relationship status												
In relationship	22	9,95	2,73	0,58	3	18	0,45	-1,08	1,99	48,00	0,59	0,56
Single	28	9,50	2,65	0,50	5	15						
HLOE												
Matric or less	10	9,80	2,57	0,81	5	14	0,13	-1,79	2,04	48,00	0,13	0,90
Post Matric	40	9,68	2,72	0,43	3	18						
Contact with grandchildren												
At least weekly	30	10,13	2,70	0,49	5	18	0,80	-1,05	2,65	40,00	0,88	0,39
Less than weekly	12	9,33	2,61	0,75	5	14						
Meals with protein d												
1 meal	20	9,50	2,98	0,67	3	15	-0,33	-1,89	1,23	48,00	-0,43	0,67
2 or 3 meals	30	9,83	2,48	0,45	5	18						
Number of medical conditions												
0-2 conditions	29	9,86	3,04	0,57	3	18	0,39	-1,16	1,93	48,00	0,50	0,62
3 or more conditions	21	9,48	2,09	0,46	5	14						
Number of medications												
0-2 medications	25	9,52	2,68	0,54	3	14	-0,36	-1,89	1,17	48,00	-0,47	0,64
3 or more medications	25	9,88	2,70	0,54	5	18						

Variable	***n***	***M***	***SD***	***SE***	**Min.**	**Max.**	**Mean Difference**	**95% CI for Mean Difference**		***Df***	***t***	***p***
Number of medications												
0-2 medications	25	9,36	2,51	0,50	5	13	0,57	-0,95	2,09	47,00	0,75	0,46
3 or more medications	24	8,79	2,77	0,56	2	14						
Exercise frequency												
3x week or more	30	9,90	2,89	0,53	5	18	0,37	-1,21	1,96	47,00	0,47	0,64
less than 3x week	19	9,53	2,32	0,53	3	14						
Daily use of 2 languages												
No	32	9,88	3,15	0,56	3	18	0,49[a]	-0,84[a]	1,81[a]	47,09[a]	0,74[a]	0,46[a]
Yes	18	9,39	1,50	0,35	6	12						
ESS Total												
0-6 points	35	9,60	2,55	0,43	3	15	-0,33	-2,00	1,34	48,00	-0,40	0,69
7 or more points	15	9,93	3,01	0,78	7	18						

Note. N=50; *n* = sample size in group; *M* = mean; *SD* = standard deviation; Min. = minimum; Max. = maximum; CI = confidence interval; *df* = Degrees of freedom; *t* = *t*-test statistic; *p* = probability; RC = Retirement Community; HLOE = Higher level of Education; ESS = Epworth Sleepiness Scale

a. Results from Satterthwaite approximation reported as variances were unequal

* $p < .05$

Table 4: *Independent sample t-tests comparing demographic groupings on Symbol Span scores*

Variable	***n***	***M***	***SD***	***SE***	**Min.**	**Max.**	**Mean Difference**	**95% CI for Mean Difference**		***df***	***t***	***p***
Age												
<=75 years	16	8,69	2,98	0,75	5	13	-0,59	-2,20	1,03	47	-0,73	0,47
=>76 years	33	9,27	2,47	0,43	2	14						
Location												
RC	30	9,13	2,52	0,46	2	14	0,13	-1,43	1,70	47	0,17	0,86
Not RC	19	9,00	2,87	0,66	5	13						
Relationship status												
In relationship	22	8,18	2,52	0,54	2	13	-1,63	-3,09	-0,17	47	-2,25	0,03
Single	27	9,81	2,53	0,49	5	14						
HLOE												
Matric or less	10	8,90	2,92	0,92	5	12	-0,23	-2,12	1,66	47	-0,24	0,81
Post Matric	39	9,13	2,59	0,41	2	14						
Contact with grandchildren												
At least weekly	30	9,13	2,90	0,53	2	14	-0,05	-2,04	1,95	39	-0,05	0,96
Less than weekly	11	9,18	2,48	0,75	5	13						
Meals with protein d												
1 meal	20	9,30	2,85	0,64	5	14	0,37	-1,18	1,92	47	0,48	0,63
2 or 3 meals	29	8,93	2,51	0,47	2	13						
Number of medical conditions												

Variable	*n*	*M*	*SD*	*SE*	Min.	Max.	Mean Difference	95% CI for Mean Difference		*df*	*t*	*p*
0-2 conditions	29	8,69	2,78	0,52	2	13	-0,96	-2,49	0,57	47	-1,26	0,21
3 or more conditions	20	9,65	2,35	0,52	5	14						
Number of medications												
0-2 medications	25	9,36	2,51	0,50	5	13	0,57	-0,95	2,09	47	0,75	0,46
3 or more medications	24	8,79	2,77	0,56	2	14						
Number of mental activities												
1-3 activities	11	8,64	2,94	0,89	5	13	-0,57	-2,40	1,25	47	-0,63	0,53
4-6 activities	38	9,21	2,56	0,42	2	14						
Exercise frequency												
3x week or more	29	9,03	2,56	0,47	2	13	0,03	-1,54	1,61	46	0,04	0,97
less than 3x week	19	9,00	2,79	0,64	5	14						
Daily use of 2 languages												
No	32	8,97	2,60	0,46	2	13	-0,33	-1,93	1,28	47	-0,41	0,68
Yes	17	9,29	2,76	0,67	5	14						
ESS Total												
0-6 points	34	9,32	2,54	0,44	5	14	0,79	-0,85	2,43	47	0,97	0,34
7 or more points	15	8,53	2,83	0,73	2	13						

Note. N=50; *n* = sample size in group; *M* = mean; *SD* = standard deviation; Min. = minimum; Max. = maximum; CI = confidence interval; *df* = Degrees of freedom; *t* = *t*-test statistic; *p* = probability; RC = Retirement Community; HLOE = Higher level of Education; ESS = Epworth Sleepiness Scale

* $p < .05$

There was no significant difference in the mean Digit Span Total Scaled Score, Arithmetic Scaled Score, or Symbol Span Scaled Score and Age, Location, higher level of Education, Frequency of contact with grandchildren, Meals per day with protein, Number of medical conditions, Number of medications, Number of mental activities, Exercise frequency, Daily use of two or more languages, or the Epworth Sleepiness Scale Score.

There was also no significant difference in the mean Digit Span Total Scaled Score, or Arithmetic Scaled Score and Relationship status. No significant differences were found in any of the variables except the mean Symbol Span Scaled Score was significantly higher for single participants (9.8; SD 2.5) compared to those in a relationship (8.2; SD 2.5; p=0.029).

Conclusion

Two objectives were set for the statistical analyses covered in this chapter. The first was to ensure that the three tests chosen to measure working memory functioning of the sample population were tapping different aspects of working memory. The lack of significant correlations in this analysis indicated that the tests were measuring different components of working memory. The second objective was to consider whether there were working memory differences in the individuals assessed, based on their demographic features and their life-style choices. This analysis provided no significant results, other than one positive correlation between being single and the Symbol Span test scores. These results will be discussed in depth in the following chapter where the reasons for the lack of significant results will be considered.

Chapter Four

Discussion

Introduction

This project set out to investigate whether certain life-style choices led to advantages in working memory functionality in neurotypically healthy adults over the age of 65 and if so, what dimension of working memory was affected, and which life-style factors were pivotal to this advantage. The previous chapter described the results of the data analyses undertaken in an attempt to answer these questions. This chapter is an interpretation of these results, drawing on the theoretical and empirical literature covered in Chapter One. Other than one positive relationship between being single or married and the Symbol Span subtest of working memory, this study produced no significant results. As was expected, there were no significant correlations between the three working memory skills measured in the study but what was unexpected, was that no relationships between the life-style factors chosen for this analysis and the working memory dimensions used to measure the anticipated advantages were found. It is acknowledged that the very small sample size of only 50 participants means that the study may have been statistically underpowered: at least 130 participants were needed to get a medium effect size and this limitation of the study will be discussed in detail in the body of this discussion. In addition, a homogenous socio-economic status level among the participants weighed negatively against finding variations in the results and is a further limitation which will be deliberated in the next sub-section.

The first part of this discussion highlights these findings and limitations, taking the non-significant results at face value and interpreting them against the research questions of this investigation, the statistical analyses performed, and the literature reviewed to inform the study about the anticipated results. The second part will question whether this pattern of results ought to be taken at face value and will look to theoretical and methodological concerns which could have influenced the results achieved. The final section of this chapter will reflect on the study as a whole, highlighting any contributions made and suggesting directions for future research in this area.

Key findings and interpretations

The objectives of this research project were to determine if there were any life-style factors that affected working memory, either positively or adversely, in neurotypically healthy people over the age of 65. Advancing age is associated with declines in a number of cognitive functions, including verbal and visuo-spatial working memory (Nittrouer et al., 2016) and it is assumed that deficits in working memory in older adults are likely to have multiple sources. To achieve the objectives set, a cross-sectional correlational research design, outlined in Chapter Two, was chosen to test the above suggested outcomes and to examine the effect of these groups of life-style factors on three different components of working memory, namely the two verbal working memory components of Digit Span and Arithmetic, and the visuo-spatial working memory component of Symbol Span.

Two objectives were set for this statistical exercise: firstly, understanding the findings required some detail about the measures used in the study as well as the limitations associated with these measures. Tasks designed to tap the processes involved in working memory are complex as storage and information processing overlap and do not always draw on verbal or visuospatial modalities in isolation. In fact, they often simultaneously draw on multiple cognitive functions, including short-term memory, long-term memory and attention. The overlay of executive functions, as well as the range of cognitive abilities involved in performing any one task, means that the task impurity problem, always a challenge when measuring of specific executive functions is needed, comes into play (Miyake et al., 2000). In working memory tasks, what counts as impurity usually depends on how much the processing aspect of the task needs to depend on executive functioning for its success, and this varies by domain. Alloway et al. (2004) for example, found that visuo-spatial working memory tasks rely more heavily on the use of executive control than do verbal memory tasks and scores for working memory in one domain can be influenced by working memory capacity in the other. In other tasks, the distinction between storage and processing becomes blurred as, for example, in the Digits Backward tasks where it has been claimed that this is a processing task in children but a storage task in older adults (St Clair- Thompson, 2010). These issues were considered when selecting measures for this study.

In order to obtain the necessary information on the working memory functioning of the sample group, two subtests were chosen from the fourth edition of the Weschler Adult Intelligence Scale (WAIS- IV), a scale widely used globally to measure intelligence and cognitive ability in adults. One test came from the Weschler Memory Scale – IV. This battery of tests provided a measure of Baddeley's (1974) three components of working memory, all of which were used as the dependent variable in the correlation analyses conducted.

The three tests administered were the Digit Span and Arithmetic subtests of the WAIS-IV Working Memory Index, and the Symbol Span subtest, a visuo-spatial working memory subtest, from the Weschler Memory Scale (WMS- IV). Looking to Baddeley's working memory theory and model (1974; 2000), these tests were selected to test the three identified components of the model. As discussed in Chapter One, the fourth component of the model, the episodic buffer, a link between working memory and long-term memory that was added to the model in 2000, was not measured in the current study as there is debate about its conceptualisation and measurement (Logie & Cowan, 2015.) The Digit Span and Arithmetic subtests link to Baddeley's (2000) components of the central executive, which is responsible for co-ordinating the actions of the other two components of working memory and for allocating attention to differing tasks, and to the phonological loop, which stores and processes auditory information and which is further sub-divided into the phonological store and articulatory rehearsal system. The Arithmetic subtest is also linked to long-term memory skills such as vocabulary and sentence comprehension. The Symbol Span subtest was chosen because it measures the central executive and the storage processes of the visuo-spatial sketchpad, the working memory component which stores and processes visual and spatial information.

It was necessary to determine that the three tests chosen for the measurement of the working memory components were not testing the same component. The lack of significant correlations found between the three working memory tests suggested that each of the tests tapped different aspects of working memory and that the tests drew on different skills to perform the task sets.

The second objective for the statistical exercise undertaken in this study was to consider whether, in this sample of older adults, there were working memory differences based on the demographic features of the population under consideration. Using the information gleamed from the self-report demographic questionnaire, the sample was divided into two groups for each life-style factor, generally in the classification of a high and a low group. The groups' three working memory test scores were then compared against each factor: for example, in the category of medications, the study considered whether there was a significant difference in Digit Span functioning between participants who took three or more prescribed medications per day and those who were on fewer medications, and then completed the same exercise with the Arithmetic and Symbol Span scores. The factors that elicited enough information to do this were: age (under/over 75), living independently or in a retirement community, relationship status (in a relationship/single), level of education (matric or less/post matric), contact with grandchildren (at least weekly/less than weekly), meals per day with protein (one per day/ two or more per day), medical conditions (two or fewer/ three or more), number of medications prescribed (two or fewer/three or more), exercise frequency (three times per week or more/less than three times a week), daily use of two languages (yes/no) and sleep efficiency (less than six/more than six). Categories with less than ten participants could not be included in the analysis as it was impossible to make inferences based on so few cases, and so the factors of gender, socio-economic status, working status, nationality, mother tongue, and contact with pets were not analysed. Working status, socio-economic status and being engaged in stimulating leisure activities are identified in the literature as life-style factors that have a very strong positive effect on working memory (Rzezak et al., 2015; Smart et al., 2014; Valenzuela & Sachdev, 2006) and the ommission of these factors from the study is a limitation. These factors could not be analysed because all of the participants fell into the same socio-economic status group, the majority of participants were retired/not working, and most of the participants participated in many daily/weekly activities. Homogeneity of sample as a limitation of this study will be discussed under limitations later in this section.

The literature reviewed in Chapter One suggested that all of the factors considered in this study would have at least some effect on working memory and it was anticipated that the factors of level of education, occupation, and stimulating leisure and social activities, the most commonly used proxies for measuring cognitive reserve (Bartres-Faz, 2018) would all exert a positive effect on working memory scores. The consensus from the literature covered in Chapter One is that none of these variables protects individuals from developing the signs of normal brain ageing or neuropathology or even brain damage, but that they appear to mitigate the impact of neuropathology. Cognitive reserve can only be estimated by measuring the aforementioned factors where those with a higher education, a complex work environment and satisfying career and participation in an enriched social environment and varied leisure activities are considered likely to have a higher cognitive reserve and that it is this that leads to better cognitive functioning. A limitation of this approach is that it is difficult to determine exactly how each of the factors influences this cognitive performance since these factors might confound with each other (Jones, et al., 2011) and one questions if they work individually or only in combination. For instance, formal education, the most commonly used proxy measure of cognitive reserve, is often touted as the most robust contributor of reserve but it is extremely difficult to isolate the contribution of this single factor from other factors, such as premorbid intelligence or socio-economic status, as they can highly influence educational attainment. Educational levels then also influence occupational achievement and career paths, and professional activity increases social interaction (and a sense of self-efficacy), which in turn contributes to the maintenance of cognitive reserve. This circular influence would seem to be at play in this study and might be a reason why there were no significant results found for these factors. The participants in this sample were all from a similar socio-economic status level, and fell into the high-status 10H grouping, as measured by an adapted version of The Living Standards Measure (LMS) (SAARF, 2001). There was a very uniform pattern of life experiences in the sample group: they were all well-educated, and educated in the same schooling system; they came from similar cultural backgrounds; they had generally all enjoyed stimulating working lives; and they were all very socially active and involved in many leisure activities. This cohort effect could, at face value, be the reason for the lack of variation in results found. It might be more advantageous, when studying a sample's cognitive functioning, to account for, and measure, combined multiple contributors of cognitive reserve in this grouping of factors, instead of examining each one individually. Doing so might offer a more accurate estimate of each participant's cognitive reserve and be a truer reflection of his/her cognitive functioning.

The next grouping of life-style factors considered in this study, and which are thought to positively mitigate cognitive health, relate more to daily living habits such as diet, exercise, sleep patterns, health and medication regimes, and mental activities and bilingualism, an enriching mental activity. The literature on the protective feature of these factors for cognitive health, covered in detail in Chapter One, led to an anticipation that there would be significantly positive results associated with these correlations but again, this was not the case. The lack of significant correlations here could stem from the same reasons discussed in the paragraph above. Because the participants were all from a high socio-economic status group and had all had good educations and successful working lives, they all had the finances and opportunities to look after their health, eat well and generally have enriching social lives. The participants were all well informed about health issues and knew the value of exercise and healthy diets and so, without a comparison group of low socio-economic status participants who did not have all the benefits these individuals did, it was difficult to show any significant differences in the results.

The only significant correlation found in this study was between being single and the Symbol Span test results, or the visuo-spatial component of working memory. The main demographic factors used in this study were age, living independently or in a retirement village and working status and it was somewhat unexpected that it was one of these factors, and not one of the main proxies used to measure cognitive reserve, that showed a significant result. On reflection and re-examination of notes taken during the interviews and the demographic questionnaires, it seems that the single participants have more time to engage in social and mentally enriching activities while those in relationships often spent more time caring for older partners and living more isolated lives. An example of this was a ninety-year old woman who had never been married, and who stood out by scoring in the top three on both the MoCA and the working memory tests. She had started working as a bookkeeper at

16 and had educated herself, ending up as a senior manager in a large firm. She had speculated in the property market, had done well and had only retired in her late seventies. She still drove and insisted on going somewhere different everyday to see new places and enjoy different things, often serving as the driver for her much younger village companions. She used a laptop, iPad and smart phone daily and had decided on the day of her assessment to start using Uber for her evening outings, and had signed up to the app. (Her purple toe-nail polish was also a talking point among the other participants.) In contrast, her younger sister, who lived next door to her, had married and had never worked, was often poorly, had not generally recovered from the death of her husband, and had to be visited by her children and grandchildren as she rarely left her home. She did not score sufficiently well on the MoCA to be included in the study.

Contrary to expectations, however, none of the other life-style factors examined in this study exerted a noticeable impact on working memory and, on face value, there is no evidence of any advantage to working memory from any of the life-style factors investigated in this research. It was generally assumed that the pattern of effects found in the literature, with involvement in positive lifestyle activities leading to better working memory functionality, would accurately capture the pattern of effects in the sample population in this study. There may be many reasons however, why this was not the case, the main one being the small and homogenous sample. The nature of inferential statistics means that the conclusions drawn from any empirical study are necessarily tentative, especially in a study of this kind, where the statistical analyses are designed to explore the relationships among a wide range of factors, rather than for the testing of one or two precise hypotheses. Because the data in this study are not from an experiment, alternative explanations for the pattern of results achieved must be sought. The relationships between the life-style factors and working memory outcomes were different here than from the previous empirical findings discussed in detail in Chapter One and from theoretical reasoning. Bialystok (2016) points out, however, that a non-significant result is an absence of evidence for a relationship and not evidence for a lack of relationship. A range of factors related to the statistic design chosen or the methodology employed could be responsible for the inability in this study to detect any of the expected relationships between life-style factors and working memory functioning discussed above and these are discussed in the following sub-section.

Limitations and future considerations

This sub-section questions whether the pattern of results ought to be taken at face value by critically looking at the theoretical and methodological concerns which may have influenced the results achieved. A range of factors related to methodology and the statistical design selected could result in an inability to detect significant relationships. In Chapter One, the difficulty with controlling for covariates in a study of this sort, where proxies are used to measure outcomes, was discussed, and will underlie this discussion.

The main limitation of this study is encompassed in the sample itself: the small size of the sample, its homogeneity, and the convenience sampling procedures utilised all contributed to the non-significant outcomes of the project. It is important to remember that this study set out to explore the working memory functionality of neurotypically healthy adults. For the purposes of this investigation, therefore, it was essential that, for the selected tests to show reliable working memory scores, screening to eliminate participants who showed evidence of cognitive decline beyond what would be typically anticipated in this age group was conducted. This was achieved using the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) screening test. This assessment was administered as the first step, once participants had agreed to participate, and had arrived for their assessment. In hindsight, a further step should have been incorporated into the method section: all interested participants should have been screened using the MoCA before been accepted into the project. Over thirty percent of the participants had to be excluded due to low scores of under 23 and this reduced the sample size greatly. If a screening stage had been incorporated, this issue may have been noticed and extra participants could have been recruited.

Finding extra participants would have been difficult however as procedurally, the assessment phase of the study brought many challenges. It was originally planned that most participants would be sourced from retirement homes in the greater Johannesburg area and eight homes of differing socio-economic levels were approached. Letters were sent to the matrons or managing bodies of the homes, explaining the project needs and asking for introductory meetings, but most homes did not even respond, despite prompting. Only one home responded favourably but even here, communal advertising was frowned upon and the social worker herself recruited the participants as she stressed that the over sixty-fives were a vulnerable age group and she would need to speak to each individual, and sometimes his/her family, personally and get permission for the exercise. Of the over 100 individuals she approached, only 35 participants were recruited, and of these, only 22 scored well enough on the MoCA to be included.

The initial exercise in this venue was very instructive and many lessons were learnt about the state of mind of the participants and their attitudes towards this exercise, about the time each assessment took and about the difficulty of the participants to ignore distractions and concentrate on the task at hand. All issues that, in their own way, influenced the study outcome and needed special attention.

As discussed in Chapter One, internalised ageism and the stereotype threat effect undermine older adults' memory performance and have a detrimental effect on working memory test scores (Armstrong et al., 2017; Marquet et al.,2016). Evidence of these factors were ever- present and participants were extremely anxious during the assessment phase, especially the females who constantly undermined their abilities with statements like ‘my husband always looked after the finances as my maths is bad, and now my memory is gone as well so I am going to fail this test’. We were told repeatedly that they couldn’t answer the questions because they were old and stupid and the participants compared experiences and answers after the assessments with trepidation. On the other hand, they reacted angrily if they thought we were patronising them because they were old. During the first stages on the tests, where questions are simple, they would ask why we were asking such easy questions and did we think they were stupid. There was also almost always a negative reaction to the sections on the demographic questionnaire asking about their eating habits and they would irately stress that they knew how to eat healthily and why did we think differently. It was obvious too that they were often giving the answers they thought were correct rather than the truth as they wanted to be seen as independent and capable. Lastly, they would tell stories about other residents, usually older than them, who weren’t coping with daily life skills, with the implication that they themselves were. Although the stereotype effect threat was anticipated, it was the level that was surprising and allaying these fears and attitudes took up a lot of the assessment time. In the planning of this study, more attention should have been paid to the psychological factors that influence memory performance.

What wasn’t anticipated was the high level of distraction that plagued the assessments. Participants’ attention wavered easily from the tasks at hand and some would stand up and go and check on something or start telling a story or ask unrelated questions, even when testing was done in a very quiet, private space, but especially when others were near, such as in the next room. Rodrigues (2015) investigated the effect of a distracting environment on the performance of attentional and working memory tasks in the elderly and results revealed better performance in the attentional tasks when these were administered in a non-distracting environment than when presented in a distracting environment. Participants were also faster at giving the correct answers when in a non-distracting space. This data confirmed our experience in the initial group of assessments and greater care had to be given to the potential damaging consequences of a distracting environment in the following sets of assessments.

For all of the above reasons, it was realised during this phase that it was extremely difficult for one person to handle the interviewing and the group's questions alone and permission was granted by the University's Research Ethics Committee to train three research assistants to help with future group sessions. This proved to be extremely useful: the assistants helped by administering the MoCA and helping the participants with the demographic questionnaires while the researcher did the memory tests privately without being disturbed. This had a very positive effect as most participants arrived at the sessions extremely nervous and negative about their 'poor memories'. They were sure they were going to 'fail' and, having someone with them at all times to reassure them, proved to have a calming influence on the group. As a result, participants were less tense and negative during the memory tests.

As none of the other homes allowed permission for the assessments, it became necessary to resort to finding a person in each of four other community villages in Johannesburg and Pretoria, and a manager in a small company, who would invite friends or colleagues from the complex or work place to his/her unit and meet with me. The disadvantages of this form of convenience sampling will be discussed later but two other challenges arose here that need mention: 1) the four people who were prepared to do this were all from very similar villages and no contact was possible with places housing lower socio-economic status residents and this made the final sample very homogenous and 2) it was difficult to follow the planned procedure with this arrangement. Some participants arrived uninformed and this made them feel pressurised into doing ‘tests’ that they did not want to do. These individuals were not pressured at all to continue, although they all stayed once the procedure had been explained. Others thought of it as a social tea party and it was often difficult to get participants to settle down. The issue of distraction and limited space to do assessments in private areas was exacerbated here.

The above scenario is further complicated by a sample population that was homogenous with regard to socio-economic status, culture and language usage, education levels and working experience, health concerns and social activity levels. The socio-economic status information on the participants was gleamed from an adapted version of the LSD Index (SAARF, 2001) which was designed by the South African Advertising Research Foundation to profile the South African market into homogeneous groups. In this Index, people are grouped according to their living standards using criteria such as urbanisation and ownership of vehicles and appliances and the index is supported to be a wealth measure based on standard of living rather than on income. Variables such as income, level of education and occupation are not considered at all and the index does not capture these variables. Used in combination with demographic questionnaires like the one used in this study however, it gives a fuller picture of the participants’ backgrounds. The fact that all the participants fell into the same LSM group and that their demographic markers showed them to all have had very similar life-styles and educations, left very little variation in the data with which to show real effect in the correlational analyses. If there had been variation, one could have expected more evidence that different life-style factors affected working memory.

The problematic recruitment trials culminated in a sample of only 50 and with this resultant small sample, this study did not bring enough information to the research to find real answers to the research questions posed.

Together with sample size and population representation discussed above as limitations to the study, the sampling method used in this study was a further limitation. As highlighted above, recruitment of participants was a major challenge in this research and convenience snow-balling sampling was used as a strategy to get individuals into the project. Unlike population-based sampling strategies, convenience sampling is a nonprobability sampling strategy, which implies that no form of random selection can occur. It cannot be claimed that the sample is representative of any population, as the sampling procedure does not ensure that each person in the target population had an equal chance of being included in the sample (Babbie & Mouton, 2014). Individuals are selected based on proximity and accessibility and the result of this is that the group has an ad hoc sociodemographic composition, which is not necessarily tailored to the parent population. There are clear advantages to this form of sampling as, of all the sampling strategies, convenience sampling is the easiest, least time-intensive, and least expensive to implement. But the disadvantage to this type of sampling is that it is impossible to determine the possible sampling error and make generalisations or statistical inferences from the sample to the population as results that derive from convenience sampling have known generalizability only to the sample studied and any research question addressed by this strategy is limited to the sample itself (Bornstein, Jager & Putick, 2013). The fact that convenience sampling was used in this study means that there may be something particular about the sample that is driving the non-significant results achieved.

The sample in this study was a serious limitation to achieving the anticipated outcomes and more care would be needed in future studies of this sort with sample selection. Random sampling should also be considered so that a sample representative of the larger population is achieved.

A further limitation of this study is the issue of the self-report element of the demographic questionnaire. A common methodology in the behavioural sciences is to use a self-report questionnaire to gather data which can be used to identify relationships between scores of the variables that the questionnaire is assumed to measure and behavioural or cognitive tasks that are measured during the study. The main strength of this method of data collection, other than is it very cost effective, can be easily implemented to large samples easily and quickly and can examine a large number of variables at the same time, is that it allows participants to describe their own experiences rather than the researcher inferring this information from observation or peer reports, and this is assumed to be more nuanced and authentic. Many of the demographic details needed in a study such as this one are only known by the participants themselves and this is the only way to obtain the necessary information. However, when using a self-report questionnaire in any scientific study, researchers are relying heavily on the honesty of their participants and, while the degree to which this is a problem varies with the topic of the questionnaire, there are different reasons why answers might not be fully truthful. Even when a participant is trying to be honest, he/she might not have the introspective ability to provide a completely accurate reply to the questions posed and this is especially true where cognitive functioning is questioned. Secondly, participants may also vary regarding their interpretation or understanding of the questions asked, again a concern with participants where cognitive functioning and decline is at the centre of the investigation. But central to this study was the concern about response bias or social desirability bias where participants answer questions in a way that portrays themselves in a good light and especially in a socially acceptable manner. This occurs even when the questionnaire is anonymous.

The stereotype threat effect (Armstrong et al., 2017) was very evident in this group and, as has been mentioned, there were negative reactions from participants when they thought we were pointing out negative old age behaviours. There was a strong feeling that participants were not always honest when completing their questionnaires, especially with regard to factors such as nutrition and sleep, and that they were supplying the socially desirable answers in a bid not to be judged incompetent. The Epworth Sleepiness Scale (ESS), discussed in Chapter Two, was a case in point. Sleep is a very important factor in the analysis of cognitive functioning but could not be analysed here as almost all the participants rated themselves highly on the questionnaire, ie., as having no sleep difficulties at all. A study in Australia (Sharwood, et al., 2012) compared the information from the self-report Epworth Sleepiness Scale (ESS), also used in this study, completed by long-distant drivers against home recordings using a flow monitor used during one night of sleep of the same drivers. Only 4.4% of the drivers reported any diagnosis or symptoms of sleep apnae on the ESS while the home diagnostic test found that 45% of the drivers were likely to have sleep apnae. They concluded that objective testing for sleep disorders was necessary as self-identification and reporting was insufficient to accurately identify sleep patterns. This could be true of other sections on the demographic questionnaire and more objective methods of data collection should perhaps have been introduced as checks against response and social desirability bias.

Central to the post-positivism approach underlying this study is that different research methods, including the use of different kinds of data and different forms of data collection, should be selected based on the details of the study undertaken (Zammito, 2004). One can question here whether the effects of life-style factors on cognition and working memory are not more suitable to detection by a qualitative investigation, with its more intuitive depth, than to a quantitative investigation. A study that models the concepts involved as numbers can only capture certain aspects of the relation between the concepts (in this case, life-style choices and working memory), as the information contained in quantitative measurements depends on what goes into the numbers. Some aspects of a person's life-style choices and habits, or at least the depth and nuance associated with them, cannot be captured numerically, even if others can. A mixed-method approach to this type of investigation may offer a more comprehensive depiction of the relationships sought and should therefore be considered in future endeavours.

Conclusion

In summary, this study set out to investigate if there is any relationship between life-style choices and working memory ability in older adults, exploring the concepts of neuroplasticity and cognitive reserve as mechanisms through which these constructs function. Cognitive reserve is a rich concept that has great heuristic and investigative value for research. While reserve is basically a simple concept, it has many layers and cannot be considered as a one-dimensional entity. The concepts of brain reserve and cognitive reserve may overlap somewhat, and they produce different predictions about the impact of brain pathology on function, so careful thought must go into translating theories about reserve into unidimensional research designs. However, the concept of reserve does have great salience for the investigation of variability in individual performance in old age and for the understanding of how the brain responds to challenges and pathologies typically expected in this group (Stern, 2002). Because cognitive reserve factors cannot be measured directly, and in vivo measures of neuropathology are not often available, sampling, operationalising and studying how cognitive reserve mitigates the relationship between neuropathology and cognitive functioning outcome has proven challenging both generally and specifically, and especially in this study. Moreover, the fact that no cause-and-effect relationships between measures of cognitive reserve and outcomes can be established, and only correlations can be recognised, muddies the scope of this research even further.

Despite the challenges encountered in this study and the lack of significant results achieved, there is a huge body of research, using different techniques and methodologies, that show converging evidence to support the hypothesis that life-style factors, used as proxies to measure the concept of cognitive reserve, do moderate cognitive functioning in old age. It is also evident from the many research studies that these factors influence the clinical course of dementia and cognitive functioning diseases. Therefore, despite the many limitations and caveats, there is enough evidence to suggest that life-style factors do contribute to cognitive functioning, and specifically working memory performance, in older adults but that perhaps it is necessary to broaden the framework to access the relationship of these two processes and contemplate additional issues, including brain reserve, genetic and psychological factors , and the effects of ageism on cognitive functioning. Understanding these relationships would foster a healthier old age population of the future, a societal imperative.

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Appendix A: Demographic Questionnaire

CODE | | | | |

Demographic Questionnaire

Gender: [ ] [ ] Date of Birth: [ ][ ] [ ][ ] [ ][ ][ ][ ]

Nationality:---

Marital status: please tick the relevant box

Married	
Living together as husband and wife	
Widow/widower	
Divorced/separated	
Other	

Do you have any children? ------------------------------------ How many?...........................

Do you have any grandchildren ?------------------------------ How many?...........................

How often do you see them? ---------------------------------

Educational and occupational status:

Level of Education		**Occupation**	
No schooling		Current occupation	
Less than primary school completed		Previous occupations:	
Primary school completed		1.	
Secondary school not completed		2.	
Secondary school completed		3.	
Tertiary education completed		4.	
Other		5.	

Level of Education		Occupation	

What medical conditions have you been treated for in the past five years:

1. ---
2. ---
3. ---
4. ---
5. ---
6. ---
7. ---
8. ---

What medications do you take everyday and what are they for?

1. ---
2. ---
3. ---
4. ---
5. ---
6. ---
7. ---
8. ---

How many meals do you eat a day? ---

How many of your meals have protein (per week)? --

How many pieces of fruit do you eat each day? ---

How many vegetables do you eat per day? ---

Do you play bridge? Yes No How often? ---------------------------------

Do you do crosswords? Yes No How often? ----------------------------------

Do you read the Newspaper? Yes No How often? ---------------------------------

Do you read novels? Yes No How often? ----------------------------------

Do you read magazines? Yes No How often? --------------------------------

Do you watch TV? Yes No How often? --------------------------------

What sort of exercise do you enjoy? How many times a week do you do this?

1. -- --
2. -- --
3. -- --
4. -- ---
5. -- ---

Do you ever go dancing? ---

Do you have a pet? --

What is your mother-tongue? --

Please list all the languages you know in order of dominance:

1. …………………………………….
2. ……………………………………..
3. ……………………………………..
4. ………………………………………

Please list all the languages you know in order of acquisition

1. ……………………………………….
2. ………………………………………..
3. …………………………………………
4. ……………………………………………….

At what age did you become proficient in these languages?

1……………………………………………….

2………………………………………………

3………………………………………………

4…………………………………………………….

Please rate your proficiency in each of the languages in terms of speaking, reading and writing, where

1 = excellent

2 = good

3 = fair

4= weak

Language 1.: Speaking ………………
Reading……………….
Writing……………….

Language 2.: Speaking ………………
Reading……………….
Writing……………….

Language 3.: Speaking ………………
Reading……………….
Writing……………….

Language 4.: Speaking ………………
Reading……………….
Writing……………….

Do you use more than one of these languages on a daily basis? …………………………

Which languages? ………………………………………………………………………...

Living Standards Measure:

Adapted from Living Standards Measure (LMS: South African Audience Research Foundation, 2001).

Please answer the following questions according to your circumstances while running your own home, and not in your current accommodation.

Question	Answer	
1. I had the following in my household:		
TV set	TRUE	FALSE
VCR	TRUE	FALSE
DVD player	TRUE	FALSE
M-Net/DStv subscription	TRUE	FALSE
Hi-fi/music centre	TRUE	FALSE
Computer / Laptop	TRUE	FALSE
Vacuum cleaner/floor polisher	TRUE	FALSE
Dishwashing machine	TRUE	FALSE
Washing machine	TRUE	FALSE
Tumble dryer	TRUE	FALSE
Home telephone (excluding a cell)	TRUE	FALSE
Deep freezer	TRUE	FALSE
Fridge/freezer (combination)	TRUE	FALSE
Electric stove	TRUE	FALSE
Microwave oven	TRUE	FALSE
Built-in kitchen sink	TRUE	FALSE
Home security service	TRUE	FALSE
3 or more cell phones in household	TRUE	FALSE
2 cell phones in household	TRUE	FALSE
Home theatre system	TRUE	FALSE
2. I had the following amenities in my home:		
Tap water in house/on plot	TRUE	FALSE
Hot running water from a geyser	TRUE	FALSE
Flush toilet in/outside house	TRUE	FALSE
3. There was a motor vehicle in our household	TRUE	FALSE
4. I was a city dweller	TRUE	FALSE
5. I lived in a house, cluster or town house	TRUE	FALSE
6. I lived in a rural area outside Gauteng and the Western Cape	TRUE	FALSE
There were no radios, or only one radio (excluding car radios) in my household	TRUE	FALSE
There were no domestic workers or household helpers in household (both live-in &	TRUE	FALSE

Question	Answer	
part time)		

Epworth sleepiness scale

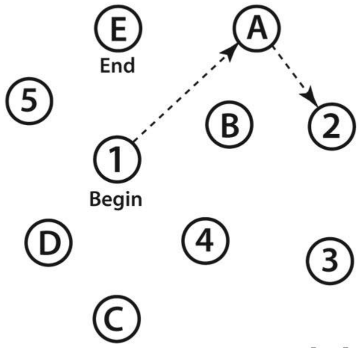
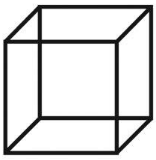
How likely are you to doze off or fall asleep in the following situations after you've had your usual night's sleep: (circle one number for each)

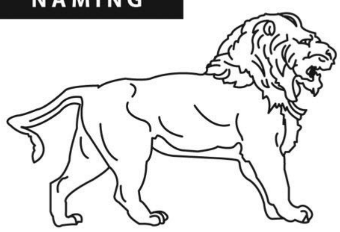
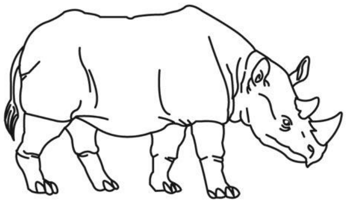
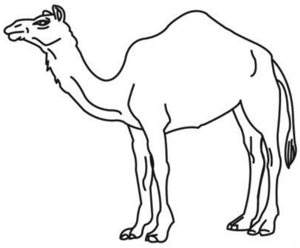
	Would never doze	**Slight chance**	**Moderate chance**	**High chance**
a. Sitting and reading	0	1	2	3
b. Watching television	0	1	2	3
c. Sitting inactive in a public place	0	1	2	3
d. Passenger in a car for an hour without a break	0	1	2	3
e. Lying down to rest in the afternoon	0	1	2	3
f. Sitting and talking to someone	0	1	2	3
g. Sitting quietly after lunch with no alcohol	0	1	2	3
h. In a car, while stopped for a few minutes in the traffic	0	1	2	3

Appendix B: The Montreal Cognitive Assessment

MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME :
Education :   Date of birth :
Sex :   DATE :

VISUOSPATIAL / EXECUTIVE			POINTS
 [ ]	Copy cube  [ ]	Draw CLOCK (Ten past eleven) (3 points) [ ] Contour [ ] Numbers [ ] Hands	___/5

NAMING			
 [ ]	 [ ]	 [ ]	___/3

MEMORY		FACE	VELVET	CHURCH	DAISY	RED	
Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.	1st trial						No points
	2nd trial						

ATTENTION		
Read list of digits (1 digit/ sec.).	Subject has to repeat them in the forward order [ ] 2 1 8 5 4 Subject has to repeat them in the backward order [ ] 7 4 2	___/2
Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors	[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B	___/1
Serial 7 subtraction starting at 100	[ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65 4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**	___/3

LANGUAGE		
Repeat :	I only know that John is the one to help today. [ ] The cat always hid under the couch when dogs were in the room. [ ]	___/2
Fluency / Name maximum number of words in one minute that begin with the letter F	[ ] _____ (N ≥ 11 words)	___/1

ABSTRACTION		
Similarity between e.g. banana - orange = fruit	[ ] train – bicycle [ ] watch - ruler	___/2

DELAYED RECALL		FACE	VELVET	CHURCH	DAISY	RED		
	Has to recall words **WITH NO CUE**	[ ]	[ ]	[ ]	[ ]	[ ]	Points for UNCUED recall only	___/5
Optional	Category cue							
	Multiple choice cue							

ORIENTATION		
	[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City	___/6

 www.mocatest.org Normal ≥26 / 30

TOTAL ___/30
Add 1 point if ≤ 12 yr edu

Administered by: ________________________________

Appendix C: Ethic's Clearance Certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Sinovich

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H17/11/53**
PROJECT TITLE	Factors that predict working memory in older adults
INVESTIGATOR(S)	Ms M Sinovich
SCHOOL/DEPARTMENT	Human and Community Development/
DATE CONSIDERED	17 November 2017
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	24 January 2021

DATE 25 January 2018 **CHAIRPERSON** ______________________
(Professor J Knight)

cc: Supervisor : Professor K Cockcroft

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

______________________ Signature

____/____/____ Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix D: Email to village(s) identified for research

Date

Dear Ms ……..

My name is Mary-Anne Sinovich and I am a Psychology Masters Student at The University of the Witwatersrand. I am conducting research into Working Memory in older adults.

I got your details from ……. and was hoping I could set up an appointment to come and discuss the project with you as I am looking for volunteers to participate in the study. I would need to see groups of participants for about 90 minutes: each participant would complete a questionnaire and do a short, non-intrusive memory test. I would provide tea and snacks for these sessions.

Please could I come and discuss this with you in more detail at a time convenient to you? My supervisors and I would also like to offer your residents talks on Memory and Sleep in return for their participation.

Kind regards

Mary-Anne Sinovich

084 504 0399

Appendix E: Invitation letter calling for Participants

School of Human and Community Development

CALL FOR PARTICIPANTS

Are you retired and over 65 years of age?

If you are and you would like to participate in a **study about Working Memory,** please contact me.

The study will involve you filling out a demographic questionnaire, as well as completing some memory tests and will take approximately 1 hour and 30 minutes of your time.

If you are interested, please contact Mary-Anne Sinovich on 084 504 0399 or email me at maryanne@thecodfather.co.za.

Alternatively, let us know you are willing to participate in the project by detaching a piece of paper below, writing your name on it and putting it in the box at reception.

Appendix F: Participant's cover information letter

School of Human and Community Development

Private Bag 3, Wits

2050

Johannesburg, South Africa

Tel: 27 (0)11 717 4524/5   Fax: 27 (0)11 717 4556

Dear Participant,

My name is Mary-Anne Sinovich and I am a student completing a Master's degree in Research Psychology at the University of Witwatersrand.

My research aims to identify the relationship between working memory and certain lifestyle factors in older South Africans. One of the reasons for doing this project is to discover why some people struggle more than others with memory problems. To discover more about this, I would very much like to invite you to fill in a questionnaire – which you are welcome to look at in advance, and which we will help you fill out. The questionnaire should take you between10 and 20 minutes to complete. After you finish the questionnaire, I would also like you to complete a few tests of working memory. Some of the questions on these tests will include things like remembering numbers and remembering sequences of events and this should take a further 30 – 40 minutes. You are most welcome to look at these test questions beforehand.

There will be a break in-between the exercises and tea and snacks will be served.

Participation in this study is totally voluntary and you are free to withdraw from the study at any time or for any reason, with no questions asked. There is no foreseeable benefit or harm in participating in this study and confidentiality is guaranteed as all results will be published in terms of group trends. As soon as the data is collected, it will be assigned an anonymous code. No findings that could identify any individual participant will be published and the raw data will only be accessed by myself and my supervisors, Professor Kate Cockcroft and Doctor Alison Bentley.

Results from this study will be written up in a research report for submission to the examiners. In addition, the results may be written up for publication and presented at conferences. All Wit's Masters reports are stored in the main library as well as being made available on the www. General feedback will be available to participants on request but, as no identifying information will be collected, individual feedback is not possible and will not be given.

By taking part in this study, you as a participant, agree to allow the data collected from this study to be published and used in further studies and consent to the above information.

Should you have any further questions please do not hesitate to contact me. My contact details appear below my signature.

Thank you for considering being part of this research project.

Kind Regards

Mary-Anne Sinovich

MA Research
084 504 0399
maryanne@thecodfather.co.za

Supervisors:

Professor Kate Cockcroft

011 717 4511

Kate.cockcroft@wits.ac.za

Doctor Alison Bentley

dralisonbentley@gmail.com

Appendix G: participants' Consent Form

School of Human and Community Development

Private Bag 3, Wits

2050

Johannesburg, South Africa

Tel: 27 (0)11 717 4524/5   Fax: 27 (0)11 717 4556

Working Memory in older Adults.

I, --, consent to taking part in the questionnaire session conducted by Mary-Anne Sinovich for her study exploring the factors associated with memory in older adults.

As a participant in her study, I understand that:

- My participation is voluntary.
- I am able to withdraw from the study at any time.
- I do not have to answer any question(s) I do not wish to.
- All my personal details and information will remain private and confidential, although I may be quoted in the final report.
- If however, I am quoted, it will be under a pseudonym given to me.
- None of my personal information will be stated in the final research (I will remain anonymous).

Signed: ---

Date: --