Subjective Age, Lifestyle Behaviours and Cognitive Functioning in Older Adults: Findings from the English Longitudinal Study of Ageing (ELSA)

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Abstract

Objective: Subjective age has been associated to a number of health related outcomes. The present study aimed to investigate whether subjective age (how younger or old an individual feels) as well as lifestyle behaviours are associated with cognitive functioning in older adults. *Method*: Data from two waves of the English Longitudinal Study of Ageing were used. Analysis was conducted at wave four (2008/2009), wave seven (2012/2015) and longitudinally, participants were aged 50 years and over. Subjective age, lifestyle behaviours – physical activity, sleep, smoking and alcohol consumption and covariates – chronological age, sex, relationship status and education were assessed to predict levels of immediate recall, delayed recall and verbal fluency at both wave four, seven and over time. *Results*: Overall, the sample felt younger than their chronological age and the discrepancy between chronological age and subjective age increased as age grew. A younger subjective age was associated with engaging in healthy lifestyle behaviours. Hierarchical multiple regression revealed that a younger subjective age was associated with better cognitive function and over time was associated with better immediate and delayed recall. *Conclusion*: The present study provides further evidence for an association between a younger subjective age and cognitive function in older adults. In particular, the findings from the longitudinal analysis found that even after adjusting for covariates, lifestyle behaviours and cognitive function at baseline the subjective experience of ageing predicted levels of episodic memory.

Literature review

Introduction

Over the past century, the life expectancy of an individual has increased. Consequently, the population has witnessed an unprecedented growth in the number of older adults (Lisanne, Hsu, Best, Barha & Liu Ambrose, 2018; Chatterji, Byles, Cutler, Seeman & Verdes, 2015). It is anticipated that by 2020 there will be as many people over 60 years as there are under 15 years globally (Harper, 2014). In Ireland the Central Statistics Office (2016) states that the age group of 65 years and over has increased the most since 2011, an increase of 19%. As a result of this increase in the ageing population there has been a shift in the causes of mortality (Ritchie et al., 2016). Posing a number of challenges for our society, such as higher demands for various health and welfare care (Schneider & Yvon, 2013). Accordingly, there is now a need for the development of strategies to help the ageing population remain in good health.

With this increase of older adults globally there is an urgent demand on maintaining older adult's independence (Anton et al., 2015). Ageing is characterised by cognitive and physical decline, and it is also linked with a higher prevalence of illness and disability (Aldwin, Park & Spiro, 2007). Among these challenges, this brings with it a greater proportion of the older population experiencing cognitive decline, one of the most feared and costly consequences of ageing (Ritchie et al., 2016; Wimo, Jonsson, Bond, Prince & Winbald, 2013). Furthermore, age related cognitive decline is pervasive irrespective of pathology even in the healthy older population without dementia (Boyle et al., 2013). It is also associated with a decline in an individual's ability to accomplish daily tasks, thus remain independent (Boyle et al., 2012; Deary et al., 2007). Consequently, research efforts to understand and potentially alleviate the effects of normal cognitive ageing is of great importance.

Research has suggested many risk and protective factors for cognitive ageing. With characteristics such as age, sex and education linked to cognitive function (Salthouse, 2009). Parisi and colleagues (2011) reported there being a differential change in both males and females in relation to their cognitive function. In regards, to education individuals with a higher level of education perform better across a range of cognitive tasks (Lenehan, Summers, Saunders, Summers & Vivkers, 2015). Researchers have also shown an interest in the role of lifestyle behaviours in age-related cognitive changes. With lifestyle behaviours such as diet, sleep, alcohol consumption, smoking and physical activity all being linked to cognitive ageing (Lafortune et al., 2016; Salthouse, 2009).

It has been well established that the normal ageing process is accompanied by a decline in cognitive function (Gard, Holzel & Lazer, 2014). Chronological age has been highlighted as one of the greatest risk factors for cognitive ageing (Bishop & Yankner, 2010; Blazer et al., 2015). However, the ageing process is a highly subjective experience (Montepare, 2009). In addition, a growing body of research considers that other constructs of age such as subjective age promotes healthy ageing (Stephen, Demuler & Terracciano, 2012; Montepare, 2009). The concept of subjective age provides a multidimensional view of the ageing process and it provides a more social, psychological and personal meaning to ageing than chronological age itself (Barrett, 2005). Though chronological age is an important factor for development, research considers that the age an individual feels can promote successful ageing (Stephen et al., 2012). This is because individuals with a younger subjective age are more likely to engage in healthy lifestyle behaviours (DeNeve, Diener, Tag & Xuereo, 2013). More recently, subjective age has been associated with cognitive function and dementia (Jaconelli et al., 2017; Stephen, Caudroit, Jaconelli & Terracciano, 2014). With a younger subjective age associated with better cognitive function 10 years later (Stephen et al., 2014). This is why it is important to focus on whether a younger subjective age with better cognitive function, irrespective of chronological age.

The present review will focus on subjective age and lifestyle behaviours in relation to cognitive function in older adults. With the ageing population and its relation to cognitive decline, developing strategies to maintain or preserve individuals cognitive functioning has become increasingly important. It is evident that engaging in healthy lifestyle behaviours is related to better cognitive function throughout the lifespan (Salthouse, 2009) and also the relation between a younger subjective age and engaging in healthy lifestyle behaviours (DeNeve et al., 2013). Yet, more recently how young or old and individual feels in relation to their chronological age, is associated with many health related outcomes including cognitive performance, dementia and higher risk mortality (Stephan, Sutin, Terracciano, 2018). Thus, subjective age is an important construct of age to look at considering its many associations. Extending on the small amount of research that has focused on a younger subjective age and cognitive function.

Cognitive function

With the rapidly ageing society it has become more important to counter the normal age-related change in cognitive function (Gard, Holzel & Lazar, 2014). Cognitive function is fundamental to our daily living (Bherer, Erickson & Liu-

Amberose, 2013) relating to an individual's ability to manage and perform daily tasks and to live independently (Boyle et al., 2012). With life expectancy continuing to grow, so too does the risk of cognitive decline as chronological age itself is the greatest risk factor for decline in cognitive function (Bishop & Yankner, 2010). Although cognitive decline is common along with ageing, there is a high degree of variability (Bourassa, Memel, Woolverton & Sbarra, 2017). A wide variety of important individual characteristics are associated with this inter-individual variability in cognitive decline. These characteristics include lifestyle behaviours (Almeida, 2014; Chen et al., 2016; Neafsey & Collins, 2011; Zhu et al., 2017; Zheng, Xia, Zhou, Tao & Chen, 2016), mental health (Hantke et al., 2016) and social engagement (Freeman, Spirgiene, Martin-Khan & Hirdes, 2017). Current research supports the idea that excessive alcohol consumption, poor diet, smoking and sedentary behaviour all have deleterious effects on cognitive ageing (Kesse-Guyot, Andreeva, Lassale, Hercberg & Galan, 2014).

Cognitive ageing, as a normal process of ageing has been well researched. Cognitive ageing has been defined as a process of gradual, ongoing, and highly variable changes in individual's cognitive function as they age (Blazer, Yaffe & Liverman, 2015). Studies have suggested that cognitive change is not unitary and that some cognitive abilities decline more rapid than others (Bamidis et al., 2014; Harada, Love & Triebel, 2013). Processing speed reaches its peak during early adulthood and declines from midlife onwards (Salthouse, 2009). A decline in mental processing speed manifests as increased reaction times during tasks (Jiang et al., 2017; Salthouse, 2010). Ageing is associated with impairments in language production, yet most comprehension abilities remain stable over time and word knowledge is said to improve and only declines in very old age (Burke & MacKay, 1997; Schafto & Tyler, 2014; Verhaegen, 2003). Visuospatial abilities deteriorate with age, studies have shown that older adults have more difficulty visually constructing objects (Bigelow et al., 2015; Howieson, Holm, Kaye, Oken & Howieson, 1993). On the other hand, according to Harada and colleagues (2013) object perception or recognising familiar objects and spatial perception remain relatively stable over time. Fortenbaugh and colleagues (2015) found that sustained attention peaked in one's 40's and began to decline thereafter, these results were consistent with other findings (Yeatman, Wandell & Mezer, 2014). Research has shown that processes such as concept formation, abstraction and mental flexibility decline with age (Lezak et al., 2012). Declines in executive function can be seen in healthy adults from the age of 45 to 65 years (Royall et al., 2002).

Fluid and crystallised intelligence are the most prominent theories of intelligence and are well researched (Schroeders, Schipolowski & Wilhelm, 2015). Fluid intelligence is the ability to "understand relations among stimuli, comprehend implications and draw inferences" whereas crystallised intelligence is defined as "acculturation knowledge using tasks indicating breadth and depth of the knowledge of the dominant culture" (Horn & Noll, 1997, p.69). Studies on the age-related changes of both fluid and crystallised intelligence have found crystallised intelligence to remain stable or even improve throughout the lifespan, whereas fluid intelligence reaches its peak in early adulthood and this is then followed by decline (Horn, 2008; Horn & Cattell, 1967).

One of the most common complaints among older adults is their memory (Bamidis, 2014). Short term or working memory functions are prone to age-related changes (Zinke et al., 2014). Within long term memory a divide is drawn between implicit and explicit memory. Explicit memory is the information that you consciously recall an implicit memory is the information that is recalled unconsciously and effortlessly (Park & Donaldson, 2016). In contrast to explicit memory, implicit memory tends to remain stable over time (Lezak, Howieson, Bigler & Tranel, 2012). Cognitive ageing has shown age-related declines for episodic memory (Levine et al., 2002). However, semantic memory is maintained over the course of the lifespan (Brickman & Stern, 2009). This contrast between episodic memory and semantic memory has been long researched (Tulving, 1972). Episodic memory pertains to the recollection of events and information storage, whereas semantic memory refers to general knowledge (Brickman & Stern, 2009; Levine, 2002). Although these are two separate entities, these systems interact with one another, as episodic memory brings together information in semantic memory to form a theoretically related time based event (Brickman & Stern, 2009). Episodic memory is usually tested by getting participants to learn information such as a list of words and recall them immediately and after a delay (Cheke & Clayton, 2015). This requires three aspects including the encoding phase, the storage phase and the retrieval of stored information (Brickman & Stern, 2009). Semantic memory is tested using verbal fluency tasks. Requiring participants to retrieve words of a particular category (Shao, Janse, Visser & Meyer, 2014).

There is though variability in age-related cognitive changes from individual to individual and other health related factors can also accelerate age-related cognitive decline (Salthouse, 2012). This variability in cognitive change can be explained by individual differences in life experiences, health status, lifestyle behaviours, education, emotional factors, socioeconomic status and genetics (Blazer et al., 2015). Ageing is associated with frontal system declines even in the absence of pathology, with Singh-Minoux and colleagues (2012) finding that the average performance in all cognitive domains except vocabulary declined over a period of 10 years, with decline evident in individuals as young as 45 years.

Neuroscience research will help to understand the structural and functional changes of the ageing brain and the individual differences in cognitive change. Neuroimaging studies have shown that older adults demonstrate differential activity in the same areas or other areas of the brain in comparison to younger individuals (Bishop, Lu & Yankner, 2010; Cabeza, Nyberg & Park, 2016). Areas of the brain have shown less coordinated activity in interacting with other areas of the brain and this is related to poorer performance in a number of cognitive domains (Andrews-Hanna et al., 2007). This change in activity patterns in older adults represents adaptive plasticity to face age-related change in the brain to maintain performance (Bishop et al., 2010; Cabeza et al., 2016; Harada et al., 2013). The preservation of cognitive abilities in some domains such as vocabulary and comprehension and the decline in others such as memory and processing speed (Bamidis et al., 2014; Deary et al., 2009) has led to hypothesis that preserved cognition is a construct of latent neural changes (Meuier, Stamatakis & Tyler, 2014). This supporting the idea that brain structures decline over time because of the ageing process and other structures from other brain regions are recruited to preserve function.

Research has shown that the ageing process has differential effects across individuals (Baltes, Reese & Nesselroade, 1977; Salthouse, 2014). Brain and cognitive reserve were proposed to explain why some individuals have a greater ability to endure pathological changes in the brain. According to Barulli and Stern (2013) cognitive and brain reserve are complementary rather than competing, they influence one another and are interconnected. Brain reserve posits that susceptibility to brain damage or pathology is a function of both the extent of the damage and a quantitative measure of brain reserve capacity (Barulli & Stern, 2013). Thus, when such pathology reduces brain reserve capacity beyond a certain point, clinical onset occurs. Cognitive reserve can be considered an active model, whereas brain reserve is more of a passive model, with the idea that there is a threshold based on brain reserve capacity. This leading onto the limitations of brain reserve in that it does not account for individual differences in cognitive or functional processing (Bartres-Faz & Arenaza-Urquijo, 2011).

Cognitive reserve theory posits that some individuals have a greater ability to gather and coordinate specific brain regions. This meaning that these individuals are able to endure a high level of brain pathology before a clinical onset is reached (Lenehan, Summers, Saunders, Summers & Vickers, 2015). The idea of reserve comes from the fact that there does not seem to be a direct relationship between the extent of brain pathology and the clinical manifestation of that change (Stern, 2002). Evaluating an individual's level of cognitive reserve involves concluding from indirect factors such as lifetime experiences, educational and occupational attainment and engagement in leisure and social activities (Barulli & Stern, 2013; Lenehan et al., 2015; Tucker & Stern, 2011). Studies have indicated that educational attainment modifies the link between brain pathology and neuropsychological test performance (Dufouil, Alpervitch & Tzourio, 2003; Rentz et al., 2010). Educational attainment is regarded as one of the most widely excepted risk factors for dementia (Xu et al., 2016), with Brayne and colleagues (2010) stating that school education has a dose related effect on reducing the risk of dementia with ageing. However, the transition from normal cognitive ageing to dementia is not definitive, mild cognitive impairment relates to the transition from normal cognitive ageing to probable dementia (Vandenberghe & Tourney, 2005).

The underlying mechanisms of cognitive reserve operates through the concept of neural plasticity. The plasticity of the brain is the response to environmental stimuli that enables the brain to adapt and allows for learning and the formation of new memories (Spires-Jones & Knafo, 2012). Studies on animal subjects have indicated that there are certain factors that can inhibit or promote the brains capacity to generate neurons even in adulthood, physical activity and mental stimulation are these such factors (Lee et al., 2012). Individuals that have greater cognitive reserve can access alternative neural networks to complete a task when their primary networks are damaged (Tucker & Stern, 2011). Evidence for reserve is based on the assumption that disease pathology slowly develops over time and that the pathology begins many years before a clinical diagnosis is made (Tucker & Stern, 2011). Earlier studies such as Richards and Sacker (2003) examined how data on cognitive reserve variables such as education and leisure activities collected at different time points affected cognitive function in midlife. Results indicated that life experiences at several points over the course of the lifespan including childhood IQ, educational attainment in adolescence and occupational attainment in adulthood all contributed to cognitive performance. This suggesting that early childhood factors are crucial for the build-up of cognitive reserve and that it continues to build depending on experiences throughout the lifespan. Brain reserve adapts different approaches used by healthy older adults when managing task demands and reiterates differences in neural efficiency or capacity (Martins, Joanette & Monchi, 2015). Reserve uses brain networks or cognitive resources that are less susceptible to disruption. Whereas, neural compensation refers to adopting new compensatory brain networks after pathology has affected those specific networks. It shows the individual differences in being able to cope with age-related changes or pathology. (Bartres-Faz & Arenaza-Urquijo, 2011; Stern, 2009).

There are a number of factors associated with cognitive ageing (Blazer et al., 2015). It is evident from the literature that all individual's cognitive changes vary with ageing (Harada et al., 2013). It's because of this variability that these different models of cognitive ageing have been hypothesised. Cognitive reserve and brain reserve are explaining these individual differences. Yet, combining the two models, Sumouski and colleagues (2014) found that individuals with larger brain reserve capacity and better lifetime experiences were protected against cognitive decline over a period of four to five years. More well-established brain measures are necessary rather than the standard mechanisms of brain reserve, such as brain size. Therefore, the cognitive reserve theory is a more well-established and applicable model that can be appropriate throughout the lifespan.

The scaffolding theory of ageing and cognition (Park & Reuter-Lorenz, 2009) is a model of cognitive ageing that explains how the combined effects of conflicting and compensatory neural processes produce varying levels of cognitive function (Reuter-Lorenz & Park, 2014). The scaffolding theory explains age differences in cognitive function by combining the effects of biological and neurophysiological factors that are associated with the normal ageing process, and to outline their interactions with protective factors and new compensatory processes that are at work in the ageing brain (Reuter-Lorenz & Park, 2014). Thus, age-related changes would be met with functional variations in affected brain regions in order to minimise cognitive impact on brain changes. The scaffolding theory of ageing and cognition differs from cognitive reserve as it applies the concept of ageing and also the brains response to brain damage or pathologies throughout the lifespan (Barulli

& Stern, 2013). Yet it overlooks the fact that cognitive reserve focuses on lifetime experiences and its use to predict differences in the cognitive performance of older adults (Barulli, Rakitin, Lemaine & Stern, 2013), as well as differences in performance and brain activation because of changes in task difficulty (Stern et al., 2012). Cognitive reserve is applicable across the lifespan and also across different brain changes and it can also account for compensatory behaviours in a way that the scaffolding theory of ageing and cognition cannot (Barulli & Stern, 2013).

A poor cognitive status is one of the most disabling conditions in older adulthood (Brummel et al., 2014; Singh-Manoux et al., 2012). Cognitive decline refers to pathological change and is considered a great threat to the ageing population, with 50% of individuals aged over 85 years having Alzheimer's disease (Bishop et al., 2010). Whereas cognitive ageing is non-pathological (Blazer et al., 2015), yet both are linked to disability and hospitalisation (Brummel et al., 2014; Woods et al., 2011). Functional magnetic resonance studies have suggested that changes in the hippocampus and other associated regions can help to distinguish between pathological and non-pathological decline (Bishop et al., 2010; Rodríguez & Raz, 2004). Reduced activity in the subiculum and the denate gyrus, which are thought to contribute to memory function are related to age-related cognitive decline, whereas reduced activity in the entorhinal cortex also associated with memory, has been linked to the early onset of Alzheimer's disease and cognitive impairment (Schultz, Sommer & Peters, 2015). Those with cognitive decline are at an increased risk of it developing into mild cognitive impairment and dementia (Plassman, Williams, Burker, Holsinger & Benjamin, 2010). Some cognitive decline comes from reduced brain size and plasticity; this can occur normally in most individuals.

However, not all cognitive decline would be considered normal decline (Miller, Taler, Davidson & Messier, 2012).

Though age has been considered the greatest risk factor for cognitive decline and is considered a normal process (Bishop & Yankner, 2010). Ageing is considered to be a highly subjective experience (Montepare, 2009). As individuals age there is an increasing discrepancy between their subjective age and chronological age. It is now well-established that the majority of individuals feel younger than their chronological age (Montepare, 2009; Stephan et al., 2012) this is regardless of age-related changes (Rubin & Bernsten, 2006). It is evident this benefit of feeling younger. However, little research has focused on the contribution of subjective age in relation to cognitive functioning in older adults. Consistent in the research is the clinical importance of one's self-perception of cognitive decline (Rabin, Smart & Amariglio, 2017). If feeling older than one's chronological age is linked to cognitive function (Schafer & Shippee, 2010; Stephan et al., 2011). It is also likely that subjective age may reflect the pathological brain changes and age-related brain changes, that are not always detectable with cognitive tests (Kwak, Kim, Chey & Youm, 2018).

Subjective age

Research on subjective age begun in the 1950s by researchers wanting to develop a further understanding of adult's attitudes towards ageing (Barack & Stern, 1986). Primary work suggested that subjective age was a complex personal concept that reflected how old individuals perceived themselves to act, look, feel and are desired to be (Montepare, 2009). With subjective age initially being defined as "the individual's self-perception in terms of reference age groups" (Blau, 1956). Later subjective age or self-perceived age was defined as how old one feels (Settersten & Mayer, 1997) and that is characterises the way in which an individual experiences their own age (Guiot, 2001). It's more recently just being defined as how old an individual feels (Lindner & Nosek, 2018; Montepare, 2009; Stephan et al., 2012; Stephan et al., 2014, Stephan et al., 2017). Research up to date has suggested that individuals often fail to identify with their real age classification, subjective age seems to be determined by important autobiographical and social markers throughout individual's lifespan (Montepare & Clements, 2001). Thus, there are changes in subjective age across the lifespan (Galambos et al., 2005). Subjective age is a proxy for being able to help the challenges and experiences of old age (Infurna, Gerstorf, Robertson, Berg & Zarit, 2010). For example, minimising the impact of age-related changes in physical and cognitive domains with a younger subjective age contributes to having a positive self-perception of one's own ageing.

The manner in which individuals age varies widely from person to person. For example, the activity restriction model of depressed affect suggests that health related stressors lead to a restriction in any physical activity, which in turn heightens depressive affect (Williamson, 1998). The strengths and vulnerabilities integration model implies that ageing related vulnerabilities such as functional limitations and chronic health conditions threaten older adult's skills and experiences that are used to maintain an affective living (Charles, 2010). Some individuals often appraise their own ageing process, this appraisal contributes to individuals building a subjective view of how well they are ageing (Hughes & Lachman, 2016). As important as chronological age is in relation to development, research suggests that having a younger subjective age than your chronological age, promotes successful ageing (Stephan, Demuler & Terracciano, 2012; Montepare, 2009). Subjective ageing is a growing area in Gerontology and this is because of its links to important outcomes in older adults (Stephan, Terracciano & Hess, 2017). Providing a different meaning to ageing than chronological age on its own (Barrett, 2005). Chronological age is of limited value when studying individual differences in development because it cannot explain the difference in subjective perceptions of ageing and the ageing processes (Kornadt, Hess, Voss & Rothermund, 2016). This tendency to feel younger than your chronological age is a crucial construct in old age (Stephan et al., 2012). Indeed, research to date has shown that independent of chronological age, a younger subjective age is linked to health promoting behaviours, better physical and mental health, better cognitive performance and a slower decline in cognitive function over time (Stephan et al., 2017).

Early research on the concept of subjective age has suggested that it is a motivational facet of identity that is linked with the desire to be either younger or older (Galambos, Turner & Tilton-Weaver, 2005). Research of subjective age across the lifespan has shown that adolescents tend to feel older than their chronological age and beginning around the age of 30 years' adults tend to feel younger than their chronological age (Galambos et al., 2005) despite age related changes (Stephan et al., 2014). This discrepancy between chronological age and subjective age becomes more definitive with ageing, as individuals over the age of 40 years feel on average 20% younger than their actual age (Rubin & Berntsen, 2006). Several studies have shown that older people perceive themselves as younger in age than they actually are (Eibach, 2011; Schafer & Shippee, 2010; Stephan et al., 2012). Additionally, those who feel younger than their actual age act and even appear younger (Choi, Dinitto & Kim, 2014; Stephan, Chalabaev, Kotter-Gruhn & Jaconelli, 2013). Considering the stigma that is attached to growing older, having a younger subjective age is a self-enhancing strategy and has been shown to have several beneficial effects (Keyes & Westerhof, 2012). Diehl and Wahl (2010) proposed five domains in which these beneficial effects associated with subjective age might manifest. These domains are physical functioning, cognitive functioning, interpersonal relations, social and emotional functioning and lifestyle behaviours. A younger subjective age being associated with increase health, productivity and longevity including better well-being, physical functioning and cognitive function (Montepare, 2009; Stephan et al., 2014; Stephan et al., 2013). In addition, a younger subjective age is also linked to fewer depressive symptoms (Keyes & Westerhof, 2012) and those who feel sad tend to feel older (Dutt & Wahl, 2017), which in turn is associated with cognitive performance (Kwak, Yang & Koo, 2016). It also contributes to well-being (Mock & Eibach, 2011), which has been linked to health and longevity (Chida & Steptoe, 2008), with a younger subjective age adding an additional 7.5 years onto one's life (Kotter-Gruhn, Klienspehn-Ammerlahn, Gerstorf & Smith, 2009). Interestingly, in the majority of these studies subjective age rivalled and even outperformed chronological age as a predictor of psychological and health related outcomes (Stephan, Chalabaev, Kotter-Gruhn & Jaconelli, 2012). Thus feeling older than your chronological age in middle age and older adulthood is associated with a number of negative outcomes (Eibach, 2011). To be specific those who report feeling older, experience lower life satisfaction (Teuscher, 2009), lower self-esteem (Montepare, 2009), lower self-efficacy (Boehmer, 2007) and higher pessimism (Schafer & Shippee, 2010). A younger subjective age results in better overall health which leads to lower health care costs (Barrett, 2005; Boehmer, 2007; Stephan, Caudroit & Chalabaev, 2011).

As outlined above, chronological age is a powerful predictor of cognitive ageing (Singh-Manoux et al., 2012), research has suggested that cognitive functions tend to decline as part of the normative ageing process (Stephan, Sutin, Caudroit & Terracciano, 2016). Individuals performance on cognitive tasks is unrelated to level and change in subjective age (Infurna, Gerstorf, Robertson, Berg & Zarit, 2010) although subjective age has been found to play a role in cognitive ageing. Stephan and colleagues (2014) found that younger subjective age was associated with better cognitive function 10 years later, independent of chronological age. The strength of this association was comparable or larger than the effects seen for well-established risk factors for cognitive decline (Stephan et al., 2014). Whereas feeling older is predictive of low concurrent memory performance (Stephan, Sutin, Caudroit & Terracciano, 2015). This study finding that a younger subjective age is associated with a slower decline in immediate recall, delayed recall and global memory functioning. Thus suggesting that the emotional stability of an individual with a younger subjective age may help them maintain their memory function over time (Stephan et al., 2015). One promising aspect of this study in relation to the link between subjective age and changes in delayed recall, is that as delayed recall has a high accuracy for differentiating individuals with mild cognitive impairment from individuals maintaining their cognitive function (Zhao, Lv, Zhou, Hong, & Guo, 2012). Research into cognitive ageing has focused on memory self-efficacy as important for older adults. Memory self-efficacy is the beliefs about one’s ability to use memory in different situations (Herzog, Hultsch & Dixon, 1989) with a higher memory self-efficacy being linked to motivational effects in relation to cognitive challenges and as a result a higher cognitive performance (Valentijn et al., 2006). Irrespective of chronological age, subjective age has a strong impact on individual’s attitudes about their cognitive ageing. With individuals that feel younger being more optimistic about maintaining their memory function (Schafer & Shippee, 2010). Thus, those with a younger subjective age may be linked to better confidence in their memory function resulting in better cognitive performance (Stephan, Caudoit & Chalabaev, 2011). This subjective experience of ageing may be a result of an individual's own subjective experience of age-related cognitive decline. As subjective reports of an individual's cognitive function are an important predictor of neurophysiological or brain changes (Kwak et al., 2018). This developing the link between the subjective age and neurophysiological ageing. This study focused on the relation between subjective age and the ageing brain. They found that the main component of subjective age is located in the fronto-striatal dopaminergic system. This structure is essential for illustrating brain ageing and cognitive decline (Backman, Lindenberger, Li & Nyberg, 2010). This association between subjective age and cognitive functioning is likely to be reciprocal. As Stephan, Sutin, Kornadt, Caudroit and Terracciano (2018) found an association between adolescents IQ and subjective age in older adults. A higher IQ in adolescence was a predictor of feeling younger in later life. This is consistent with existing research that links a higher cognitive ability in adolescence to more positive outcomes in older adulthood (Ritchie et al., 2016).

The age one feels may change how an individual views or approaches one's health (Hubley & Russell, 2009) with a younger subjective age predicting better perceived health (Demakakos, Gjonca & Nazroo, 2007). Although older participants report a less positive perception of the ageing process the effects of chronological age faded when functional indicators were taken into consideration. Given the association between subjective age and health related outcomes, subjective age may also be associated to lifestyle behaviours (Stephan, Sutin, Bayard & Terracciano, 2017). It is well-established the importance of physical activity in protecting and enhancing cognitive function (Bamidis et al., 2014; Kramer, Erickson & Colcombe, 2006). Prior research has found that individuals with a younger subjective age are more inclined to engage in physical activity (Caudroit, Stephan, Chalabaev & LeScanff, 2012). Given the relation between subjective age, mortality and longevity, it is likely that feeling younger is also associated with slower physiological ageing, better health and physical fitness (Stephan, Sutin & Terracciano, 2015). This is based on the idea of interoception, where physiological processes and afferent biological messages are unified into individual's self-assessments (Stephan et al., 2015). As a result, subjective age may be associated with physical functioning. Chronological age is often used to explain changes in one's sleep quality (Grandner et al., 2012; Hirschkowitz et al., 2015). Given the association between subjective age, health and lifestyle behaviours it may also be associated with sleep quality. Stephan, Sutin, Bayard & Terracciano, (2015) found that individuals who reported an older subjective age had poorer sleep quality over time. This maybe because subjective age is a biopsychosocial marker of ageing that predicts a range of processes that are manifested in sleep quality (Stephan et al., 2015). For example, feeling older than one's chronological age may amplify some of these processes such as sedentary behaviours and thus result in a poorer sleep quality (Chen, Steptoe, Chen, Ku & Lin, 2017). The results of Stephan and colleagues (2015) study show that sleep quality is a potential process that links subjective age to many cognitive and health related outcomes. As sleep is also related to cognitive functioning (Fortier-Brochu, Beaulieu-Bonneau, Ivers & Morin, 2012; Hirshkowitz et al., 2015). In relation to subjective age and alcohol consumption research has mainly focused on adolescents

(Galambos et al., 2005; Montepare, 2009). Showing that adolescents with a more mature subjective age tend to consume more alcohol, this may not be the same for older adults as these behaviours in adolescence can be related to their change in age status (Montepare, 2009). However, it is evident that there is a link there, which also may be caused by the relationship between subjective age and health outcomes in older adults. Smoking is known to have a number of negative outcomes (Lozano et al., 2012), yet research to date has not focused specifically on smoking and subjective age. Research has found that individuals who smoke tend to engage in less physical activity (Papathanasiou et al., 2012) yet it is inconsistent. However, the relation between smoking and physical fitness is well documented (Papathanasiou et al., 2010). Individuals who feel younger may engage in more positive lifestyle behaviours, as lifestyle behaviours do not occur in isolation they tend to cluster (Conry et al., 2011).

Chronological time is the same for everyone, whereas subjective perceptions of ageing are not considered invariant across people and ages (Miche et al., 2014). In that regard, it’s important to look at alternative concepts of age to understand individual differences in development. Individuals are consciously aware of age-related changes such as greying of hair, but the personal experience of ageing is more subjective, with older adult’s self-perceptions depending on contextual factors or life domains (Diehl & Wahl, 2010; Kornadt & Rothermund, 2011). The majority of older adults indicate feeling younger than their chronological age and individuals are considered to engage in healthier lifestyle behaviours when their subjective age is younger, with feeling older being linked to several negative outcomes (Eibach, 2011; Stephan, Chalabaev, Kotter-Gruhn & Jaconelli, 2013). Subjective age is related to both social and biological factors, which in turn may influence the age-related outcomes of older adults.

Lifestyle behaviours

The risk of developing a major disease and the leading cause of death in the world is distinctly affected by our lifestyle choices (WHO, 2011). An unhealthy diet, physical inactivity, smoking, excessive amounts of alcohol consumption, obesity, disturbed sleep and other lifestyle behaviours are associated with the development of diseases and mortality (Lozano et al., 2012). It has been suggested that these lifestyle behaviours are interrelated and cluster within individuals (Conry et al., 2011; Heroux et al., 2011) indicating that individual's who smoke tend to engage in other unhealthy lifestyle behaviours. As well as the biological age-related changes, ageing is a time of a social and psychological shift in one's life. Entering older adulthood can lead to major changes in lifestyle, which can directly or indirectly impact on older adult's health. These changes to one's life can have a negative impact on older adults engaging in healthy lifestyle behaviours (McNaughton, Crawford, Ball & Salmon, 2012). This is why investigating lifestyle behaviours among older adults is particularly important, because of the impact of chronic diseases that may present in older adults and age-related cognitive decline. The risk of chronic diseases and cognitive decline increases with the number of unhealthy behaviours, with low levels of physical activity, poor diet, high levels of alcohol consumption and smoking all shown to have adverse effects on one's health (Artaud et al., 2013; Harrington et al., 2009). Several studies have shown that the above lifestyle behaviours have also been linked with cognitive health (Elwood et al., 2013; Lee et al., 2010). With Lee and colleagues (2010) indicating that, physical activity, moderate alcohol consumption and a healthy diet give some protection against age-related cognitive decline and dementia. Midlife lifestyle behaviours were also found to contribute to cognitive function in later life (Lee et al., 2010).

Physical activity enhances brain vitality (Groot et al., 2016). A substantial amount of research has linked physical activity to cognitive function (Bherer, Erickson & Ambrose, 2013; Elwood et al., 2013). Research has suggested that individuals who are active throughout their lifespan, especially in midlife seem to perform better cognitively in later adulthood (Sofi et al., 2011). A meta-analytic review of this literature on physical activity and cognitive function indicated that there was a 38% reduction in the risk of cognitive decline with vigorous levels of physical activity and a 35% reduction in participants engaging in moderate physical activity (Sofi et al., 2011). Also, Etgen and colleagues (2010) found that older adults demonstrated a reduction of incidence of cognitive impairment over a 2-year period as a result of moderate to high levels of physical activity. Thus, physical activity is not just associated with increased longevity but also related to preserving cognitive function in older adults, giving older adults a better quality of life (Blondell, Hamersley-Mather & Veerman, 2014). Several studies have investigated whether physical activity can slow down cognitive decline even in individuals with a clinical diagnoses of dementia. There is some evidence that physical activity can improve dementia patients cognitive function (Bossers et al., 2015; Christofoletti et al., 2011; Groot et al., 2016). A meta-analysis of physical activity interventions on dementia patients found an overall positive affect of physical activity (Groot et al., 2016).

With ageing there seems to be a decrease in duration of good quality sleep and an increase in sleeplessness and sleep disturbances (Banks et al., 2010). According to Hirshkowitz and colleagues (2015) sleep is an essential element for health and well-being, including cognitive function, physiological processes, emotion regulation, and quality of life. Total sleep time decreases to between 5-7 hours a day in older adulthood (Gooneratne & Vitiello, 2014). Short or long sleep duration and sleep disturbance have all been found to be associated with poorer cognitive functioning and a risk factor of dementia (Chen et al., 2016). With one study suggesting that individuals who move towards the short and long ends of sleep are subjected to an accelerated cognitive ageing equivalent to a 3 to 8-year increase in age (Ferrie et al., 2011). Middle-aged adults with a long sleep duration reported poorer cognitive function for memory and global cognitive function (Oostrom, Nooyens, Van Boxtel & Verschuren, 2018). Improving older adults sleep quality is a promising approach to preserve cognitive health (Falck et al., 2018).

It is well-established that smoking is unhealthy (Kenfield et al., 2010). It was originally considered that smoking could potentially maintain cognitive function and decrease the risk of dementia (Lee, 1994). However, since then research has completely contradicted this claim, suggesting that chronic smokers experience greater cognitive decline, greater decrease in memory scores and greater loss of grey matter in the right thalamus, semi lunar lobule and left parietal lobule over 2 years when compared with non-smokers (Almeida et al., 2011). Studies on individuals without cognitive impairment reported that smokers had an increased risk of dementia (Ott et al., 2004) looking at over 9,000 non demented men and women, smokers were found to have a significantly greater decline in Mini Mental State Examination scores than those who did not smoke. Current smoking was related to a faster decline in cognitive function specifically memory function, whereas past smoking was not related to cognitive decline (Reitz, Luchsinger, Tang & Mayeux, 2005).

Alcohol use in older adults has received less attention than its use in younger adults, as it is evident that the use of alcohol in younger cohorts is much larger (St John, Snow & Tyas, 2010) but as this group age, the use of alcohol among older adults may also rise. Thus, understanding the health risks and the possible benefits of alcohol consumption in older adults is important. The use of alcohol varies between cultures, however, a common trend is that the level of alcohol use tends to decrease with age (St John et al., 2010). Research has stated that both light and moderate drinking neither reduced or had no risk of dementia or cognitive impairment (Neafsey & Collins, 2011). Yet, excessive consumption of alcohol is associated with multiple cognitive deficits across many domains such as, verbal fluency, processing speed, attention, executive function and memory (Stavro, Pelletier & Potvin, 2013; Neafsey & Collins, 2011). Ganguli, Vander Bilt, Saxton, Shen and Dodge (2005) examined the association between the changes in cognitive function over time and self-reported alcohol consumption in a community based older sample. Results showed that individuals who consumed minimal or moderate levels of alcohol performed better on cognitive tasks and had lesser decline over time than those who reported no alcohol consumption.

All the above mentioned lifestyles behaviours are linked to cognitive health (Elwood et al., 2013; Lee et al., 2010). Physical activity (Sofi et al., 2011) good quality sleep (Chen et al., 2016) smoking (Reitz et al., 2005) excessive alcohol consumption (Neafsey & Collins, 2011) all being protective factors against age-related cognitive decline. Engaging in a number of healthy lifestyle behaviours has been associated with a better quality of life and subjective health (Tan et al., 2018) subjective health which is considered an antecedent of subjective age (Hubley & Russell, 2009). With strong evidence to show the predictive power of subjective age on health related outcomes (Stephan et al., 2012). This link between feeling younger and engaging in healthy lifestyle behaviours is evident in the literature, and these lifestyle behaviours are also associated with cognitive decline.

Conclusion

The purpose of this review was to address the literature on cognitive ageing, lifestyle behaviours and subjective age. These three constructs have all been linked to positive health related outcomes. As cognitive ageing is a normal process of ageing (Blazer et al., 2015) some cognitive domains decline quicker than others (Bamidis et al., 2013; Deary et al., 2009; Harada et al., 2013) and there is variability in cognitive ageing from individual to individual (Blazer et al., 2015; Salthouse, 2012). Cognitive reserve was a theory proposed to explain this variance. Cognitive reserve refers to factors that help build a reserve that protects individuals against brain pathology which can lead to cognitive decline (Stern, 2002). Factors such as lifetime experiences, educational and occupational attainment, engagement in leisure and social activities can effect this level of reserve in individuals (Barulli & Stern, 2013). This variability can also be explained by a number of other factors, but in particular this review focused on lifestyle behaviours. Lifestyle behaviours such as sedentary behaviour, poor diet, sleep quality, smoking and excessive alcohol consumption have all shown to be related to cognitive health and ageing (Elwood et al., 2013; Lee et al., 2010).

The age one feels can change how an individual views or approaches their health. Research suggesting that individuals with a younger subjective age may be more inclined to engage in healthier lifestyle behaviours, as lifestyle behaviours tend to cluster (Caudroit et al., 2012; Conry et al., 2011). Subjective age has become a well-established and researched construct, with a younger subjective age been found to have a number of positive outcomes for older adults (Eibach, 2011). Subjective age also outperforming chronological age as a predictor of positive outcomes (Stephan et al., 2012). More recently the literature has found that subjective age is associated with a better cognitive function (Stephan et al., 2014). Feeling younger being related to optimistic attitudes of individuals cognitive ageing (Schafer & Shippee, 2010) better performance on delayed and immediate recall tests and global memory function (Stephan et al., 2015). Feeling older may manifest quicker ageing brain structures (Kwak et al., 2018). Subjective age is different from chronological age in that it gives us an insight into individual's health and their experiences of the ageing process. Little research has focused on the construct of subjective age and cognitive functioning; it is important to identify factors such as subjective age that are related to cognitive function. Individuals who feel younger than their chronological age are generally healthier (Stephan et al., 2014). Therefore, it is likely that feeling younger may be associated to cognitive function due to its association with engaging in healthy lifestyle behaviours.

Based upon the data from two waves of the English Longitudinal Study of Ageing (ELSA). The main purpose of this present study is to examine whether subjective age is associated with cognitive function in older adults, assessed through measures of delayed recall, immediate recall and verbal fluency, also including the lifestyle behaviours, physical activity, sleep, smoking and alcohol consumption. There is reason to believe that subjective age is related to cognitive function regardless of the small amount of research in this area. Given that it has been related to psychological, physiological and behavioural outcomes which all also influence cognitive function. Based on prior research it is hypothesised that, the majority of the sample will feel younger than their chronological age and that this discrepancy will grow with age, a younger subjective age is associated with engaging in healthier lifestyle behaviours in older adults. A younger subjective age is associated with better cognitive performance in older adults using measures of immediate and delayed recall and verbal fluency. This association will be consistent over both waves and longitudinally.

Method

Design

The English Longitudinal Study of Ageing (ELSA) was used to conduct secondary analysis. ELSA is an ongoing cohort study that contains a nationally representative sample of the English population above 50 years and their partners if living in the same household. Individuals recruited from 2002-2017 have provided 8 waves of data thus far. In every wave, participants complete a computer assisted personal interview and a self-completion questionnaire. Further than that nurse visits were conducted to collect blood samples and assess physiological functioning. For the purpose of the current study both wave 4 and wave 7 were selected. These waves were selected because they had the necessary variables in common. Variables such as subjective age, lifestyle behaviours and cognitive function. Of these variables subjective age, lifestyle behaviours specifically smoking, physical activity, sleep and alcohol consumption were the independent variables and cognitive function measures immediate recall, delayed recall and verbal fluency were the dependent variables. Cross sectional analysis was conducted on both wave 4 and 7 (study 1 and study 2) and longitudinal analysis was then conducted over the course of these two waves (study 3).

Participants and Procedures

The initial sample is drawn from respondents to the Health Survey for England (HSE), they recruit participants using a multistage stratified probability sampling. Participants gave full written consent to take part in the study and ethical approval was obtained by the London Multi-Centre Research Ethics Committee. All participants who took part gave informed consent and the study was also approved by the appropriate ethical board (Taylor et al., 2007). Ethical approval for the current study was obtained by the Maynooth University Research Ethics Committee for undertaking research using secondary data. The present study was restricted to participants aged 50 years and above because this study focused on the ageing population specifically. This current study reports on data from wave 4 (08/09) to wave 7 (14/15). Initially in wave 4 of ELSA there was a sample of 11,050 participants. Analysis for the current study was then performed on a sample of 10,714 participants. The average age of the sample was 66 years with a range of 50-99 years. Of these participants, 54.8% were female and were more likely to be married/co-habiting (71%), have a second level education (40%), be a non-smoker (84%), engage in weekly moderate physical activity (74%) and consume alcohol on a weekly basis (36%). Of this sample .26% (n = 28) had been diagnosed with dementia.

Analyses at wave 7 was performed on a sample of 7,481 participants, which were included from wave 4. The average age of this sample was 69 years with a range of 56-89 years. Of this sample 55% were female, 90% were non-smokers, 69% were married/co-habiting, 44% have a second level education, 72% engaged in moderate weekly physical activity and 57% consumed alcohol on a weekly basis. Compared to the previous wave in this sample .53% (n = 40) participants had been diagnosed with dementia.

For the purposes of the longitudinal analyses, participants from waves 7 were only included in this stage of the analysis if they were also included in wave 4. This was to avoid the inclusion of those recruited as refreshment samples. Attrition rates in ELSA is complicated due to the refreshment samples (Banks et al., 2011). Refreshment samples were added in wave 6 and 7. To assess the participants over time these new entrants were excluded from the analysis and only those who were included in wave 4 were included for this longitudinal analysis at wave 7. In wave 4 a total of 11,050 participants were recruited for ELSA and in wave 7 a total of 9,666 were recruited. This longitudinal analysis was then performed on a sample of 7,432 individuals.

Measures

Subjective age was measured in the main questionnaire using one question, "How old do you feel that you are?". Participants subjective age was subtracted from their chronological age to obtain a subjective age discrepancy (number of years felt younger/older). A positive value denotes a younger subjective age and a negative value represents an older subjective age. For example, a value of 10 indicating an individual feeling 10 years younger and a value of -10 indicating that an individual feels 10 years older than their chronological age. For the purpose of the analysis of variance, subjective age discrepancy was categorised into 3 groups, the lowest 10% of age discrepancy, the middle 50-60% and the highest 10% of age discrepancy (i.e. those top 10% who felt the youngest in the sample). As this was a continuous variable, responses that deviated widely from the mean were considered outliers and were excluded from the analysis.

Physical activity. Physical activity was measured using the self-report questionnaire of ELSA. Questions included were based on the frequency of participation in vigorous and moderate levels of physical activity (more than once a week, once per week, 1 to 3 times a month and hardly ever). Physical activity was then further categorised into 3 groups; a couple of times a week, a couple of times a month and hardly ever/never. The variables were further categorised for the purpose of the hierarchical multiple regression, two categories were included in the model and the third was considered the reference group. This is to avoid multicollinearity within the model. This process was the same for both wave 4 and 7.

Smoking. Smoking was measured using one closed ended question “Do you smoke cigarettes at all nowadays?” and participants answered either yes or no.

Sleep. Sleep in wave 4 was measured by an open ended question, asking participants to report how many hours they slept on an average weeknight. Responses were then coded into 3 groups (less than 5 hours, 5-8 hours and 9+ hours). In wave 7 sleep was measured using time of sleep onset and offset. “What time did you go to sleep at yesterday?” and “What time did you wake up at yesterday?”. These were then converted into sleep duration same as in wave 4. Sleep was categorised into these specific groups as less than 5 hours sleep is considered to be a very short sleep duration and 9+ hours is considered to be a long sleep duration (Matthews, Long, Narcisse, Martin & McElfish, 2018).

Alcohol consumption. Alcohol consumption was measured in the self-report questionnaire. Frequency of alcohol intake was assessed by 8 groups in the initial data ranging from “almost every day to not at all over the last 12 months”. These responses were further categorised into 3 groups (every day/couple of times a week, couple of times a month and rarely/never). This measure was the same in both wave 4 and 7. Alcohol consumption was again further categorised for the purpose of the hierarchical multiple regression.

Immediate and delayed recall. The cognitive function measures, immediate and delayed recall were assessed using a 10-word learning task. This is a measure of episodic memory and is from the Health and Retirement Study. Ten common words (book, tree, child etc.) are presented to the participants aurally by a computer. Participants are then asked to recall as many words as possible immediately and then again after a delay with tasks in-between the two. *Verbal fluency task* is a measure of executive function and is from the Delis Kaplan Executive Function System. A test in which the participants have to produce as many words a possible from a specified category. In ELSA verbal fluency measured how readily participants are able to think of as many animals as they can in 60 seconds. Table 1 indicates the number of participants who gave data on the cognitive function measures in each wave.

Table 1

Number of Participants in Both Wave 4 and Wave 7 with Cognitive Function Data

	Wave 4	**Wave 7**
	Total	Total
Sample	**10,714**	**7,481**
Immediate recall	10,245	7,141
Delayed recall	10,270	7,153
Verbal fluency	10,244	7,152

Statistical analysis

For the present study all data analyses were performed in SPSS software. Before beginning the analyses, the data was checked for errors and the data was cleaned to make sure it was consistent and coherent. Preliminary analyses were conducted to assess the data for missing data and outliers. Associations between all independent and dependent variables were assessed. Skewness and kurtosis values were within the acceptable range for all the variables, and so to the multicollinearity, which was assessed using variance inflation factors (VIF). To address the first and second hypotheses. 1) That the majority of the sample will feel younger than their chronological age. 2) That the discrepancy between subjective age and chronological age will increase with age descriptive statistics were utilised to summarise the features of these hypotheses. Graphs and tables were utilised to illustrate these descriptive statistics. To address the third hypothesis 3) that a younger subjective age is associated with engaging in healthier lifestyle behaviours. A one-way analysis of variance was used to determine whether there were any statistically significant differences between the mean subjective age discrepancy and the specific lifestyle behaviours. Again to address the fourth hypothesis 4) that a younger subjective age is associated with better cognitive performance on measures of immediate recall, delayed recall and verbal fluency. A one-way analysis of variance was conducted to determine whether there were any statistically significant differences between the mean score on the immediate recall, delayed recall and verbal fluency tasks and subjective age discrepancy. Post-hoc analyses was conducted using Tukey's Honestly Significant Difference Test (HSD) for all analyses of variance.

A series of hierarchical multiple regression analyses were performed to explore the relationship between the independent variables (demographics, lifestyle behaviours and subjective age) and the dependent variables of cognitive function (immediate recall, delayed recall and verbal fluency) in both wave 4 and 7. This was again to focus on hypothesis number four. Three separate hierarchical regressions were performed. In each case, sex (male = reference group), age, educational attainment (no qualification = reference group) and relationship status (single = reference group) were entered into step 1 as covariates. At step 2, lifestyle behaviours, smoker (smoker = reference group), vigorous and moderate physical activity (hardly ever/never = reference group), sleep (9+ hours = reference group) and alcohol consumption (rarely/never = reference group) were entered into the model. Finally, at step 3, subjective age was entered into the model to determine the additional variance explained by the model, to determine which of the predictors in the 3 steps was more strongly associated with immediate recall, delayed recall and verbal fluency.

Examining the change over the course of wave 4 and wave 7 a hierarchical multiple regression was again performed. There are many ways to examine change using regression analysis. In the present study time 2 cognitive function was used as a dependent variable and incorporated into the predictors as a control variable was time 1 cognitive function. This hierarchical regression was conducted to explore the relationship between the independent variables all from wave 4 (demographics, cognitive function, lifestyle behaviours and subjective age) and the dependent variables of wave 7 cognitive function (immediate recall, delayed recall and verbal fluency). Following the same format as the above, three consecutive hierarchical regressions were performed. In each case age, sex, educational attainment, relationship status and baseline cognitive function were entered into step 1 as covariates. At step 2 lifestyle behaviours, smoker, vigorous and moderate physical activity, sleep and alcohol consumption were entered into the model. Finally, at step 3, subjective age was entered into the model to determine the additional variance explained by the model and to determine which of the predictors from wave 4 was more strongly associated with cognitive function at wave 7 when controlling for cognitive function at wave 4. According to Cronbach and Furby (1970) this model is a more appropriate way of examining change rather than thinking in terms of different scores. The use of time 2 scores as a dependent variable depicts a more generalised model (Markus, 1979).

As some of the variables included, for example age and subjective age in the regression presented concerns for the violation of the assumption of multicollinearity and therefore the VIF values were reported for each independent variable. VIF values above 10 are indicative of violation of multicollinearity (Craney & Surles, 2002).

Results

Study 1

Descriptive statistics

Descriptive statistics were performed on all variables; Table 1 presents the descriptive statistics for the demographics variables. A total of 10,714 participants were included in the analysis at wave 4 of ELSA. The age range of this sample was 50-99 years (M = 65.79, SD = 10.13). Within this 45.2% (n = 4847) were male (M = 65.72, SD = 9.60) and 54.8% (n = 5867) were females (M = 65.85, SD = 10.52).

Table 1

Descriptive Statistics of Categorical Demographic Variables

Variable	Frequency	Valid Percentage
Gender		
Male	4847	45.2
Female	5867	54.8
Relationship status		
Married/Co-habiting	7641	71.3
Neither	3073	28.7
Education		
Degree/higher education	3277	30.6
2nd level education	4234	39.5
No qualification	3103	29.0

Looking at the descriptive statistics of the lifestyle behaviours, 15.6% (n = 1485) were smokers and 84.4% (n = 9496) were non-smokers. The sample (n = 10,705) engaged in more moderate physical activity (74%) on a weekly basis than vigorous physical activity (28.7%). Individuals (n = 10,267) slept for an average of 6.85 hours per night (SD = 1.34) with a range of 1-14 hours. Thirty-six percent of participants (n = 8855) consumed alcohol on a weekly basis.

Table 2

Descriptive Statistics of all the Lifestyle Behaviour Variables

Variable	Frequency	Valid Percentage
Smoker		
Yes	1485	15.6
No	8011	84.4
Vigorous physical activity		
Hardly ever	6066	61.7
Couple times a month	1024	9.6
Couple times a week	3075	28.7
Moderate physical activity		
Hardly ever	2037	19.0
Couple times a month	746	7.0
Couple times a week	3103	74.0
Sleep		
1-5 hours	577	5.7
5-8 hours	8938	88.5

9+ hours	583	5.8
Alcohol consumption		
Every day/couple times a week	3267	36.9
Couple times a month	3191	36.0
Rarely/never	2397	27.1

Table 3 presents the descriptive statistics of immediate recall, delayed recall and animal naming. On average, participants recalled more words immediately (58%) than after a delay (45%), and participants named an average of 20.65 animals.

Table 3

Descriptive Statistics of Immediate Recall, Delayed Recall & Animal Naming

Variable	n	M	SD	Range
Immediate recall	10242	5.82	1.79	0-10
Delayed recall	10267	4.54	2.12	0-10
Animal naming	10241	20.65	6.87	0-50

Subjective age: As expected individuals generally felt younger than their chronological age (chronological age – subjective age = subjective age discrepancy). There was also an increase in this discrepancy with age, as a result of individuals feeling younger than their chronological age (Table 4). Table 4 includes the descriptive statistics regarding subjective age discrepancy and chronological age. Figure 1 also shows that 74% of individuals had scores of subjective age that were less than their chronological age, and these individuals can be described as reporting themselves to feel younger than their chronological age. Participants felt on average 17% younger the mean discrepancy between chronological age and subjective age was 11.09, a positive discrepancy indicates that subjective age was lower than chronological age. This positive discrepancy also grew with age. For example, as seen in Table 4 participants in the 50-59 category felt on average 15% younger, whereas participants in the 80+ category felt on average 16% younger than their chronological age.

Figure 2 below illustrates this growing discrepancy between chronological age and subjective age as chronological age grows. Negative score here indicate that participants felt older than their chronological age. Figure 3 illustrates the discrepancy by grouping the lowest 10%, the middle 50-60% and the highest 10%. The highest 10% category were the individuals who felt the youngest in the sample. Those participants in the highest 10% category as shown in Figure 3 are on average slightly older than the lowest 10% and middle 50-60% categories. In regards to sex, males felt on average 17% younger and females felt on average 15% younger than their chronological age.

Table 4

The Average Discrepancy between Chronological Age and Subjective Age in the Different Age Categories

Age	***N***	**M**	***SD***
50-59	3219	8.65	12.54
60-69	3480	11.33	12.96
70-79	2323	11.97	14.00
80+	962	13.87	15.88
Total	**9984**	**11.09**	**13.51**

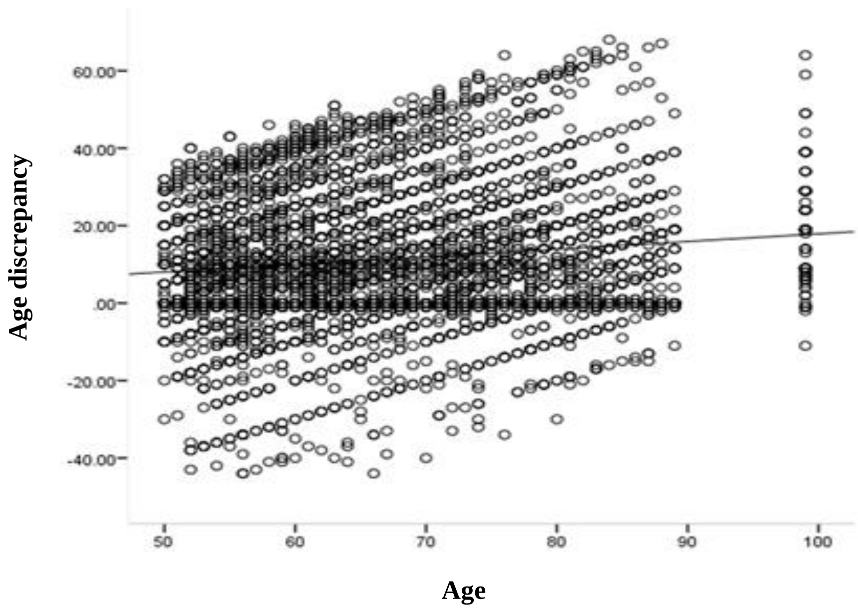


Figure 1. Illustrating that the majority of individuals felt younger than they actually are. Negative scores indicating that one feels older than their chronological age and positive scores indicating feeling younger than their chronological age.

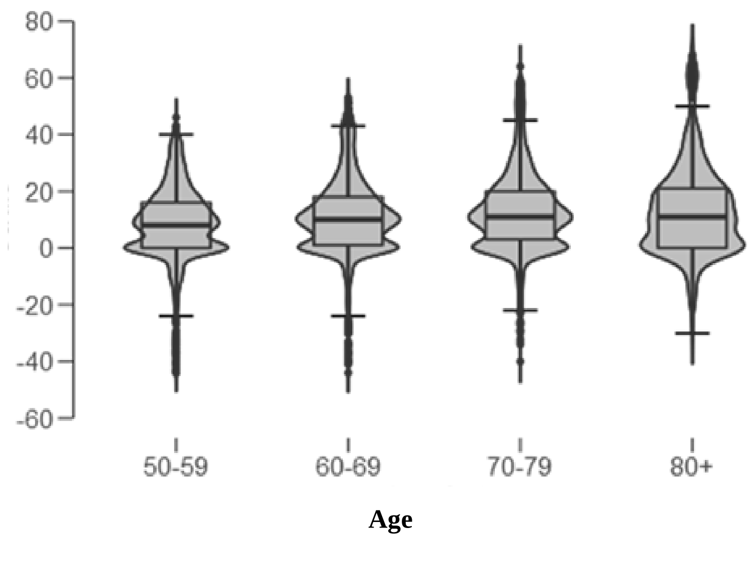
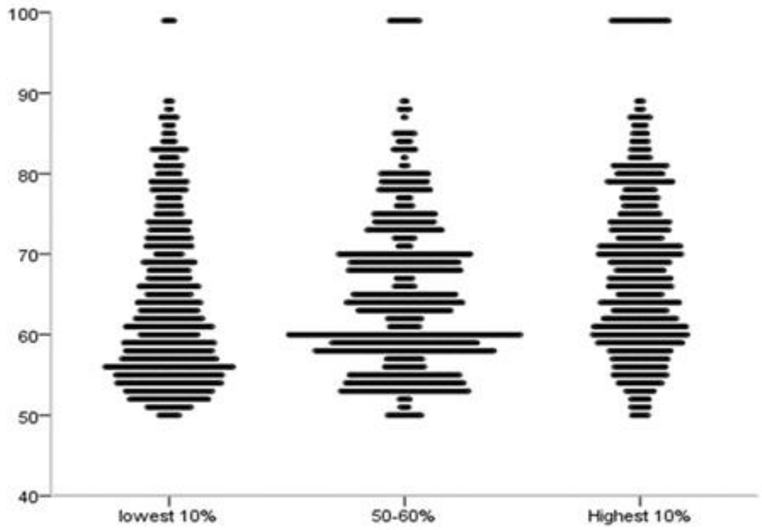


Figure 2. Illustrating the average discrepancy between chronological age and subjective age in regards to chronological age. Negative scores here indicate feeling older and positive score indicate feeling younger than their chronological age. The

older the age category the greater the positive discrepancy between chronological age and subjective age (younger one felt).



Age discrepancy (lowest 10%/50-60%/highest 10%)

Figure 3. Illustrating using the grouped discrepancy variable, participants chronological age and the discrepancy. The lowest 10% are those who feel closer to their chronological age or older and the highest 10% are those who feel the youngest in the sample. Participants in the lowest 10% category are on average younger than those in the other two categories.

Inferential Statistics

A two-way analysis of variance was conducted to explore the relationship between chronological age and the discrepancy between chronological age and subjective age. Age discrepancy was divided into three categories n = 3,213 (lowest 10%, middle 50-60% & highest 10%). To illustrate the differences between the groups Table 5 indicates the average age discrepancy in each of the three categories.

There was a statistically significant difference between the three categories F(2, 4788) = 49.92, $p < .001$, $\eta p^2 = -.16$. Post-hoc comparisons using Tukey's HSD, indicated that the mean age for individuals in the highest 10% group (M = 66.70, SD = 9.97) was not statistically significant from the middle 50-60% (M = 64.80, SD = 9.76) but was statistically significant ($p < .001$) from and the bottom 10% (M = 63.93, SD = 10.01).

Table 5

ANOVA Comparisons of Chronological Age and Subjective Age

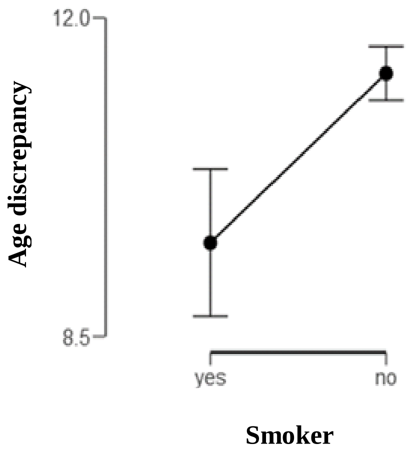
				Tukey's HSD Comparisons	
Group	*n*	Mean	*SD*	Highest 10%	50-60%
Highest 10%	997	66.70	9.97		
50-60%	1211	64.80	9.76	.09	
Lowest 10%	1005	63.93	10.01	< .001	< .001

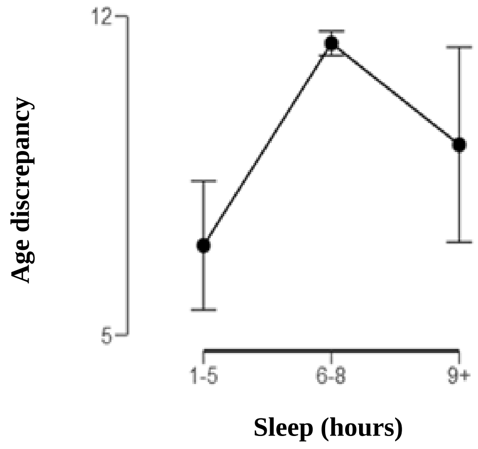
Lifestyle behaviours: Analysis of variance was again conducted to explore the association between lifestyle behaviours and age discrepancy. Firstly, looking at the relationship between smoking and feeling younger. Participants were divided into two groups (smoker & non-smoker). There was a statistically significant difference between the two groups F(1, 8926) = 58.99, $p < .001$, $\eta p^2 = -.14$. This demonstrates what was expected, that non-smokers feel younger than smokers. Vigorous physical activity was divided into three groups (hardly ever/never, couple of times a month & couple of times a week). There was a statistically significant difference between the groups F(2, 9979) = 44.06, $p < .001$, $\eta p^2 = -.18$. Post-hoc comparisons indicated that there was a statistically significant difference ($p < .001$) in age discrepancy in the hardly ever/never (M = 10.23, SD = 14.33), a couple of times a month (M = 11.82, SD = 12.50) and a couple of times a week group (M = 12.65, SD = 11.81). However, there was no significant ($p = .22$) difference between couple of times a month and the couple of times a week group. Moderate physical activity was divided into three groups same as above. There was a statistically significant difference between the three groups $F(2, 9979) = 90.64$, $p< .001$, $\eta p^2 = -.27$. The post-hoc comparisons showed that there was a statistically significant difference ($p< .001$) between hardly ever/never (M = 8.27, SD = 16.27), a couple of times a month (M = 10.44, SD = 14.28) and a couple of times a week (M = 11.82, SD = 12.53). There was no significant difference between the couple of times a month and couple of times a week group. Individuals who engaged in both vigorous and moderate physical activity on a weekly basis felt younger than their chronological age. Sleep duration was divided into three groups (less than 5 hours, 5-8 hours & 9+ hours per night). There was a statistically significant difference $F(2, 9274) = 25.25$, $p< .001$, $\eta p^2 = .04$. Post-hoc comparisons indicated that there was a statistically significant difference ($p<.001$) between less than 5 hours (M = 6.83, SD = 17.26), 5-8 hours (M = 11.38, SD = 13.25) and 9+ hours (M = 10.07, SD = 19.41). There was also a significant ($p< .05$) difference between 5-8 hours and 9+ hours. Those who sleep between 5-9 hours felt younger as the others on either extreme of sleeping less than 5 hours or 9+ hours feel closer to their chronological age. Finally, alcohol consumption was divided into three groups (everyday/a couple of times a week, a couple of times a month & rarely ever/never). This was statistically significant $F(2, 8625) = 53.68$, $p< .001$, $\eta p^2 = .09$. Post-hoc comparisons indicated that there was a statistically significant difference ($p< .01$) between, a couple of times a month (M = 11.48, SD = 12.70) and rarely ever/never (M = 10.48, SD = 15.09). However, there was no significant difference between everyday/couple of times a week (M = 11.68, SD = 12.32) and couple of times a month. Individuals who consumed alcohol a couple of times a week or a couple of times a month felt younger than those who rarely ever or never consumed alcohol. Table 6 illustrates the above findings giving significance values for all Tukey's HSD post-hoc comparisons.

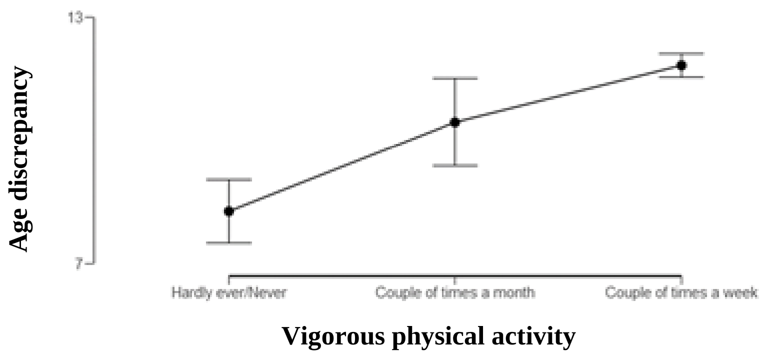
Table 6

ANOVA Comparisons of Lifestyle Behaviours and Subjective Age

				Tukey's HSD Comparisons	
Group	*n*	Mean	*SD*	1	2
Smoker					
Yes	1417	9.53	15.51		
No	7511	11.39	13.07		
Vigorous PA					
Hardly ever/never	6103	10.82	14.33		
Couple times a month	959	11.82	12.50	< .01	
Couple times a week	2920	12.65	11.81	< .001	.22
Moderate PA					
Hardly ever/never	1783	8.27	16.48		
Couple times a month	699	10.44	14.28	< .001	
Couple times a week	7500	11.82	12.53	< .001	< .05
Sleep					
Less than 5 hours	553	6.83	17.26		
5-8 hours	8681	11.38	13.25	< .001	
9+ hours	561	10.07	19.41	< .001	< .05
Alcohol Consumption					
Every day/ weekly	3179	11.68	12.32		
Couple times a month	3121	11.48	12.70	.81	
Rarely/never	2328	10.48	15.09	< .01	< .02


Age discrepancy
12.0
8.5
yes
no
Smoker


Age discrepancy
12
5
1-5
6-8
9+
Sleep (hours)


Age discrepancy
13
7
Hardly ever/Never
Couple of times a month
Couple of times a week
Vigorous physical activity

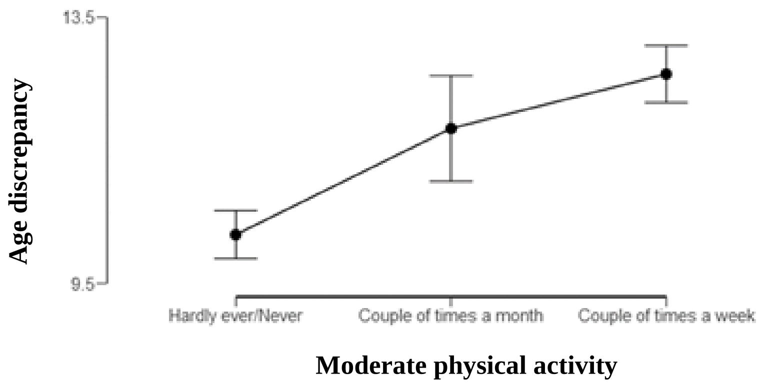

Age discrepancy
13.5
9.5
Hardly ever/Never
Couple of times a month
Couple of times a week
Moderate physical activity

Figure 4. The means plots of the lifestyle behaviours and subjective age discrepancy. The error bars here indicating the standard error.

Cognitive function: A two-way analysis of variance was performed to explore the relationship between years felt younger on immediate recall, delayed recall and animal naming scores. The discrepancy between chronological age and subjective age was divided into 3 groups (lowest 10%, middle 50-60% and highest 10%). There was a statistically significant difference between the groups and their immediate recall scores, F(2, 4122) = 6.32, p< .01 ηp^2 = -.28. Post-hoc comparisons indicated that the mean for the lowest 10% (M = 5.84, SD = 1.80) was significantly (p <.001) different from the middle 50-60% (M = 6.00, SD = 1.65) but not the highest 10% (M = 5.76, SD = 1.80).

There was a statistically significant difference between the groups and delayed recall also, F(2, 4124) = 5.11, p< .01, ηp^2 = -.25. Post-hoc comparisons indicated that the mean scores in the lowest 10% (M = 4.53, SD = 2.12) were significantly (p <.001) different from the middle 50-60% (M = 4.71, SD = 2.03) and from the highest 10% (M =4.47, SD = 2.09) p< .05. There was a significant (p

<.001) difference in the means between the middle 50-60% and the highest 10% groups.

Finally there was a statistically significant difference between the groups and animal naming scores, $F(2, 4123) = 4.21$, $p < .01$, $\eta p^2 = -.29$. Post-hoc comparisons indicated that the mean scores in the lowest 10% (M = 20.59, SD = 7.10) were significantly ($p < .001$) different from in the middle 50-60% (M = 21.17, SD = 6.69) and in the highest 10% group (M = 20.45, SD = 6.79). There was no significant ($p = .64$) difference in mean scores between the middle 50-60% and the highest 10% group.

Table 7

ANOVA Comparisons of Cognitive Function and Subjective Age Discrepancy

				Tukey's HSD Comparisons	
Group	*n*	Mean	*SD*	Highest 10%	50-60%
Immediate recall					
Highest 10%	948	5.84	1.80		
50-60%	1211	6.00	1.65	< .001	
Lowest 10%	1006	5.76	1.80	< .001	.10
Delayed recall					
Highest 10%	949	4.54	2.05		
50-60%	1211	4.76	2.10	< .001	
Lowest 10%	1006	4.01	2.08	< .001	< .05
Verbal fluency					
Highest 10%	948	20.96	6.74		
50-60%	1211	21.23	6.85	< .001	
Lowest 10%	1002	18.86	6.77	< .001	.64

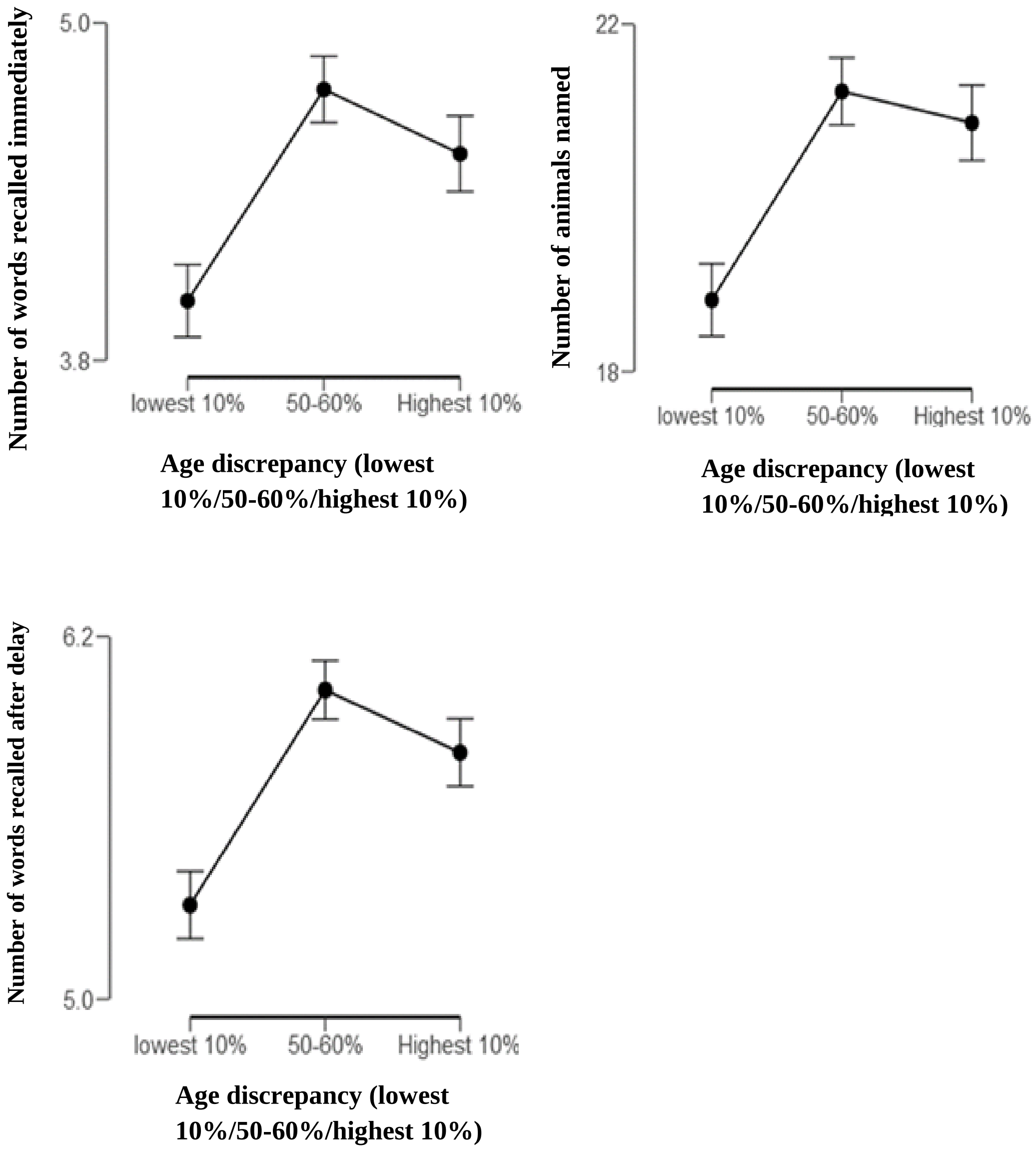


Figure 5. The means plots of the cognitive function and subjective age discrepancy. Subjective age discrepancy is categorised into 3 groups (lowest 10%, middle 50-60% & highest 10%). Error bars indicate the standard error.

Hierarchical Multiple Regression

Hierarchical multiple regression was preformed to investigate the ability of subjective age and lifestyle behaviours to predict levels of immediate recall, delayed recall and animal naming scores, after controlling for age, sex, educational attainment and relationship status. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity and homoscedasticity. In addition, the correlations amongst the predictor variables were all examined. All correlations between the independent variables were weak to moderate ranging from $r = .00$ to $r = .51$. In particular, chronological age and subjective age were of concern, correlations indicated $r = .51$. This indicates that multicollinearity was unlikely to be a problem (Tabachnick & Fidell, 2013) see Table 8 for details. All independent variables also show some relationship with each dependent variable (immediate recall, delayed recall & animal naming) ranging from $r = .10$ to .70.

Predicting immediate recall: In the first step of the hierarchical multiple regression, four predictors were entered: age, sex, educational attainment and relationship status. This model was statistically significant $F(5, 8922) = 473.47$, $p < .001$ and explained 21% of the variance in immediate recall. After the entry of lifestyle behaviours in block 2 the total variance explained by the model was 23% ($F(13, 8914) = 205.44$; $p < .001$). The introduction of the lifestyle behaviours explained an additional 2% of the variance in immediate recall scores after controlling for the above demographics, a change that was statistically significant (R^2 change = .021; $F(8, 8914) = 30.69$; $p < .001$). In the third block subjective age was introduced, this explained a further 1% of the variance in immediate recall scores. The change was also significant (R^2 change = .005; $F(1, 8913) = 60.07$; $p <$

.001). In the final model, chronological age (β = -.26, p< .001) was the strongest predictor.

Predicting delayed recall: This model was statistically significant F(5, 8922) = 507.78, $p < .001$ and explained 22% of the variance in delayed recall. After the entry of lifestyle behaviours in block 2 the total variance explained by the model was 24% (F(13, 8914) = 216.24, $p < .001$). The introduction of the lifestyle behaviours explained an additional 2% of the variance in delayed recall scores, a change that was statistically significant (R^2 change = .018; F(13, 8913) = 45.58, p <.001). In the third block subjective age was introduced, this a significant change (R^2 change = .004; F(1, 8913) = 45.58, $p < .001$). In the final model chronological age (β = -.28, $p < .001$) was the strongest predictor.

Predicting animal naming: This model was statistically significant F(5, 8922) = 343.08, $p < .001$, and explained 16% of the variance in animal naming scores. After again entering lifestyle behaviours in block 2 the total variance explained by the model was 19% (F(13, 8914) = 155.63; $p < .001$). The introduction of lifestyle behaviours explained an additional 3% of the variance in animal naming scores, a change that was statistically significant (R^2 change = .024; F(8, 8914) = 32.42, $p < .001$). In the third block subjective age was introduced, this was again a significant change (R^2 change = .004; F(1, 8913) = 44.91, p = <.001). In the final model chronological age was the strongest predictor (β = .20, p <.001).

Table 8

Correlations of all Independent Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age	1														
2. Sex(female)	.01	1													
3. 3rd level education	-.13	-.14	1												
4. 2nd level education	-.09	.05	-.54	1											
5. Married/Co-habiting	-.28	-.16	.09	.04	1										
6. Smoker	.16	-.01	.10	-.01	.08	1									
7. Vigorous PA (weekly)	-.19	-.08	.16	-.00	.12	.10	1								
8. Vigorous PA (monthly)	-.06	-.04	.06	.01	.03	.03	-.21	1							
9. Moderate PA (weekly)	-.26	-.08	.15	.05	.18	.08	.32	.11	1						
10. Moderate PA (monthly)	.01	.01	-.03	.01	-.03	-.03	-.12	.03	-.46	1					
11. Sleep 1-5 hours	.05	-.01	.05	.03	.03	.03	.06	.01	.12	.01	1				
12. Sleep 5-8 hours	.03	.00	-.02	-.01	-.03	-.04	-.03	-.02	-.04	-.01	-.16	1			
13. Alcohol consumption (everyday/weekly)	-.07	-.14	.17	.01	.13	.05	.13	.05	.16	-.04	.11	-.02	1		
14. Alcohol consumption (monthly)	-.08	-.01	.01	.06	.06	.05	.06	.01	.09	-.02	.07	-.02	-.43	1	

15. Subjective age	.51	.01	-.11	-.05	-.15	.06	-.18	-.05	-.23	.02	-.06	.03	-.07	-.06	1

Table 9

Hierarchical Multiple Regression Models Predicting Cognitive Function Outcomes

	Immediate Recall		**Delayed Recall**		**Verbal Fluency**	
	β (95% CI)	**VIF**	***β (95% CI)***	**VIF**	***β (95% CI)***	**VIF**
Step 1: R^2	**.21***		**.22**		**.16***	
***F* (*df*)**	**472.47 (5, 8922)**		**507.78 (5, 8922)**		**343.08 (5, 8922)**	
Age	-.32***(-.34/-.30)	1.31	-.33***(-.35/-.31)	1.13	-.26***(-.28/-.24)	1.13
Sex (female)	.11***(.34/.49)	1.05	.13***(.11/.15)	1.05	.01(-.01/.03)	1.05
3rd Level education	.27***(.25/.30)	1.50	.29***(.26/.31)	1.50	.01***(.26/.30)	1.50
2nd Level education	.18***(.16/.21)	1.46	.20***(.17/.22)	1.46	.18***(.16/.20)	1.46
Married/Co-habiting	.05***(.03/.07)	1.12	.04***(.02/.05)	1.12	.04***(.02/.06)	1.12
Step 2: R^2	**.23***		**.24***		**.19***	
***F* (*df*)**	**205.44 (13, 8914)**		**216.24 (13, 8914)**		**155.63 (13, 8914)**	
ΔR^2	**.02***		**.02***		**.03***	
ΔF (*df*)	**37.69 (8, 8914)**		**45.58 (1, 8913)**		**32.42 (8, 8914)**	
Age	-.30***(-.32/-.28)	1.29	-.31***(-.33/-.29)	1.29	-.24***(-.26/-.22)	1.29
Sex (female)	.13***(.11/.15)	1.07	.15***(.13/.17)	1.07	.02*(.00/.04)	1.07

3rd Level education	.22***(.20/.25)	1.64	.24***(.21/.26)	1.64	.20***(.20/.25)	1.64
2nd Level education	.15***(.13/.17)	1.52	.16***(.14/.19)	1.52	.15***(.12/.17)	1.52
Married/Co-habiting	.03**(.01/.05)	1.16	.01(-.01/.03)	1.16	.02(-.00/.04)	1.16
Non-Smoker	.04***(.02/.06)	1.09	.03**(.01/.03)	1.09	.04***(.02/.06)	1.09
Vigorous PA (weekly)	.03***(.01/.05)	1.26	.04***(.02/.06)	1.26	.05***(.03/.07)	1.26
Vigorous PA (monthly)	.02(-.00/.04)	1.11	.03**(.01/.05)	1.11	.03**(.01/.05)	1.11
Moderate PA (weekly)	.10***(.07/.12)	1.61	.07***(.05/.10)	1.61	.08***(.06/.11)	1.62
Moderate PA (monthly)	.03**(.01/.05)	1.31	.02(-.00/.04)	1.31	.02(-.01/.04)	1.31
Sleep 1-5 hours	-.02(-.05/.00)	1.06	-.03(-.05/.00)	1.06	-.02(-.04/.01)	1.06
Sleep 5-8 hours	-.00(-.02/.03)	1.03	.01(-.02/.04)	1.03	-.01(-.03/-.02)	1.03
Alcohol consumption (everyday/weekly)	.10***(.07/.12)	1.41	.10***(.08/.12)	1.41	.10***(.08/.13)	1.41
Alcohol consumption (monthly)	.05***(.03/.07)	1.33	.05***(.02/.07)	1.33	.05***(.03/.07)	1.33

Table 9

(Continued)

	Immediate Recall		Delayed Recall		Verbal Fluency	
	β (95% CI)	**VIF**	***β (95% CI)***	**VIF**	***β (95% CI)***	**VIF**
Step 3: R^2	**.24*****		**.24*****		**.19*****	
***F* (*df*)**	**196.32 (14, 8913)**		**205.06 (14, 8913)**		**148.43 (14, 8913)**	
ΔR^2	**.01*****		**.001*****		**.004*****	
ΔF (*df*)	**60.07 (1, 8913)**		**45.58 (1, 8913)**		**44.91 (1, 8913)**	
Age	-.26***(-.28/-.24)	1.59	-.28***(-.30/-.26)	1.59	-.20***(-.23/-.18)	1.59
Sex[a] (female)	.13***(.11/.14)	1.07	.15***(.13/.16)	1.07	.02*(.00/.04)	1.07
3rd Level education	.22***(.20/.24)	1.64	.23***(.21/.26)	1.64	.22***(.20/.25)	1.64
2nd Level education[b]	.15***(.13/.17)	1.52	.16***(.14/.19)	1.52	.14***(.12/.17)	1.53
Married/Co-habiting[c]	.03***(.01/.05)	1.16	.01(-.01/.03)	1.16	.02*(.00/.04)	1.16
Non-Smoker[d]	.04***(.02/.06)	1.09	.03***(.01/.05)	1.09	.04***(.02/.06)	1.09
Vigorous PA (weekly)	.03**(.01/.05)	1.27	.03***(.01/.06)	1.27	.05***(.02/.07)	1.27
Vigorous PA (monthly)	.02(-.01/.04)		.03**(.01/.05)	1.11	.03**(.01/.05)	1.11
Moderate PA (weekly)	.09***(.06/.11)	1.27	.07***(.04/.09)	1.63	.08***(.05/.10)	1.63
Moderate PA (monthly)[e]	.03*(.01/.05)	1.31	.02(-.01/.04)	1.31	.01(-.01/.04)	1.31
Sleep 1-5 hours	-.02(-.04/.01)	1.06	-.02(-.05/.00)	1.06	-.01(-.04/.01)	1.06

Sleep 5-8 hours[f]	.00(-.02/.03)	1.03	.01(-.02/.04)	1.03	-.01(-.03/.02)	1.03
Alcohol consumption (everyday/weekly)	.09***(.07/.17)	1.41	.10***(.07/.12)	1.41	.10***(.08/.13)	1.41
Alcohol consumption[g] (monthly)	.05***(.03/.07)	1.33	.04***(.02/.07)	1.33	.05***(.03/.07)	1.33
Subjective age	-.08***(-.11/-.06)	1.38	-.07***(-.09/-.05)	1.38	-.07***(-.10/-.05)	1.38

Note: VIF = variance inflation factor; [a] reference group = Males; [b] reference group = No qualification; [c] reference group = Neither; [d] reference group = Smoker; [e] reference group = Hardly ever/Never; [f] reference group = 9+ hours; [g] reference group = Rarely/Never.
Statistical significance: *$p < .05$; **$p < .01$; ***$p < .001$.

Study 2

Descriptive Statistics

Descriptive statistics were performed on all variables; Table 1 presents the descriptive statistics for the demographic variables. A total of 7481 participants were included in the analysis at wave 7 of ELSA. These participants were carried forward from the wave 4 analysis. The age range of the entire sample was 56-89 years (M = 69.66, SD = 8.04). Within this 44.5% (n = 3329) were male with an average age of (M = 69.79, SD = 7.83) and 55.5% (n = 4152) were female (M = 69.56, SD = 8.20).

Table 1

Descriptive Statistics of Categorical Demographic Variables

Variable	Frequency	Valid Percentage
Gender		
Male	3329	44.5
Female	4152	55.5
Relationship status		
Married/Co-habiting	5184	69.3
Neither	2297	30.7
Education		
Degree/higher education	2299	31
2nd level education	3259	44
No qualification	1851	25

Focusing on the descriptive statistics of the lifestyle behaviours, 9.9% (n = 740) were smokers and 90.1% (n = 6739) were non-smokers. The sample reported rarely engaging in vigorous physical activity on a weekly basis 63.9% (n = 4779), yet 72.9% (n = 5457) reported engaging in moderate physical activity a couple of times a week. Participants slept for an average of 7 hours and 40 minutes per night (SD = 1.54) with a range of 1-18 hours. The majority of participants consumed alcohol either every day or on a weekly basis 57.7% (n = 3680).

Table 2

Descriptive Statistics of all the Lifestyle Behaviour Variables

Variable	Frequency	Valid Percentage
Smoker		
Yes	740	9.9
No	6739	90.1
Vigorous physical activity		
Hardly ever	4779	63.9
Couple times a month	663	8.9
Couple times a week	2035	27.2
Moderate physical activity		
Hardly ever	1552	20.8
Couple times a month	469	6.3
Couple times a week	5457	73.0
Sleep		
1-5 hours	254	5.0
5-8 hours	3751	73.6

9+ hours	1092	21.4
Alcohol consumption		
Every day/couple times a week	3680	57.7
Couple times a month	1216	19.1
Rarely/never	1484	23.3

Table 3 presents the descriptive statistics of the cognitive function variables; immediate recall, delayed recall and animal naming. On average, participants recalled 58% immediately and 45% after a delay, and roughly 21 animals were named.

Table 3

Descriptive Statistics of Immediate Recall, Delayed Recall & Animal Naming

Variable	n	M	SD	Range
Immediate recall	7141	5.86	1.87	0-10
Delayed recall	7153	4.50	2.19	0-10
Animal naming	7152	20.86	7.29	0-67

Subjective age: Again as expected individuals felt younger than their chronological age. Table 4 includes the descriptive statistics regarding years felt younger and chronological age. Figure 1 shows that the majority of the sample felt younger than their chronological age, with 77% reporting scores of a subjective age that were less than their chronological age. Individuals felt on average 17% younger than their actual age (M = 11.90, SD = 13.27) in comparison to 11.09 in wave 4. Subjective age discrepancy also grew with age, individuals in the 50-59 age group felt on average 9 years younger and those in the 80+ group felt 13 years younger than their chronological age. Figure 2 below illustrates the growing discrepancy between chronological age and subjective age as age grew. A negative score here indicating that individuals felt older than their chronological age. Both Table 4 and Figure 1 illustrates that years felt younger increasing with age. Figure 3 illustrates the difference in the age discrepancy categories. The discrepancy between chronological age and subjective age was divided into three categories (lowest 10%, middle 50-60% and highest 10%). The highest 10% being the group of participants who felt the youngest in the sample. As shown in Figure 3, the highest 10% group are on average slightly older than the other two groups. Regarding sex, females felt younger (M = 12.03, SD = 13.48) than males (M = 11.72, SD = 12.99).

Table 4

The Average Discrepancy between Chronological Age and Subjective Age in the Different Age Categories

Age	***N***	**M**	***SD***
50-59	646	9.82	12.75
60-69	3099	11.25	12.48
70-79	2212	12.71	13.42
80+	910	13.56	15.38
Total	**6867**	**11.89**	**13.27**

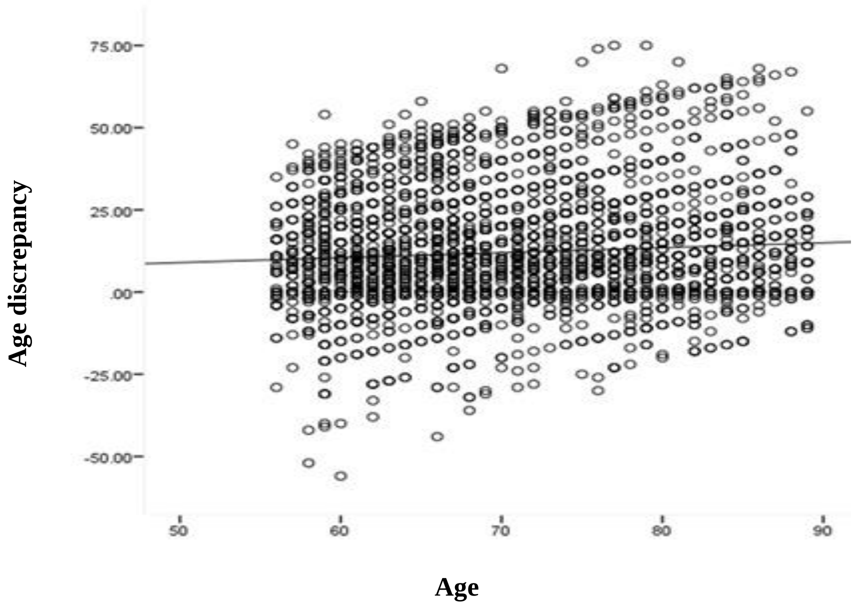


Figure 1. Illustrating that the majority of individuals felt younger than they actually are. Negative scores indicating that one feels older than their chronological age and positive scores indicating feeling younger than their chronological age.

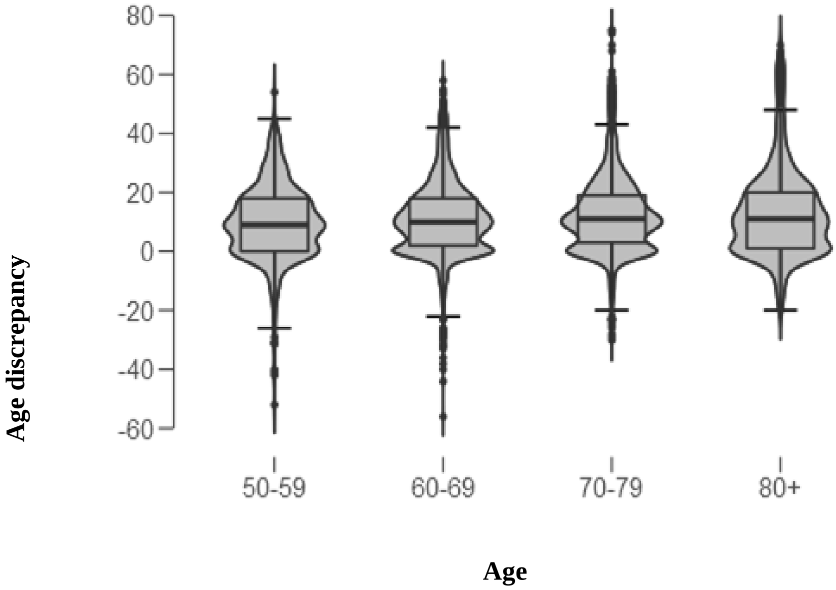


Figure 2. Illustrating the average year's participants feel younger in regards to their chronological age. Negative scores here indicate feeling older and positive score indicate feeling younger than their chronological age. The older the age category the greater the positive discrepancy between chronological age and subjective age (younger one felt).

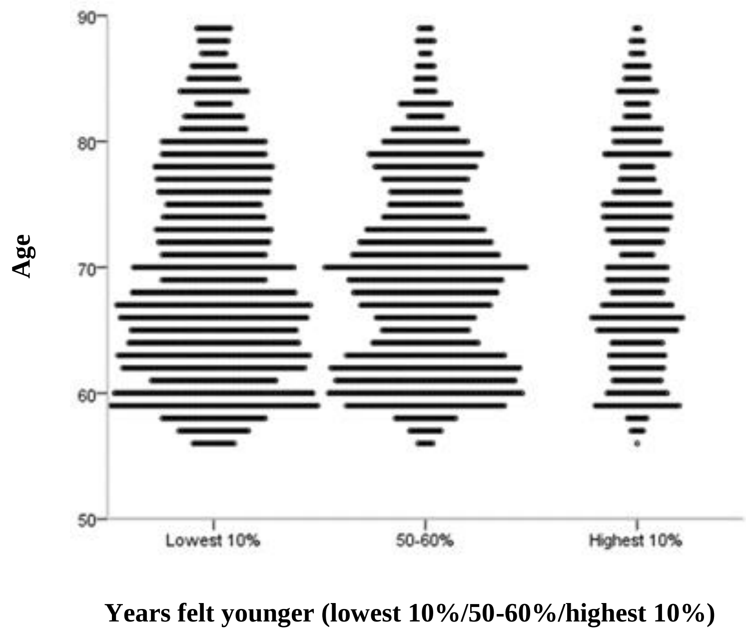


Figure 3. Illustrating using the grouped discrepancy variable, participants chronological age and the discrepancy. The lowest 10% are those who feel closer to their chronological age or older and the highest 10% are those who feel the youngest in the sample. Participants in the lowest 10% category are on average younger than those in the other two categories.

Inferential Statistics

A two-way analysis of variance was conducted to explore the relationship between chronological age and age discrepancy. Age discrepancy was divided into three categories (lowest 10%, middle 50-60% and highest 10%). To illustrate the difference between the groups Table 5 below shows the average years felt younger in each of them. There is a statistically significant difference between the three groups $F(2, 2881) = 10.23$, $p < .001$ $\eta p^2 = -.18$. Post-hoc comparisons using Tukey's HSD indicated that the mean age for individuals in the highest 10% group ($M = 70.76$, $SD = 8.13$) was not statistically significant ($p = .54$) from the middle 50-60% ($M = 69.45$, $SD = 7.82$) but was statistically significant between the lowest 10% (M = 69.31, SD = 8.26). There was also a significant ($p < .001$) difference between the middle 50-60% and the lowest 10% categories.

Table 5

ANOVA Comparisons of Chronological age and Subjective Age

				Tukey's HSD Comparisons	
Group	*n*	Mean	*SD*	Highest 10%	50-60%
Highest 10%	658	70.76	8.13		
50-60%	634	68.91	7.67	.54	
Lowest 10%	1592	69.31	8.26	< .001	< .001

Lifestyle behaviours: Analysis of variance was conducted to explore the association between lifestyle behaviours and years felt younger, see Table 6. Firstly, looking at the relationship between smoking and feeling younger. Participants were divided into two groups (smoker and non-smoker). There was a statistically significant difference between both groups $F(1, 6865) = 7.41$, $p < .01$ $\eta p^2 = -.11$.

Vigorous physical activity was divided into three groups (hardly ever/never, couple of times a month and couple of times a week). There was a statistically significant difference between groups $F(2, 6862) = 32.49$, $p < .001$ $\eta p^2 = -.22$. Post-hoc comparisons show that there was a statistically significant ($p < .05$) difference in mean age discrepancy and hardly ever/never (M = 10.96, SD = 14.10), a couple of times a month (M = 12.29, SD = 11.87) and a couple of times a week group (M = 13.86, SD = 11.46). There was also a significant difference at $p < .05$ level between the couple of times a week and month groups. Moderate physical activity was divided into the same groups as above. Again, there was a statistically significant difference between the three groups $F(2, 6863) = 48.05$, $p < .001$ $\eta p^2 = -.31$. Post-hoc comparisons indicate that all groups had a statistically significant ($p < .001$) difference in mean in age discrepancy, hardly ever/never (M = 6.62, SD = 16.40) couple of times a month

(M = 11.88, SD = 14.32) and a couple of times a week (M = 12.69, SD = 12.16). However, there was no significant difference between group a couple of times a week and a couple of times a month.

Sleep duration was divided into three groups (less than 5 hours, 5-8 and 9+ hours). There was a statistically significant difference between groups $F(2, 6086) = 3.45$, $p < .05$) $\eta p^2 = -.06$. Post-hoc comparisons indicate that there was no significant difference in the mean between groups. Less than 5 hours (M = 10.54, SD = 16.52) 5-9 hours (M = 12.21, SD = 12.58) and 9+ hours (M = 11.37, SD = 13.40).

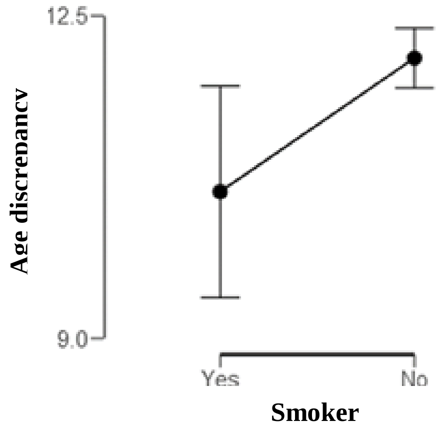
Alcohol consumption was divided into three groups everyday/couple of times a week, couple of times a month and rarely/never). There was no significant difference between the groups $F(2, 6185) = 1.54$, $p = .215$ $\eta p^2 = .05$. Post-hoc comparisons indicated that there was again no significant difference between everyday/couple of times a week (M = 12.00, SD = 11.86) couples of times a month (M = 12.22, SD = 12.37) and rarely/never (M = 11.40, SD = 15.53).

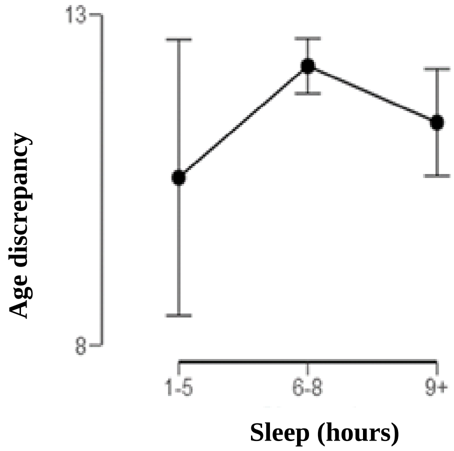
Table 6

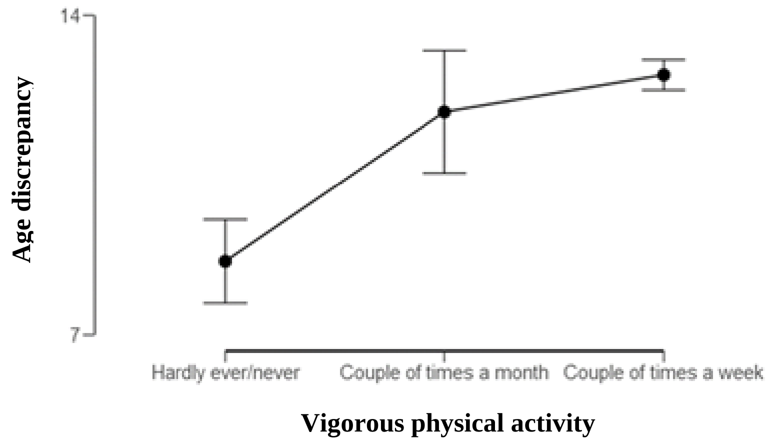
ANOVA Comparisons of Cognitive Function and Subjective Age Discrepancy

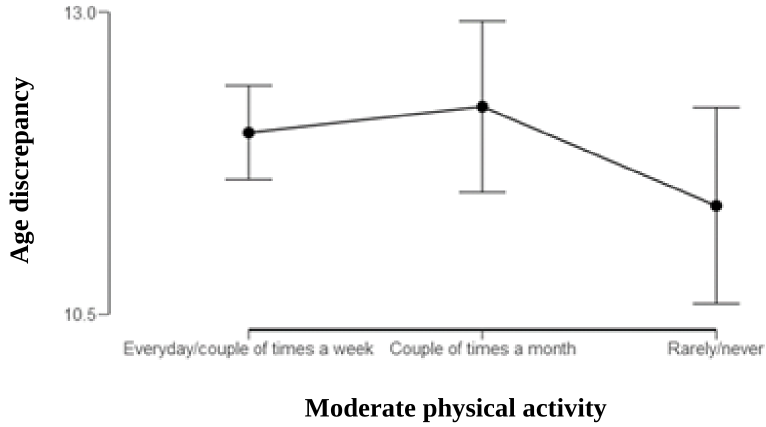
Group	*n*	Mean	*SD*	Tukey's HSD Comparisons 1	2
Smoker					
1. Yes	690	10.59	15.35		
2. No	6177	12.04	13.01		
Vigorous PA					
1. Hardly ever/never	4294	10.96	14.10		
2. Couple times a month	640	12.29	11.87	< .05	
3. Couple times a week	1931	13.86	11.46	< .001	< .05

Moderate PA					
1. Hardly ever/never	1249	8.62	16.40		
2. Couple times a month	442	11.88	14.32	< .001	
3. Couple times a week	5175	12.69	12.16	< .001	< .05
Sleep					
1. Less than 5 hours	553	6.83	17.26		
2. 5-8 hours	8681	11.38	13.25	< .001	
3. 9+ hours	561	10.07	19.41	< .001	.42
Alcohol Consumption					
1. Every day/ weekly	3599	12.00	11.86		
2. Couple times a month	1178	12.22	12.38	.87	
3. Rarely/never	1411	11.40	15.53	.29	.24









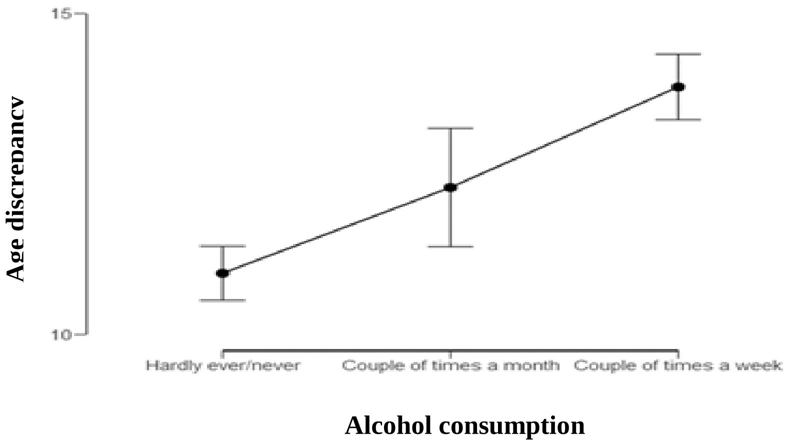


Figure 4. The means plots of the lifestyle behaviours and subjective age discrepancy. The error bars here indicate the standard error.

Cognitive function: A two-way analysis of variance was performed to explore the relationship between years felt younger and each of the cognitive function variables (immediate recall, delayed recall and animal naming) Table 7 illustrates these results. The discrepancy between chronological age and subjective age was divided into three groups (lowest 10%, middle 50-60% and highest 10%). There was a statistically significant difference at the p <.001 level in the number of words recalled immediately for the three groups $F(2, 3589) = 17.97$, $p < .001$ $\eta p^2 = -.14$. Post-hoc comparisons indicated that the mean for the lowest 10% of years felt younger ($M = 5.65$, $SD = 1.93$) was significantly ($p < .01$)

different from the middle 50-60% (M = 6.05, SD = 1.72) and the highest 10% (M = 5.92, SD = 1.90). There was no significant difference in mean scores between the middle 50-60% and the highest 10%.

This was again performed to test the relationship between the age discrepancy and delayed recall. This was statistically significant $F(2, 3594) = 15.38$, $p < .001$ $\eta p^2 = -.13$. Post-hoc comparisons indicated that the mean for the lowest 10% group (M = 4.27, SD = 2.31) was significantly ($p < .01$) different from the middle 50-60% (M = 4.71, SD = 2.03) and the highest 10% (M = 4.56, SD = 2.15). There was no significant difference in mean scores between the middle 50-60% and the highest 10% groups.

Finally, analysis of variance was used to explore the association between age discrepancy and animal naming scores. There was a significant difference at the $p < .001$ level in animal naming scores for the three groups $F(2, 3594) = 19.24$, $p < .001$ $\eta p^2 = -.20$. Post-hoc comparisons indicated that the mean for the lowest 10% group (M = 19.96, SD = 7.55) was again significantly ($p < .01$) different from the middle 50-60% (M = 21.47, SD = 6.80) and the highest 10% (M = 21.44, SD = 7.06). There was no significant difference in mean scores between the middle 50-60% and the highest 10% groups.

Table 7

ANOVA Comparisons of Cognitive Function and Subjective Age Discrepancy

				Tukey's HSD Comparisons	
Group	*n*	Mean	*SD*	Highest 10%	50-60%
Immediate recall					
Highest 10%	658	5.92	1.93		
50-60%	634	6.11	1.68	< .001	
Lowest 10%	1587	5.65	1.90	< .01	.16
Delayed recall					
Highest 10%	658	4.56	2.15		

50-60%	634	4.73	2.02	< .001	
Lowest 10%	1592	4.27	2.31	< .05	.35
Verbal fluency					
Highest 10%	658	21.44	7.06		
50-60%	634	21.38	6.59	< .001	
Lowest 10%	1592	19.96	7.55	< .001	.98

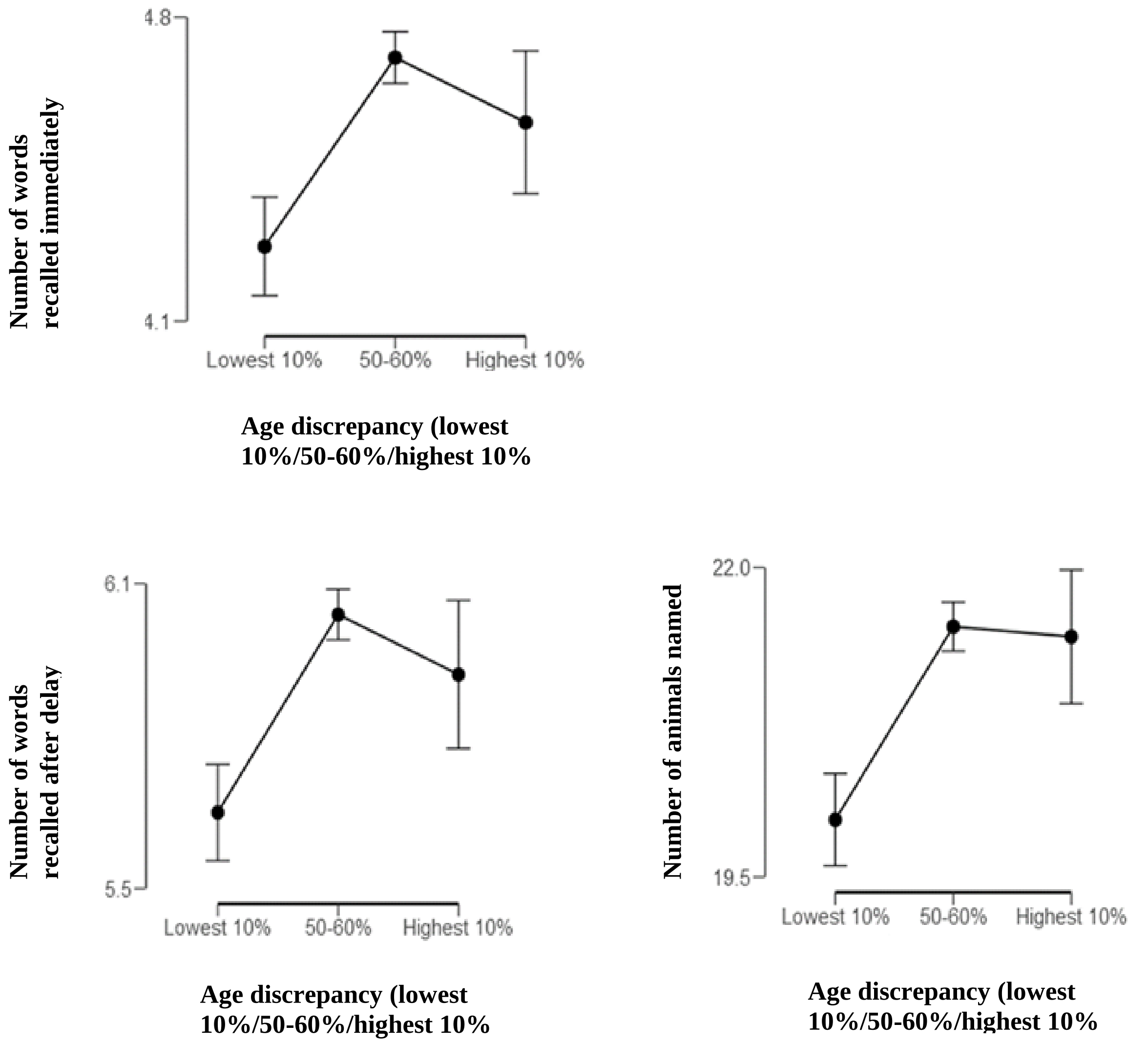


Figure 5. The means plots of cognitive function and subjective age discrepancy. Age discrepancy is categorised into 3 groups (lowest 10%, middle 50-60% & highest 10%). Error bars indicate the standard error.

Hierarchical Multiple Regression

Hierarchical multiple regression to investigate the ability of subjective age and lifestyle behaviours to predict levels of immediate recall, delayed recall and animal naming scores, after controlling for age, sex, educational attainment and relationship status using wave 7 of the ELSA data. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity and homoscedasticity. All correlations between the independent variables again were consistent with wave 4 ranging from weak to moderate $r = .00$ to $r = .51$. In particular, subjective age and chronological age were of concern, and correlations ($r = .46$) indicated that multicollinearity was unlikely to be a problem (Tabachnick & Fidell, 2013). All independent variables also show some relationship with each dependent variable (immediate recall, delayed recall & animal naming) ranging from $r = .10$ to $r = .70$.

Predicting immediate recall: In the first step of the hierarchical multiple regression, four predictors were entered: age, sex, educational attainment and relationship status. This model was statistically significant $F(5, 6861) = 320.71$, $p < .001$ and explained 19% of the variance in immediate recall. After the entry of lifestyle behaviours in block 2 the total variance explained by the model was 22% ($F(14, 6852) = 144.03$, $p < .001$). The introduction of the lifestyle behaviours explained an additional 4% of the variance in immediate recall scores after controlling for the above demographics (R^2 change = .038; $F(9, 6852) = 37.68$, $p < .001$). In the final model chronological age ($\beta = .25$, $p < .001$) was the strongest predictor.

Predicting delayed recall: This model was statistically significant $F(5, 6861) = 336.03$, $p < .001$ and explained 20% of the variance in delayed recall. After the entry of the lifestyle behaviours in block 2 the total variance explained by the model was 23% ($F(14, 6852) = 147.75$, $p < .001$). The introduction of the lifestyle behaviours explained an additional

4% of the variance of delayed recall scores, a change that was statistically significant (R^2 change = .035; $F(9, 6852) = 34.86$, $p< .001$). In the third block subjective age was introduced, this was a significant change (R^2 change = .004; $F(1, 6851) = 34.75$, $p< .001$). In the final model chronological age ($\beta = -.26$; $p< .001$) was again the strongest predictor.

Predicting animal naming scores: This model was statistically significant $F(5, 6861) = 222.57$, $p< .001$, explained 14% of the variance in animal naming scores. After again entering the lifestyle behaviours in block 2 the total variance explained by the model was 18% ($F(14, 6852) = 108.07$, $p< .001$). The introduction of the lifestyle behaviours explained an additional 4% of the variance in animal naming scores, a change that was statistically significant (R^2 change = .041; $F(9, 6852) = 38.39$, $p< .001$). In the third block subjective age was added into the model, this was again a significant change (R^2 change = .065; $F(1, 6851) = 43.31$, $p< .001$). In the final model third level education was the strongest predictor ($\beta = .20$, $p< .001$)

Table 8

Correlations of all Independent Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age	1														
2. Sex(female)	-.01	1													
3. 3rd level education	.07	-.14	1												
4. 2nd level education	.10	.04	-.59	1											
5. Married/Co-habiting	-.22	-.18	.09	.03	1										
6. Smoker	.11	-.01	.08	-.01	.09	1									
7. Vigorous PA (weekly)	-.19	-.09	.13	-.00	.13	.06	1								
8. Vigorous PA (monthly)	-.05	-.08	.09	-.02	.05	.02	-.19	1							
9. Moderate PA (weekly)	-.25	-.07	.14	.04	.20	.08	.34	.12	1						
10. Moderate PA (monthly)	.04	-.00	-.04	.02	-.02	-.02	-.13	.02	-.43	1					
11. Sleep 1-5 hours	.02	.02	-.04	.04	-.04	-.02	-.04	-.03	-.06	-.00	1				
12. Sleep 5-8 hours	-.05	-.03	.06	.02	.05	.03	.07	.05	.14	-.01	-.16	1			
13. Alcohol consumption (everyday/weekly)	-.11	-.16	.16	.02	.18	.07	.16	.09	.24	-.04	.11	.19	1		
14. Alcohol consumption (monthly)	-.03	.06	-.03	.05	-.02	-.02	-.01	-.01	.02	-.02	.04	.05	-.43	1	

15. Subjective age	.46	-.02	-.02	-.06	-.12	.04	-.19	-.04	-.23	.02	.02	-.05	-.07	-.03	1

Table 9

Hierarchical Multiple Regression Models Predicting Cognitive Function Outcomes

	Immediate Recall		**Delayed Recall**		**Verbal Fluency**	
	β (95% CI)	**VIF**	***β (95% CI)***	**VIF**	***β (95% CI)***	**VIF**
Step 1: R^2	**.19*** **		**.20** **		**.14*** **	
***F* (*df*)**	**320.06 (5, 6861)**		**336.03 (5, 6861)**		**222.57 (5, 6861)**	
Age	-.32***(-.34/-.30)	1.09	-.33***(-.35/-.31)	1.09	-.26***(-.28/-.24)	1.09
Sex (female)	.11***(.09/.13)	1.05	.13***(.10/.15)	1.05	.00(-.02/.03)	1.05
3rd Level education	.26***(.23/.29)	1.60	.25***(.23/.28)	1.60	.27***(.24/.29)	1.60
2nd Level education	.18***(.15/.20)	1.58	.17***(.14/.19)	1.58	.18***(.15/.20)	1.58
Married/Co-habiting	.06***(.03/.08)	1.10	.06***(.04/.09)	1.10	.03**(.01/.05)	1.10
Step 2: R^2	**.23*** **		**.23*** **		**.18*** **	
***F* (*df*)**	**144.03 (14, 6852)**		**147.75 (14, 6852)**		**108.07 (14, 6852)**	
ΔR^2	**.04*** **		**.04*** **		**.041*** **	
ΔF (*df*)	**37.68 (9, 6852)**		**34.86 (9, 6852)**		**38.39 (9, 6852)**	
Age	-.28***(-.31/-.26)	1.18	-.29***(-.32/-.27)	1.18	-.22***(-.26/-.20)	1.18
Sex (female)	.13***(.11/.15)	1.08	.14***(.12/.17)	1.08	.02*(.00/.06)	1.08
3rd Level education	.20***(.17/.23)	1.72	.19***(.17/.22)	1.72	.20***(.17/.23)	1.72
2nd Level education	.13***(.11/.16)	1.63	.13***(.10/.15)	1.64	.13***(.10/.16)	1.64

Married/Co-habiting	.02(-.00/.04)	1.14	.03**(.01/.05)	1.14	-.01(-.03/.02)	1.14
Non-Smoker	.02(-.00/.04)	1.05	.02(-.00/.04)	1.05	.02(-.01/.04)	1.05
Vigorous PA (weekly)	.04***(.02/.07)	1.26	.06***(.04/.08)	1.26	.06***(.04/.08)	1.26
Vigorous PA (monthly)	.04***(.02/.06)	1.12	.04***(.02/.06)	1.12	.04***(.02/.08)	1.12
Moderate PA (weekly)	.13***(.10/.16)	1.60	.12***(.09/.14)	1.60	.14***(.11/.16)	1.60
Moderate PA (monthly)	.05*(.07/-.03)	1.26	.05***(-.02/.07)	1.26	.05***(.02/.07)	1.26
Sleep 1-5 hours	.01(-.01/.03)	1.05	.00(-.02/.02)	1.05	.01(-.01/.03)	1.05
Sleep 5-8 hours	.05***(.03/.07)	1.11	.06***(.04/.08)	1.11	.07(.04/.09)	1.11
Alcohol consumption (everyday/weekly)	.10***(.08/.13)	1.50	.09***(.06/.11)	1.50	.09***(.06/.12)	1.50
Alcohol consumption (monthly)	.04***(.02/.07)	1.31	.03**(.01/.06)	1.31	.03**(.01/.06)	1.31

Table 9

(Continued)

	Immediate Recall		Delayed Recall		Verbal Fluency	
	β (95% CI)	**VIF**	***β (95% CI)***	**VIF**	***β (95% CI)***	**VIF**
Step 3: R^2	**.23*****		**.24*****		**.18*****	
***F* (*df*)**	**137.38 (14, 6852)**		**140.89 (15, 6851)**		**104.37 (15, 6851)**	
ΔR^2	**.004*****		**.004*****		**.005*****	
ΔF (*df*)	**34.41 (1, 6851)**		**34.75 (1, 6851)**		**43.31 (1, 6851)**	
Age	-.25***(-.28/-.23)	1.40	-.26***(-.29/-.24)	1.40	-.19***(-.21/-.16)	1.40
Sex (female)[a]	.13***(.11/.15)	1.08	.14***(.12/.16)	1.08	.02(-.00/.04)	1.08
3rd Level education	.20***(.17/.23)	1.72	.20***(.10/.15)	1.72	.20***(.18/.23)	1.72
2nd Level education[b]	.13***(.10/.16)	1.64	.12***(.10/.15)	1.64	.13***(.10/.16)	1.64
Married/Co-habiting[c]	.02(-.00/.04)	1.14	.03**(.01/.05)	1.14	-.00(-.03/.02)	1.14
Non-Smoker[d]	.02(-.00/.04)	1.05	.02(-.00/.04)	1.05	.02(-.00/.04)	1.05
Vigorous PA (weekly)	.04**(.01/.06)	1.27	.06***(.03/.08)	1.26	.05***(.03/.08)	1.27
Vigorous PA (monthly)	.04***(.02/.06)	1.12	.04***(.02/.06)	1.12	.04***(.01/.06)	1.12
Moderate PA (weekly)	.12***(.09/.15)	1.62	.11***(.08/.13)	1.62	.12***(.10/.15)	1.62

Moderate PA (monthly)[e]	.04***(.02/.07)	1.26	.04***(.02/.06)	1.26	.04***(.02/.07)	1.26
Sleep 1-5 hours	.01(-.01/.03)	1.05	.00(-.02/.02)	1.05	.01(-.01/.04)	1.05
Sleep 5-8 hours[f]	.05***(.03/.07)	1.11	.06***(.04/.08)	1.11	.07***(.04/.09)	1.11
Alcohol consumption (everyday/weekly)	.10***(.08/.13)	1.50	.09***(.06/.11)	1.50	.09***(.06/.12)	1.50
Alcohol consumption[g] (monthly)	.04***(.02/.07)	1.31	.03**(.01/.06)	1.31	.03**(.01/.06)	1.31
Subjective age	-.07***(-.10/-.05)	1.31	-.07***(-.10/-.05)	1.31	-.08***(-.11/-.06)	1.31

Note: VIF = variance inflation factor; [a] reference group = Males; [b] reference group = No qualification; [c] reference group = Neither; [d] reference group = Smoker; [e] reference group = Hardly ever/Never; [f] reference group = 9+ hours; [g] reference group = Rarely/Never.
Statistical significance: *p < .05; **p < .01; ***p < .001.

Study 3

Descriptive Statistics

Longitudinal analysis was conducted on wave 4 and wave 7 of ELSA. Data collection for wave 4 took place between 2008/2009 and for 7, 2014/2015. The analysis of response rates and attrition levels in ELSA is complicated, according to Banks et al., (2011) this is due to the refreshment samples. But in wave 4, 11,050 participants were included and in wave 7 a total of 9,666 were included. With refreshment samples added in both wave 6 and wave 7.

A total of 7,432 participants responded to both waves 4 and 7. These participants were included in this analysis of change. Table 1 indicates the descriptive statistics of those included. In wave 4 the mean age of the participants was 64.19 (SD = 8.57) with an age range of 50-89 years (n = 7432). In wave 7 the mean age of the participants rises to 69.66 (SD = 8.04) with an age range of 56-89 years (n = 7272).

Table 1

Frequencies of Males and Females and their Chronological Age over Wave 4 and Wave 7

	Wave 4			**Wave 7**		
Sex	**n(%)**	**Mean**	**SD**	**n(%)**	**Mean**	**SD**
Male	3317(44.6)	64.27	8.30	3255(44.8)	69.78	7.84
Female	4115(55.4)	64.15	8.78	4017(55.2)	69.57	8.19

Table 2 illustrates the changes in the lifestyle behaviours over the course of the two waves. In wave 7, 90.1% of the sample were currently non-smokers. There was a drop in levels of physical activity with 20.6% of the sample in wave 7 rarely engaging in moderate levels of physical activity compared to 14.4% in wave 4. Sleep patterns also changed, with 21.4% sleeping over 9 hours in wave 7 and only 5.1% in wave 4. Individual reported consuming alcohol less frequently with 57.7% drinking on a weekly basis in wave 7 compared to 60.8% in wave 4.

Table 2

Descriptive Statistics of all the Lifestyle Behaviour Variables

Variable	**Wave 4** n(%)	**Wave 7** n(%)
Current smoker		
Yes	964 (13.1)	734 (9.9)
No	6383 (86.9)	6716 (90.1)
Vigorous physical activity		
Hardly ever	4271 (57.3)	4759 (63.9)
Couple times a month	770 (10.3)	662 (8.9)
Couple times a week	2409 (32.3)	2027 (27.2)
Moderate physical activity		
Hardly ever	1070 (14.4)	1536 (20.6)
Couple times a month	480 (6.4)	467 (6.3)
Couple times a week	5900 (79.2)	5446 (73.1)
Sleep		
1-5 hours	381 (5.1)	254 (5.0)
5-8 hours	6412 (86.0)	3751 (73.6)
9+ hours	363 (4.9)	1092 (21.4)

Alcohol consumption		
Every day/couple times a week	3750 (60.8)	3668 (57.7)
Couple times a month	1695 (27.9)	1817 (28.6)
Rarely/never	724 (11.7)	876 (13.8)

As expected there was also a change in cognitive function over time, Table 3 indicating all the changes from wave 4 to wave 7. Looking at immediate recall, delayed recall and verbal fluency, over all participants recalled less words immediately in wave 7 (M = 5.86, SD = 1.87) than in wave 4 (M = 6.06, SD = 1.67), recalled less words after a delay (M = 4.50, SD = 2.19) in wave 7 compared to wave 4 (M = 4.84, SD = 1.99) and named fewer animals (M = 20.85, SD = 7.24) in wave 7 compared to wave 4 (M = 21.47, SD = 6.64).

Table 3

Descriptive Statistics of Cognitive Function (Immediate Recall, Delayed Recall and Verbal Fluency) in both Wave 4 and Wave 7

	Wave 4			**Wave 7**		
Cognitive Function	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Immediate recall	7266	6.06	1.67	7116	5.86	1.87
Delayed recall	7279	4.84	1.99	7128	4.50	2.19
Verbal fluency	7266	21.47	6.64	7127	20.85	7.24

As expected there was a slight change in subjective age over the course of the two waves, Figure 1 and 2 illustrating this change in subjective age from wave 4 to wave 7. Looking at subjective age discrepancy Table 4 indicates the changes from both waves, again showing similar results to the previous analyses of wave 4 and wave 7 that the older the participants the larger the discrepancy between chronological age and subjective age for example those in the 80+ group at wave 4 felt on average 14 years younger and those in the 80+ group in wave 7 felt an average of 13 years younger, Figures 3 and 4 illustrate these results. In Table 5 participants were divided into groups of the highest 10% of subjective age discrepancy, the middle 50-60% and the lowest 10% of subjective age discrepancy. This illustrating that in both waves, those who were the oldest hand the larger discrepancy, i.e. they felt younger (highest 10% group).

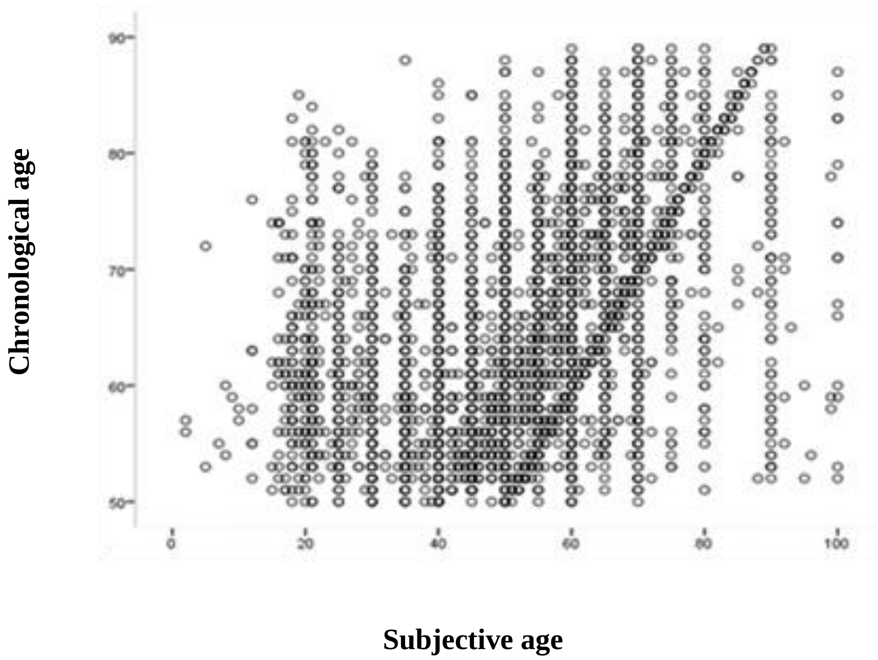


Figure 1. Plot comparing the means of chronological age and subjective age at wave 4.

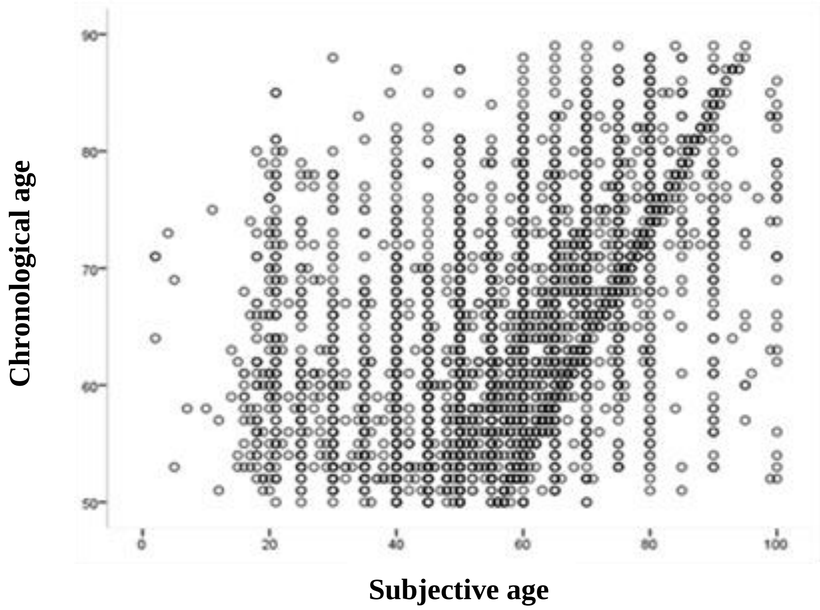


Figure 2. Plot comparing the means of chronological age and subjective age at wave 7.

Table 4

Chronological Age at Wave 4 and the Mean Absolute Subjective Age Discrepancy in Wave 4 and 7

	Wave 4			Wave 7		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
50-59	2449	9.05	12.32	2443	10.49	12.17
60-69	2682	11.79	12.60	2663	12.42	12.88
70-79	1576	13.85	13.69	1523	13.26	14.59
80+	397	13.85	15.17	214	13.26	15.34
Total	7104	11.44	13.05	6843	11.96	13.17

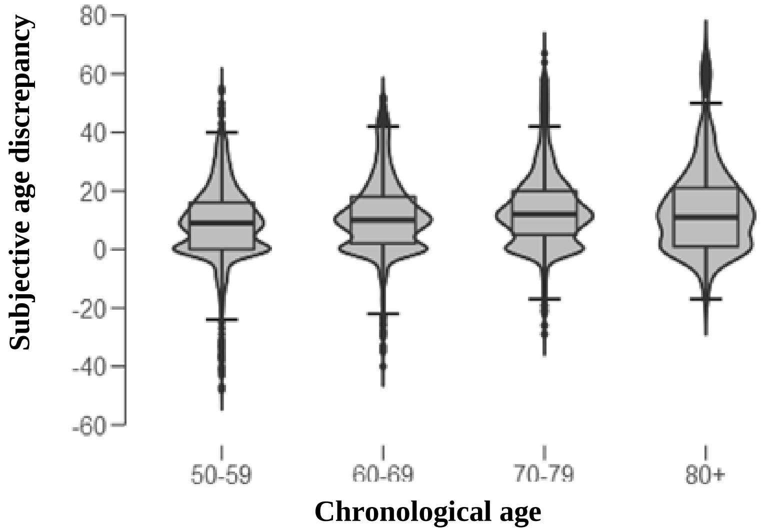


Figure 3. Illustrating the means if subjective age discrepancy and chronological age at wave 4. The participants in the older groups reported a higher positive subjective age discrepancy than their younger counterparts.

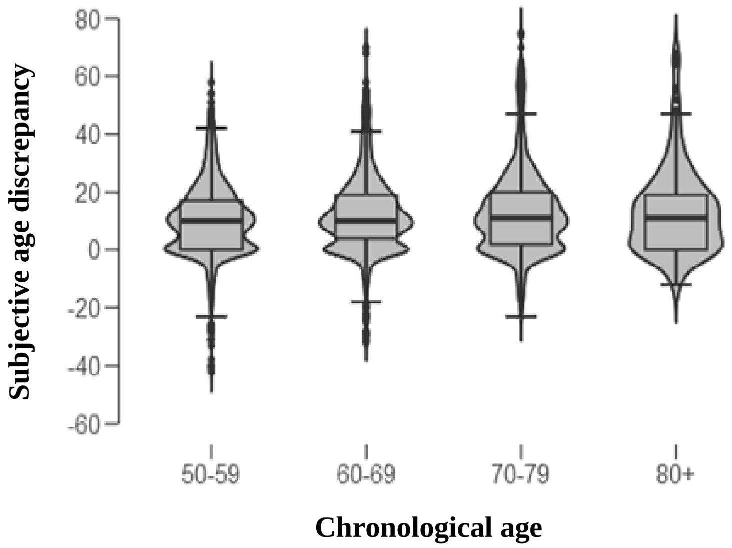


Figure 4. Illustrating the means of subjective age discrepancy at wave 7 and chronological age at wave 4. Again showing the older groups reported a higher positive subjective age discrepancy than the younger groups.

Table 5

The Mean Chronological Age of Participants in each Subjective Age Discrepancy Category; Highest 10%, Middle 50-60% and the Lowest 10%

	Wave4			**Wave7**		
Subjective age discrepancy	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Highest 10%	699	66.10	8.42	658	70.80	8.13
Middle 50-60%	646	63.80	7.93	630	68.93	7.67
Lowest 10%	1721	63.09	8.66	1579	69.30	8.26

Inferential Statistics

A paired samples t-test was conducted to evaluate the level of change between subjective age discrepancy from wave 4 to wave 7. Both subjective age discrepancy in wave 4 and 7 were normally distributed and were suitable to be used in a t-test (Appendix A). There was a significant change between subjective age discrepancy from wave 4 (M = 11.44, SD = 13.00) to wave 7 (M = 12.03, SD = 13.18), t(6638) = 3.60, p< .001 (two-tailed). The mean increase in the subjective age discrepancy from wave 4 to wave 7 was .593 with a 95% confidence interval ranging from .27 to .92. The eta squared statistic (-.04) indicated a small effect size.

Table 5

Paired Samples t-test between Subjective Age Discrepancy and Subjective Age from Wave 4 to Wave 7

	Wave 4		**Wave 7**					
Outcome	Mean	SD	Mean	SD	n	95% CI	t	p
Subjective Age Discrepancy	11.44	13.00	12.03	13.18	6639	.27/.92	3.60	< .001

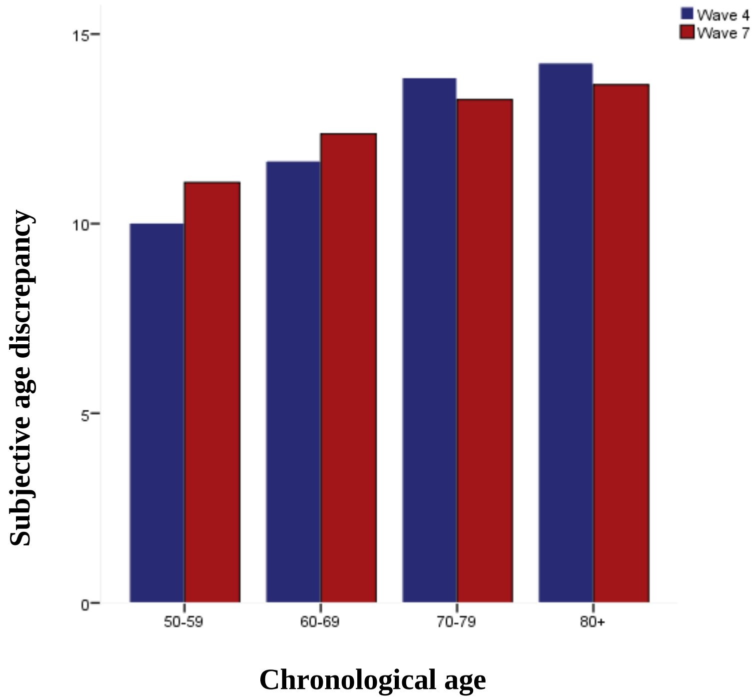


Figure 5. Bar chart illustrating the change in subjective age discrepancy from wave 4 to wave 7 in relation to chronological age at wave 4. As participants aged the discrepancy between their chronological age and subjective age grew in both wave 4 and 7.

Cognitive Function: Three paired samples t-tests were conducted to evaluate the change in cognitive function between wave 4 and wave 7. Focusing on immediate recall, delayed recall and verbal fluency, which were all normally distributed (Appendix B). In immediate recall, there was a significant change between wave 4 (M =6.02, SD = 1.62) to wave 7 (M = 5.68, SD = 1.88), $t(3927)$ = 11.85, $p< .001$ (two-tailed). The mean difference between the two-time points was .337 with a 95% confidence interval ranging from .28 to .39. The eta squared statistic (.13) indicated a medium effect size. There was a significant change between delayed recall from wave 4 (M = 4.79, SD = 1.93) to wave 7 (M = 4.31, SD = 2.20), $t(3936)$ = 15.50, $p< .001$. The mean difference between the two-time points was .483

with a 95% confidence interval ranging from .42 to .54. The eta squared statistic (.18) indicated a large effect size. Finally there was a significant change between verbal fluency from wave 4 (M =21.42, SD = 6.63) to wave 7 (M =20.35, SD = 7.20), t(3932) = 10.20, p< .001. The mean difference in verbal fluency between the two-time points was 1.07 with a 95% confidence interval of .86 to 1.27. The eta squared statistic (.11) indicated a medium effect size.

Table 6

Paired Samples t-test between Immediate Recall, Delayed Recall and Verbal Fluency from Wave 4 to Wave 7

	Wave 4		**Wave 7**					
Outcome	Mean	SD	Mean	SD	n	95% CI	t	p
Immediate recall	6.10	1.65	5.86	1.87	7043	-.28/-.19	-10.87	< .001
Delayed recall	4.88	1.97	4.51	2.19	7064	.33/.42	15.78	< .001
Verbal fluency	21.47	6.64	20.85	7.24	7055	.56/.86	9.07	< .001

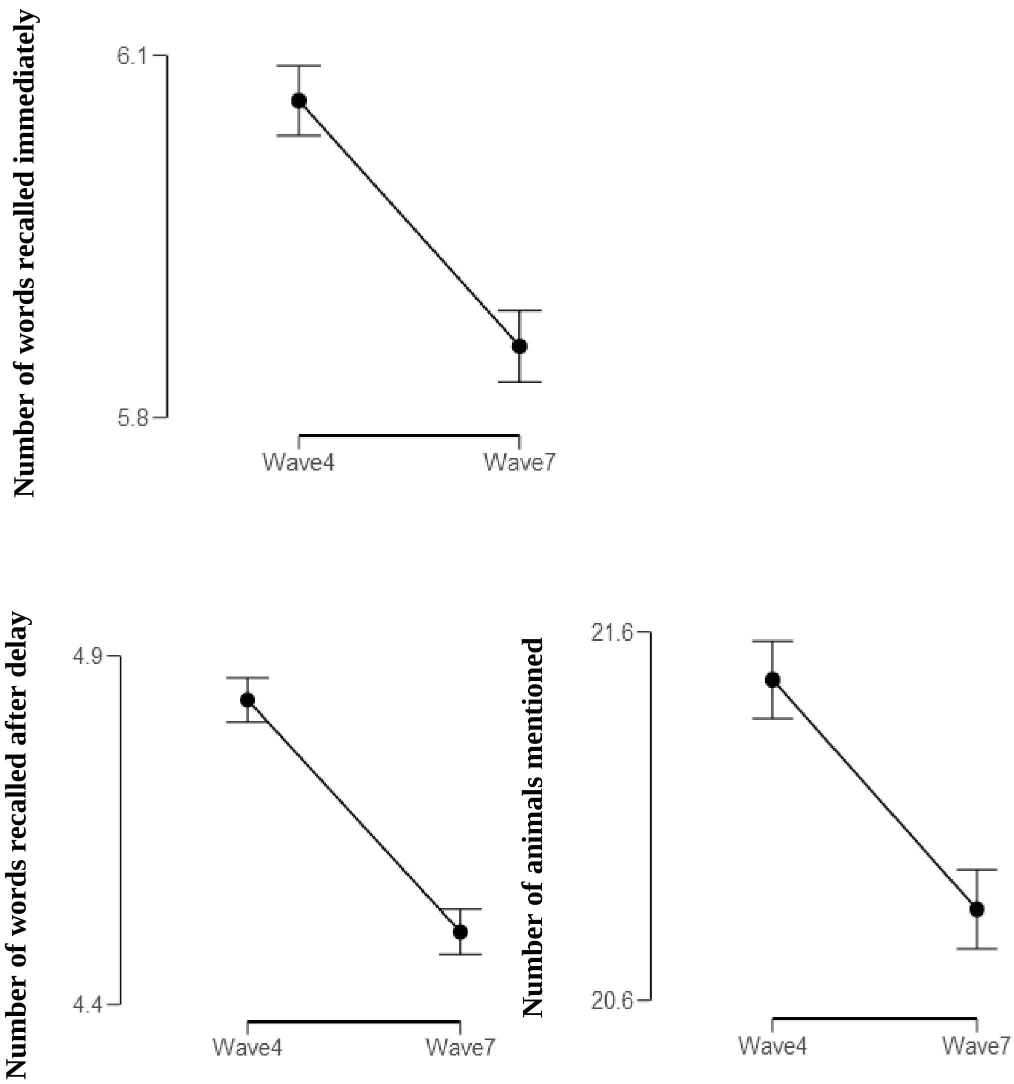


Figure 6. The means plots of cognitive function (immediate recall, delayed recall and verbal fluency) between both wave 4 and wave 7. Illustrating that participants recalled less words immediately and after a delay and mentioned less animals in wave 7 compared to wave 4.

Hierarchical Multiple Regression

Hierarchical multiple regression was preformed to investigate the ability of subjective age and lifestyle behaviours to predict levels of immediate recall, delayed recall and verbal fluency, after controlling for age, sex, educational attainment, relationship status and cognitive function (immediate recall, delayed recall and verbal fluency) at wave 4. All results for the hierarchical multiple regression are presented in Table 8. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity and homoscedasticity (Appendix C). In addition, the correlations amongst the predictor variables were all examined. All correlations between the independent variables were weak to moderate ranging from $r = .01$ to $r = .50$. Correlations between chronological age and subjective age were not a problem $r = .45$. Indicating that multicollinearity was unlikely to be a problem (Tabachnick & Fidell, 2013). Variance inflation factors were included in Table 8 to indicate that multicollinearity was not an issue. These are all indicated in Table 7. All independent variables show some relationship with the dependent variables (immediate recall, delayed recall and verbal fluency at wave 7) ranging from $r = .01$ to $r = .55$.

Predicting Immediate Recall: In the first step of the hierarchical multiple regression six predictors were entered; age, sex, educational attainment, relationship status and immediate recall at wave 4. This model was statistically significant $F(6, 6877) = 529.27$, $p < .001$ and explained 32% of the variance of immediate recall at wave 7. After the entry of the lifestyle behaviours in step two the total variance explained by the model was 32% ($F(15, 6868) = 216.90$, $p < .001$). The introduction of the lifestyle behaviours explained an additional 1% of the variance of immediate recall at wave 7, after controlling for the demographics and immediate recall at wave 4. A change that was statistically significant (R^2 Change = .005; $F(9, 6868) = 6.17$, $p < .001$). In the third step subjective age was introduced, this model was again statistically significant $F(16, 6867) = 203.80$, $p < .001$ explaining 32% of the variance. This explained a further .1% of the variance of immediate recall. The change was also significant (R^2 Change = .001; $F(1, 6867) = 5.32$, $p < .05$). In the final model immediate recall ($\beta = .34$, $p < .001$) was the strongest predictor.

Predicting Delayed Recall: In step one, the model was statistically significant $F(6, 6889) = 681.57$, $p < .001$, and explained 37% of the variance of delayed recall at wave 7. After the entry of the lifestyle behaviours the step two the total variance explained by the model was 39% ($F(15, 6880) = 279.78$, $p < .001$). The addition of the lifestyle behaviours explained a further 1% of the variance of delayed recall, a change that was statistically significant (R^2 change = .006; ($F(9, 6880) = 7.86$, $p < .001$). In the third step subjective age was introduced this model was statistically significant explaining 38% of the total variance $F(16, 6879) = 263.03$ this addition of subjective age was also statistically significant (R^2 change = .001; ($F(16, 6879) = 7.65$, $p < .01$). In the final model delayed recall was the strongest predictor ($\beta = .42$, $p < .001$).

Predicting Verbal Fluency: In step one, the model was statistically significant $F(6, 6888) = 623.95$, $p < .001$ and explained 35% of the variance of verbal fluency at wave 7. After entering the lifestyle behaviours in step two the total variance explained by the model was 36% ($F(15, 6879) = 255.76$, $p < .001$). The introduction of the lifestyle behaviours explained an additional 1% of the variance in verbal fluency, a change that was statistically significant ($R^2 = .006$; ($F(9, 6879) =

7.03, $p < .001$). In the third step, subjective age was entered, this was statistically significant $F(16, 3825) = 137.65$, $p < .001$ explaining 36% of the variance. The addition of subjective age was not significant (R^2 change = .000; ($F(1, 6878) = .33$, $p = .57$). The strongest predictor in the final model was verbal fluency ($\beta = .47$, $p < .001$).

Table 7

Correlations of all Independent Variables Included in the Hierarchical Multiple Regression

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	1 8
1. Age	1																	
2. Sex(female)	.04*	1																
3. 3rd level education	-.12**	-.19**	1															
4. 2nd level education	.05**	-.06**	.50**	1														
5. Married/Co-habiting	-.24**	-.20**	.13**	-.01	1													
6. Smoker	-.12**	.01	.07**	.01	.10**	1												
7. Vigorous PA (weekly)	-.15**	-.09**	.17**	-.04**	.10**	.09**	1											
8. Vigorous PA (monthly)	-.03	-.03	.04**	.01	.01	.03	-.23**	1										
9. Moderate PA (weekly)	-.19**	-.12**	.15**	.01	.15**	.10**	.31**	.07**	1									
10. Moderate PA (monthly)	.04*	.02	-.03*	.03	-.04**	-.02	-.13**	.05**	-.50**	1								
11. Sleep 1-5 hours	.03	.07**	-.07**	.01	-.07**	-.05**	-.05**	-.02*	-.10**	-.01	1							
12. Sleep 5-8 hours	-.06**	-.07**	.07**	.01	.03	.04**	.06**	.01	.10**	-.02	-.50**	1						
13. Alcohol consumption (everyday/weekly)	-.03**	.01	-.03	-.01	-.01	-.02	-.03	.02	-.01	.02	-.03	-.01	1					

14. Alcohol consumption (monthly)	.02	-.01	.03	.01	.02	.03*	-.02	-.03	.02	.01	.02	.01	-.54**	1				
15. Subjective age	.45**	.02	-.07**	.02	.10**	.04**	-.15**	-.04**	-.18**	.02	.04**	-.05**	-.02	.03	1			
16. Immediate recall	-.32**	.08**	.20**	.03	.13**	.05**	.13**	.05**	.17**	-.04*	-.07**	.09**	-.01	.02	-.20**	1		
17. Delayed recall	-.33**	.10**	.20**	.03*	.12**	.03*	.11**	.06**	.17**	-.03**	-.07**	.09**	-.01	.01	-.19**	.72**	1	
18. Verbal fluency	-.27**	-.05**	.22**	.01	.13**	.05**	.14**	.07**	.17**	-.04**	-.05**	.10**	-.01	.04**	-.17**	.39**	.38**	1

Note: Cognitive function (immediate recall, delayed recall and verbal fluency) at wave 4 included in separate hierarchical regression models. Statistical significance: *$p < .05$; **$p < .01$; ***$p < .001$.

Table 8

Hierarchical Multiple Regression Models Predicting Cognitive Function Outcomes

	Immediate Recall		**Delayed Recall**		**Verbal Fluency**	
	β (95% CI)	**VIF**	***β (95% CI)***	**VIF**	***β (95% CI)***	**VIF**
Step 1: R^2	**.32*** **		**.37** **		**.35*** **	
***F* (*df*)**	**529.41 (6, 6877)**		**681.57 (6, 6889)**		**623.95 (6, 6888)**	
Age	-.26***(-.29/-.25)	1.15	-.25***(-.28/-.24)	1.16	-.20***(-.22/-.18)	1.12
Sex (female)	.07***(.05/.09)	1.06	.07***(.05/.09)	1.07	.00(-.02/.02)	1.05
3rd Level education	.16***(.13/.18)	1.69	.12***(.09/.14)	1.70	.11***(.08/.13)	1.69
2nd Level education	.08***(.05/.10)	1.57	.04***(.02/.06)	1.58	.04***(.02/.06)	1.57
Married/Co-habiting	.02*(.00/.04)	1.08	.03**(.01/.05)	1.08	-.00(-.02/.02)	1.08
Cognitive function wave 4	.37***(.20/.23)	1.18	.44***(.21/.23)	1.20	.48***(.07/.08)	1.14
Step 2: R^2	**.32*** **		**.38*** **		**.36*** **	
***F* (*df*)**	**261.90 (15, 6868)**		**279.78 (15, 6880)**		**255.76 (15, 6879)**	
ΔR^2	**.01*** **		**.01*** **		**.01*** **	
ΔF (*df*)	**6.17 (9, 6868)**		**7.86 (9, 6880)**		**7.03 (9, 6879)**	

Age	-.26***(-.29/-.25)	1.22	-.25***(-.28/-.24)	1.23	-.19***(-.22/-.18)	1.20
Sex (female)	.08***(.06/.10)	1.08	.07***(.05/.09)	1.09	.01(-.01/.03)	1.06
3rd Level education	.14***(.11/.16)	1.76	.10***(.07/.12)	1.77	.09***(.06/.11)	1.76
2nd Level education	.07***(.04/.09)	1.60	.03*(.01/.05)	1.60	.03**(.01/.05)	1.59
Married/Co-habiting	.01(-.01/.03)	1.11	.02(-.00/.04)	1.11	-.01(-.03/.01)	1.11
Cognitive function wave 4	.35***(.20/.22)	1.21	.42***(.20/.22)	1.23	.47***(.07/.07)	1.16
Non-Smoker	.03**(.01/.05)	1.08	.04***(.02/.06)	1.08	.02*(.00/.04)	1.08
Vigorous PA (weekly)	.03*(.00/.04)	1.24	.02(-.00/.04)	1.24	.03**(.01/.05)	1.24
Vigorous PA (monthly)	.02(-.00/.04)	1.11	.00(-.02/.02)	1.11	.02*(.00/.04)	1.11
Moderate PA (weekly)	.04**(.00/.02)	1.62	.05***(.04/.09)	1.62	.06***(.04/.09)	1.61
Moderate PA (monthly)	.01(-.01/.03)	1.39	.03*(.01/.04)	1.39	.03**(.01/.05)	1.39
Sleep 1-5 hours	-.01(-.03/.01)	1.51	-.02(-.04/.01)	1.52	-.00(-.02/.02)	1.51
Sleep 5-8 hours	.02*(.00/.07)	1.52	.02(-.00/.06)	1.52	.03**(.01/.07)	1.51
Alcohol consumption (everyday/weekly)	.02(-.01/.04)	1.43	.01(-.01/.04)	1.43	-.00(-.02/.02)	1.43
Alcohol consumption (monthly)	.01(-.01/.04)	1.43	.01(-.02/.03)	1.43	.00(-.02/.03)	1.43

Table 8

(Continued)

	Immediate Recall		Delayed Recall		Verbal Fluency	
	β (95% CI)	**VIF**	***β (95% CI)***	**VIF**	***β (95% CI)***	**VIF**
Step 3: R^2	**.32*** **		**.38*** **		**.36*** **	
F (df)	**203.80 (16, 6867)**		**263.03 (16, 6879)**		**239.78 (16, 6878)**	
ΔR^2	**.00***		**.001** **		**.00**	
ΔF (df)	**5.32 (1, 6867)**		**7.65 (1, 6879)**		**.33 (1, 6878)**	
Age	-.25***(-.29/-.24)	1.45	-.24***(-.27/-.22)	1.46	-.19***(-.22/-.17)	1.43
Sex[a] (female)	.08***(.06/.10)	1.08	.07***(.05/09)	1.09	.01(-.01/.03)	1.06
3rd Level education	.14***(.11/.16)	1.76	.10***(.07/.12)	1.77	.09***(.06/.11)	1.76
2nd Level education[b]	.06***(.04/.09)	1.60	.03*(.00/.05)	1.60	.03*(.01/.05)	1.59
Married/Co-habiting[c]	.01(-.01/.03)	1.11	.02(.00/.04)	1.11	-.01(.03/.01)	1.11
Cognitive function wave 4	.34***(.19/.22)	1.21	.42***(.20/.22)	1.23	.47***(.07/.07)	1.16
Non-Smoker[d]	.03**(.01/.05)	1.08	.04***(.02/.06)	1.08	.02*(.00/.04)	1.08
Vigorous PA (weekly)	.02*(.00/.04)	1.24	.02(-.01/.03)	1.24	.03**(.01/.05)	1.24

Vigorous PA (monthly)	.02(-.00/.04)	1.11	.00(-.02/.02)	1.12	.02**(.00/.04)	1.12
Moderate PA (weekly)	.04**(.02/.07)	1.63	.05***(.03/.09)	1.62	.05***(.04/.09)	1.62
Moderate PA (monthly)[e]	.01(-.01/.03)	1.39	.03*(.00/.04)	1.40	.03**(.01/.05)	1.39
Sleep 1-5 hours	-.01(-.03/.01)	1.52	-.02(-.03/.01)	1.52	-.01(-.02/.02)	1.51
Sleep 5-8 hours[f]	.02*(.00/.06)	1.52	.02(-.00/.06)	1.52	.03**(.01/.07)	1.52
Alcohol consumption (everyday/weekly)	.02(-.01/.04)	1.43	.01(-.01/.04)	1.43	.-.00(-.02/.02)	1.43
Alcohol consumption[g] (monthly)	.01(-.01/.04)	1.43	.01(-.02/.03)	1.43	.00(-.02/.03)	1.43
Subjective age	-.03*(-.05/-.00)	1.30	-.03**(-.05/-.01)	1.30	-.01(-.03/.02)	1.30

Note: VIF = variance inflation factor; [a] reference group = Males; [b] reference group = No qualification; [c] reference group = Neither; [d] reference group = Smoker; [e] reference group = Hardly ever/Never; [f] reference group = 9+ hours; [g] reference group = Rarely/Never.
Statistical significance: *p < .05; **p < .01; ***p < .001.

Discussion

In cognitive ageing research, chronological age is the time metric used to predict one's cognitive functioning (Singh-Manoux et al., 2012). However, chronological age is not successful in demonstrating the ageing process alone (Miche et al., 2014) as ageing is considered to be a subjective experience (Montepare, 2009). Alternative methods of assessing development over time may add beneficial understanding into the processes that are involved in older adult's cognitive function. Leading to the growing interest in the implications of subjective age and the investigation into the outcomes of feeling younger than one's chronological age. The present study investigated the effects of subjective age and lifestyle behaviours on the cognitive function measures of immediate recall, delayed recall and verbal fluency. This study tested and also found support for the hypotheses. That the majority of individuals would feel younger than their chronological age; that this discrepancy between subjective age and chronological age will grow with age; that those with a younger subjective age will engage in healthier lifestyle behaviours and that a younger subjective age is associated with better cognitive performance on immediate recall, delayed recall and verbal fluency tasks. The hypotheses were tested on wave 4, wave 7 and over the course of these two waves in the ELSA data.

The preliminary findings of the cross sectional analyses of wave 4 and wave 7 of ELSA were consistent with each other and with previous findings. Older adults tended to feel younger than their chronological age (Eibach, 2011; Montepare, 2009; Stephan et al., 2012). The majority of the sample in both waves felt younger than their chronological age. These individuals felt on average seventeen percent younger in both waves, which is consistent with Rubin and Bertsen (2006) that individuals over the age of 40 years feel on average twenty percent younger than their chronological age. In addition to this, the findings from both waves showed that this discrepancy between subjective age and chronological age increased with age. Previous research has shown this, as adolescents and younger adults often feel older and older adults often feel younger than their chronological age (Rubin & Berntsen, 2006).

Having a younger subjective age is known as a self-enhancing strategy (Keyes & Westerhof, 2012). With feeling younger being associated with several beneficial outcomes (Diehl & Wahl, 2010; Montepare, 2009; Stephan et al., 2014). Specifically, feeling younger is associated with being physically active (Caudroit et al., 2012) lower risk of obesity (Stephan et al., 2014) and less disease burden (Demakakos et al., 2007). The results of the present study added to this existing research, as those individuals who felt younger engaged in healthy lifestyle behaviours. For example, individuals with a younger subjective age were more likely to be non-smokers, more active than their counterparts, sleep between 5-8 hours per night and consumed a moderate amount of alcohol.

Individuals in the higher level group that felt younger when compared to others in the sample, performed better on both episodic memory and semantic memory tasks. Indicating that the participants who has a younger subjective age were outperforming their counterparts in episodic and semantic memory. This is consistent with the literature (Schafer & Shippee, 2010; Stephan et al., 2011; Stephan et al., 2014; Stephan et al., 2015; Stephan et al., 2016). Which showed that subjective age remained a significant predictor of cognitive function even after controlling for potential cofounders such as demographics and lifestyle behaviours. This being the main finding of the results in wave 4 and wave 7 of ELSA. Feeling younger than one's chronological age was associated with better performance on episodic and semantic memory tasks. This was after controlling for demographic factors (age, gender, relationship status and educational attainment) and lifestyle behaviours (smoking, sleep, physical activity and alcohol consumption). This furthers Stephan and colleagues (2014) study as the present study controlled for more lifestyle behaviours rather than just physical activity, that are also linked to cognitive function. These finding were expected as episodic memory is very sensitive to age-related decline (Mohanty et al., 2016). In semantic memory age-related decline is visible mainly in language production tasks such as verbal fluency (Nyberg et al., 2003). Having a younger subjective age may help to alleviate these age-related declines.

The findings of the present study indicating the link between subjective age relative to chronological age. The idea that the majority of individuals felt younger than their chronological age relates to older adults maintaining a positive self-perception of their ageing (Kleinspehn-Ammerlahn et al., 2008). Research has also suggested that subjective age may be considered as a defensive response to protect older adults against the negative stereotypes associated with ageing (Weiss & Lang, 2012). Individuals may accept or avoid specific social identities this is determined by the negative or positive cognitive representation they hold of such identities. And this dissociation from individuals of the same age may cause someone to feel younger or older than their chronological age. In relation to the growing discrepancy between subjective age and chronological age with one's ageing, this could be due to social comparisons. Suggesting that having favourable comparisons of one's health in relation to a peer's health has enhancing effects on subjective age (Barrett, 2003; Infurna et al., 2010). Social comparisons with same aged peer's is a beneficial strategy to maintain this sense of feeling younger than your chronological age.

However, Kwak and colleagues (2018) suggested that this discrepancy could be due to an indirect awareness of an individual's neurobiological ageing rather than these negative stereotypes and social comparisons.

These findings are similar to that of previous research and this reiterates the implications of subjective age (Stephan et al., 2018). Subjective age is a motivational facet of age identification and is a meaningful construct of age throughout the lifespan (Galambos et al., 2009). Engaging in healthier behaviours may be down to other constructs of age identification, such as desired age. Many older adults would like to be even younger than they feel, with some reporting a desired age up to 30 years younger than their chronological age (Hubley & Russell, 2009; Kaufman & Elder, 2002). This idea that individuals want to be much younger than actually are could lead them to engage in healthier lifestyle behaviours and thus feel younger. As subjective age can be either a predictor or an outcome of an individual's behaviour (Galambos et al., 2009). Self-rated health is also associated with subjective age in older adults (Stephan et al., 2012). Indicating that an individual's positive perception of their health may lead to a younger subjective age. Further, as there is evidence that has linked an older subjective age to mortality (Uotinen, Rantanen & Suutama, 2005), and as such feeling older than one's chronological age may be an early indicator of deteriorating health in older adults.

Longitudinal analysis of ELSA showed a change in individual's lifestyle behaviours over the course of the two waves. Within lifestyle behaviours, the findings showed a drop in levels of physical activity, alcohol consumption and smokers over time, whereas sleep duration increased. This drop was particularly visible in levels of physical activity, which is consistent with previous research. In older adults more time is spent sedentary and recommended levels of physical activity are not met (Sparling, Howard, Dunstan & Owen, 2015). Compliance to the guidelines drops below 50% in adults 75 years and over (VanStralen, DeVries, Mudde, Bolman & Lechner, 2009). There is no consistent relation between chronological age and smoking cessation. Although, older adults may be more capable in achieving smoking cessation than their younger counterparts (Buskland & Connolly, 2005). The drop in number of smokers in ELSA could also be due to the attrition rates. Older adults have significant changes to their sleep patterns and experience more sleep disturbance (Carrier et al., 2017). The sleep measure used from ELSA asking participants to report what time they went to sleep at and woke up at yesterday. The significant change may be due to the fact that older adults tend to have more freedom to sleep than younger adults. Sleep considerations in older adults range from 6-9 hours and this is associated with a better quality of life. However, sleeping over 9 hours in older adults is associated with morbidity and mortality (Hirshkowitz et al., 2015). Higher levels of alcohol consumption is less prevalent in older adults. Although, what is considered light or moderate amounts of alcohol in younger adults may have more serious consequences for older adults (Barry & Blow, 2016). Smoking, poor sleep quality, excessive alcohol consumption and sedentary behaviour all have deleterious effects on cognitive function (Kesse-Guyot et al., 2014). Which could also be the reason that there was a drop in individual's levels of cognitive performance.

As expected there was a drop in each of the cognitive function measures. Both episodic memory and semantic memory showed declines over time. It is well established that with ageing there is a decline in cognitive functioning (Gard et al., 2014). Chronological age itself being the main predictor for cognitive decline (Bishop & Yankner, 2010) as ageing itself is associated with frontal system declines, this decline is visible in the absence of pathology (Boyle et al., 2013). In particular, an individual's memory is especially subject to age-related decline (Salthouse, 1991). As one of the most common complaints among older adults is their memory function (Bamidis, 2014). Thus, this may be the main reason for there being a slight decline in episodic and semantic memory. There is variability in this decline in functioning. There are many other factors related to predicting cognitive decline, regardless of age. Research has demonstrated that there are a number of lifestyle behaviours that are associated with cognitive function and may maintain or decline cognitive function (Gard et al., 2014). For example, current smokers are more likely to exhibit cognitive decline. Sedentary behaviour, which increases along with age, is also a significant risk factor for cognitive decline (Blondell et al., 2014). Disturbance to sleep patterns has also been shown to have an effect on cognitive function (Falck et al., 2018). In relation to alcohol consumption, light to moderate levels of intake are not considered to have deleterious effects on cognitive function (Plassman et al., 2010).

The main findings of study 3 showed that subjective age was a significant predictor of episodic memory even when controlling for demographics, lifestyle behaviours and cognitive performance at wave 4, but that subjective age was not a significant predictor of semantic memory. Although little research to date has specifically focused on cognitive performance as an outcome of subjective age, research has suggested that a younger subjective age is associated with better cognitive function (Infurna et al., 2010; Stephan et al., 2014) and that a younger subjective age is associated with slower decline in episodic memory and global memory function (Stephan et al., 2015). This could be due to individual's emotional stability (Stephan et al., 2015) but it may also be due to an individual's attitude towards ageing, as subjective age has been found to have a strong impact on people's attitudes about their own cognitive ageing (Schafer & Shipee, 2010). As previously discussed, ageing is linked to cognitive decline (Stephan et al., 2016) and resultant negative stereotypes can form with regards to older adult's cognitive abilities. Activating such negative age stereotypes causes poorer performance on cognitive tasks (Levy et al., 2016) for example research has found that older adults felt older prior to and after taking memory tests (Hughes, Geraci & DeForrest, 2013). This indicating that the perception of one's ability to conduct a task rather than their actual ability effects their performance. Those who feel younger than their chronological age have a more positive perception of their ageing and thus perform better on cognitive tasks. Findings from a meta-analysis show that negative age stereotypes have a large effect on behavioural outcomes such as memory (Meisner, 2012). Feeling older than one's chronological age predicted higher negative affect when an individual's attitudes towards ageing were less favourable (Mock & Eibach, 2011). As to why there was no association with subjective age and semantic memory over time, this could be due to the fact that episodic memory function is effected by ageing more so than semantic memory (Levine et al., 2002) which indicates that it is not as sensitive to age like episodic memory is. Sematic memory and in the present study's case, animal fluency, accumulates over the course of the lifespan with very little or no damaging effects of normal ageing (Brickman & Stern, 2009; Nyberg, 2017). With this in mind the fact that episodic memory is more sensitive to ageing this is why the present study's findings indicated that over time subjective age had little effect on semantic memory. Ageing has considerable deleterious effects on episodic memory. Older adults having more difficulty than their younger counterparts recalling information especially after a delay (Brickman

& Stern, 2009). Thus the fact that feeling younger was associated with better episodic memory is a major finding.

Research looking at a younger subjective age and cognitive function have consistently found a positive association (Stephan et al., 2014; Stephan et al., 2015; Stephan et al., 2016). The present study's results have added to the existing literature, the finding that feeling younger is associated to cognitive performance. Although the strength of this association was small, it was comparable or larger than the effects that were observed for demographics such as relationship status and lifestyle behaviours such as smoking, sleep, physical activity and alcohol consumption all of which are considered to be important predictors of cognitive function (Elwood et al., 2013; Lee et al., 2010; Kesse-Guyot et al., 2014). These results indicating that feeling older than one's chronological age may be an early indication of cognitive decline and that subjective age is also associated with many behavioural outcomes which have all been linked to cognitive functioning.

Strengths and Limitations

This study expands on the small amount of existing knowledge on the association between subjective age and cognitive function. Also integrating lifestyle behaviours into the model to show that they may be a part of the same process linking both subjective age and cognitive function together. This association between subjective age and cognitive function was demonstrated and evident in ELSA. Being a representative sample of the English population over 50 years, it supports the plausibility of the findings. Little research to date has focused on cognitive function as an outcome of subjective age. Thus, building on this literature in this area and highlighting the implications of the subjective experience of ageing on cognitive functioning and other outcomes is an important area to research.

However, this study has several limitations. The cross sectional design in both study 1 and 2 limits the ability to predict causal relationships. The present study utilised subjective age as a predictor of cognitive function, similar to previous research (Schafer & Shippee, 2010; Stephan et al., 2014) and this relationship is likely to be reciprocal (Barrett, 2003; Hubley & Russell, 2009). It may be plausible that the lifestyle behaviours are leading to a younger subjective age and thus leading to better cognitive function. Consistent with other research the finding that subjective age predicts cognitive function is relatively small (Stephan et al., 2014). Suggesting that subjective age may apply its influence through alternative pathways (Stephan et al., 2011). One potential explanation for this would be that subjective age drives forces such as one's lifestyle behaviours which makes it have a more proximal relationship with cognitive function. Self-report measures also carry potential problems in such studies with a reliance on participant honesty and introspective ability to provide accurate responses. For example, self-reported physical activity has been shown to be overestimated in older adults in particular (Manini et al., 2006). The way in which subjective age is measured may also cause methodological issues, as research to date has mainly used a single item measure to assess individuals subjective age "How old do you feel?" (Linder & Nosek, 2018; Choi et al, 2014; Stephan et al., 2014). However, there has been some investigations carried out on using a single-item measure rather than a multi-item scale, with Drolet and Morrison (2001) indicating that as the number of equivalent items increased, participants were more inclined to engage in "mindless response behaviour". As such a multiple-item scale takes more time for respondents to complete and increase response error.

Participants in ELSA responded to this single-item measure of subjective age with an age and the resultant score does not take into account participant's chronological age. As such, using subjective age discrepancy scores (subtracting reported subjective age from chronological age) gives more meaning than the raw score and this discrepancy score is more applicable and comparable among different age groups (Rubin & Berntsen, 2006; Stephan et al., 2013). In study 3 a hierarchical multiple regression was used to analysis the change from wave 4 to wave 7 of ELSA. This method of having time two as a dependent variable while controlling for time one has come under scrutiny with research suggesting that this method may cause regression to the mean and may be prone to biases (Allison, 1990). However, this is a conclusion that seems to be somewhat improbable for a lot of applications, as examining the relationship between time one and time two while controlling for time 1 alleviates the threat of spuriousness (Allison, 1990). Although there was a number of covariates included in the analyses. The present study did not control for a number of known correlates of cognitive function such as, general health, social participation and depression. Additional research is needed to account for these variables to test the strength of the relationship between subjective age and cognitive function.

Implications

This study contributes to the growing body of research on the outcomes of subjective age and also extends the small amount of research that focused on its association with cognitive function. The present study has reiterated the implications of subjective age, with the findings suggesting that subjective age shows associations with behavioural outcomes such as lifestyle behaviours that are linked with amplifying cognitive decline. The subjective perception of one's age is a marker of cognitive decline independent of chronological age and lifestyle behaviours. This advances the knowledge stimulating previous research on the role of ageing in cognitive function, by considering the subjective perception of one's age. Although the effects observed in the present study were small, this assessment of subjective age may inform about those individuals who are at an increased risk for cognitive impairment in older adulthood. This study reveals that feeling younger than one's chronological age may be a protective factor for cognitive function in older adults. Identifying factors that prevent cognitive decline or maintain cognitive function is of huge importance for society today.

Future directions

Current evidence suggests the reciprocal relationship between health and subjective age. However, more research is needed to analyse whether subjective age is better conceptualised as an outcome or a predictor of cognitive function. As Stephan and colleagues (2018) found that a higher cognitive ability in adolescence is predictive of a younger subjective age in later life. In addition, there is a need to further research the behavioural correlates of subjective age such as lifestyle behaviours. Research to date has focused in particular on physical activity, yet there is little known about its association with sleep, smoking and alcohol consumption. Relating subjective age to these lifestyle behaviours may inform about the pathways where an older subjective age leads to poorer lifestyle behaviours and thus leading to cognitive decline. Interest in interventions is directed by the rising ageing population, calling for ways to promote and maintain physical, cognitive and psychological functioning. As subjective age can be altered (Kotter-Gruhn & Hess, 2012), interventions that promote a younger subjective age may be an encouraging strategy to enhance health related outcomes and to promote physical and cognitive functioning. Although further research is needed to see if interventions inducing a younger subjective age lead to better health related outcomes. Brothers (2016) reported that behavioural interventions such as promoting physical activity, leads participants to have a younger subjective age and a more positive attitude towards their ageing.

An important goal following the present research would be to examine the association between subjective age and Alzheimer's, as only one piece of research so far has focused on subjective age and dementia and no difference between dementia patients and healthy older adults was found (Jaconelli et al., 2017). This study also only measured global cognitive function, and as such it is important to assess the effects of feeling younger on specific cognitive domains, as a decline in memory and executive function are related to developing dementia (Arvanitakis et al., 2018; Roll, Giovannetti, Libon & Eppig, 2017). Future research should take into account the multidimensionality of subjective age (Montepare, 2009). Identify the other facets of subjective age and their implications to cognitive function. Attention must also be given to the mediating or cofounding variables that also operate in the relationship between subjective age and cognitive function.

Conclusion

The present study investigated the effects of subjective age and lifestyle behaviours on cognitive function in older adults and supporting the hypothesis that feeling younger is associated with better cognitive functioning. The findings acknowledge that the behavioural pathway and the health of an individual with a younger subjective age may partially explain its relation to cognitive function. Understanding development in older adults is enhanced by utilising alternative age-related constructs such as subjective age with a growing body of research in this area supporting this view (Caudroit et al., 2012; Montepare, 2009; Stephan et al., 2011; Stephan et al., 2014). Subjective age has shown to have beneficial effects on individuals psychological, cognitive and physical functioning. The pattern of the increasing discrepancy between subjective age and chronological age as well as their relation to health and functioning have attached influence and significance to its research in older adults. Subjective age may be considered to be an adaptive strategy to ageing (Keyes & Westerhof, 2011) although emerging research has now shown that subjective age may be more than that, and represent an important construct in lifespan development in and of itself. An individual's rating of their subjective age is an indicator of one's psychological and physiological ageing and thus may help to identify individuals at risk of cognitive decline. The present study's findings show the importance and the implications of studying subjective age as a predictor of cognitive function. Given that the majority of older adults feel younger than their chronological age, subjective age seems to play a more significant role in older adults (Montepare, 2009). Paving the way for future research focusing on the effects of subjective age on cognitive functioning in older adults. It is recognised that these findings can lead to as many questions as answers. However, the present study has added to the literature and provided clear evidence that the construct of subjective age is associated with better cognitive functioning.

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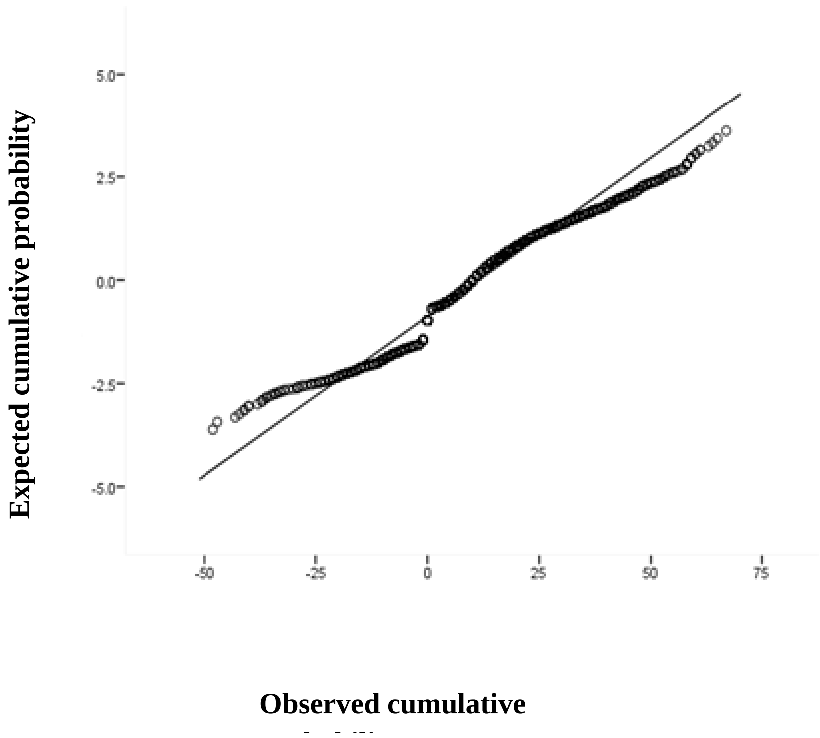
Appendix A



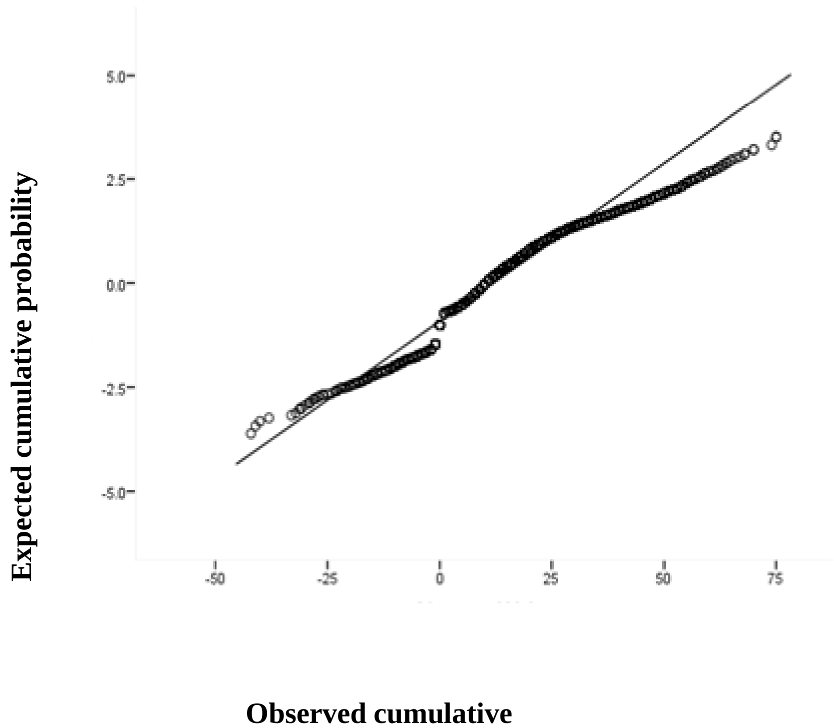
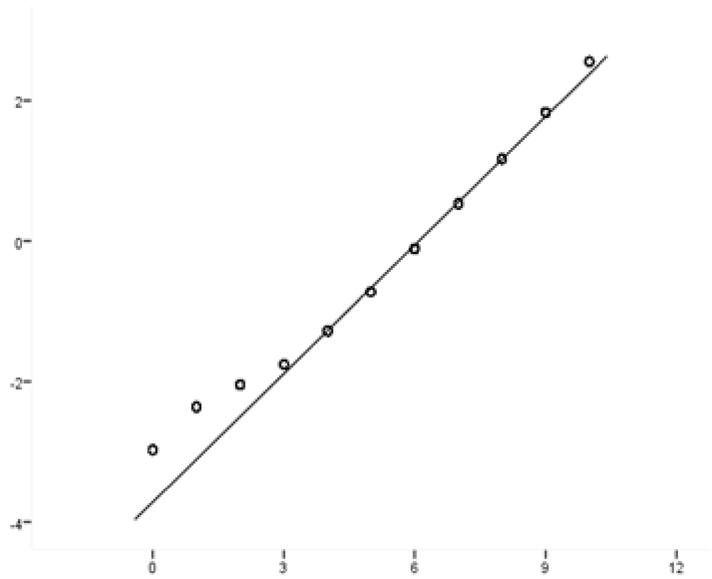


Figure 1. Probability plot of subjective age discrepancy at wave 4 and wave 7.

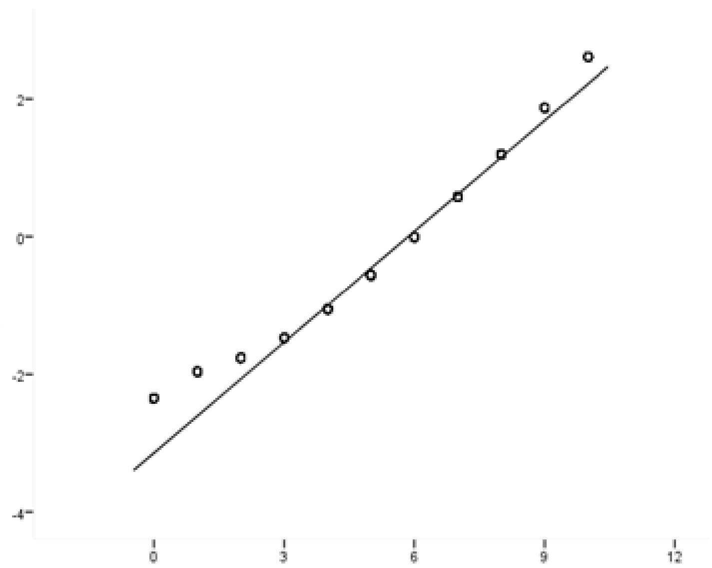
Appendix B

Expected cumulative probability



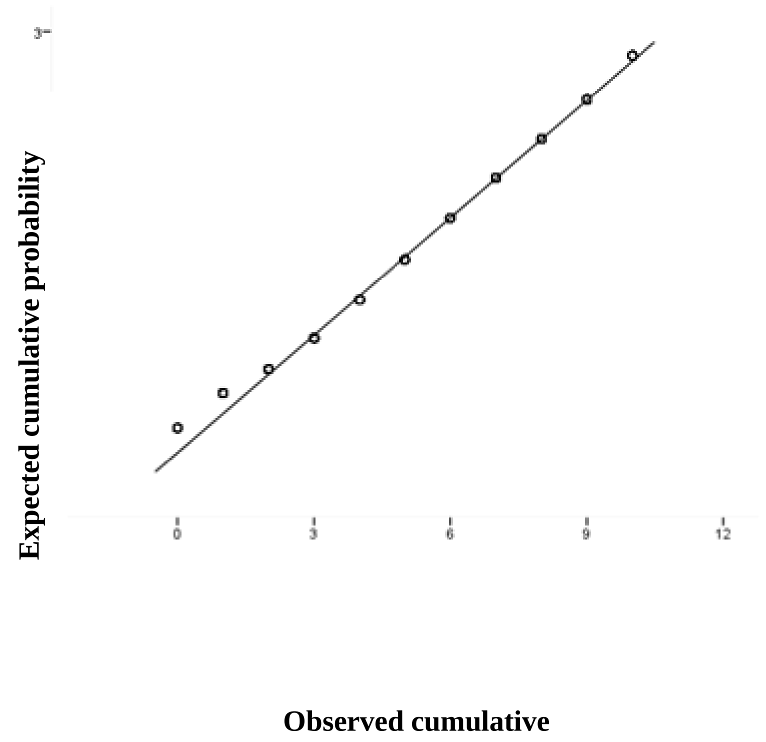
Observed cumulative

Expected cumulative probability



Observed cumulative probability

Figure 2. Probability plots of immediate recall in both wave 4 and wave 7.



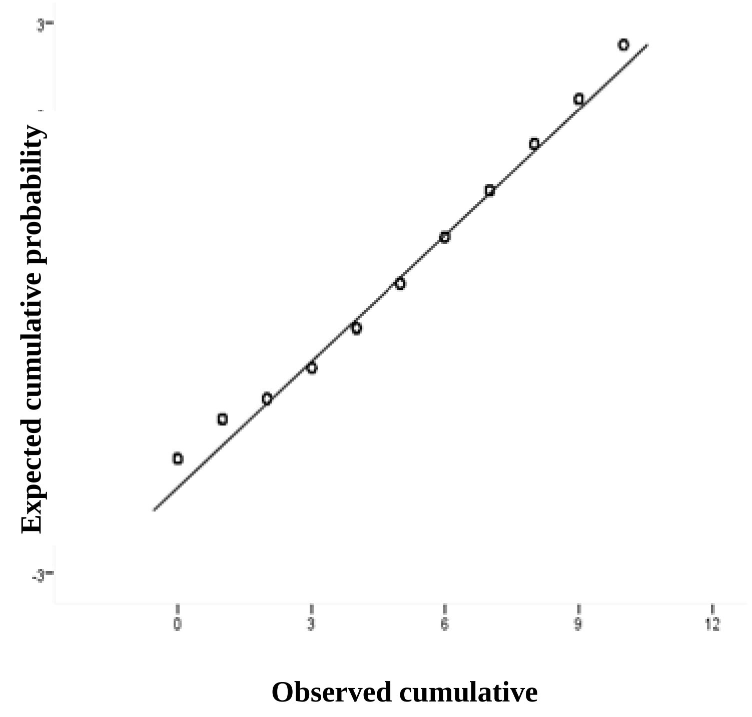
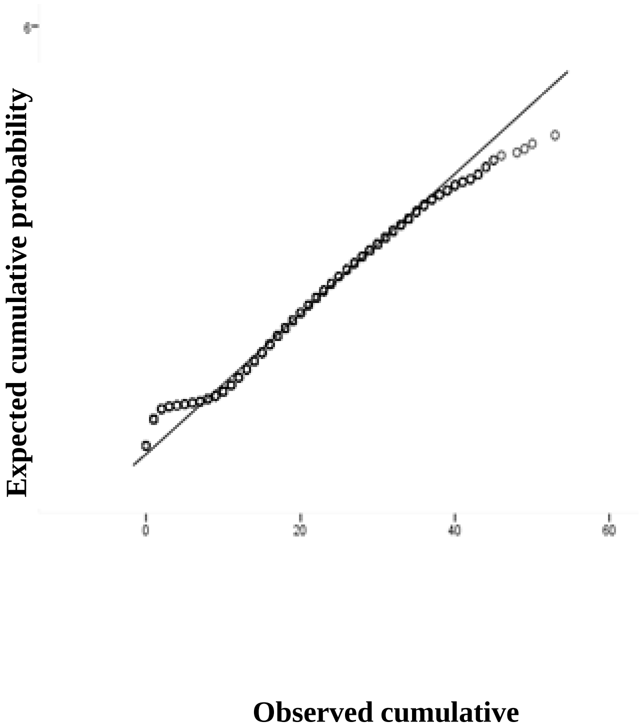


Figure 3. Probability plot of delayed recall at both wave 4 and wave 7.



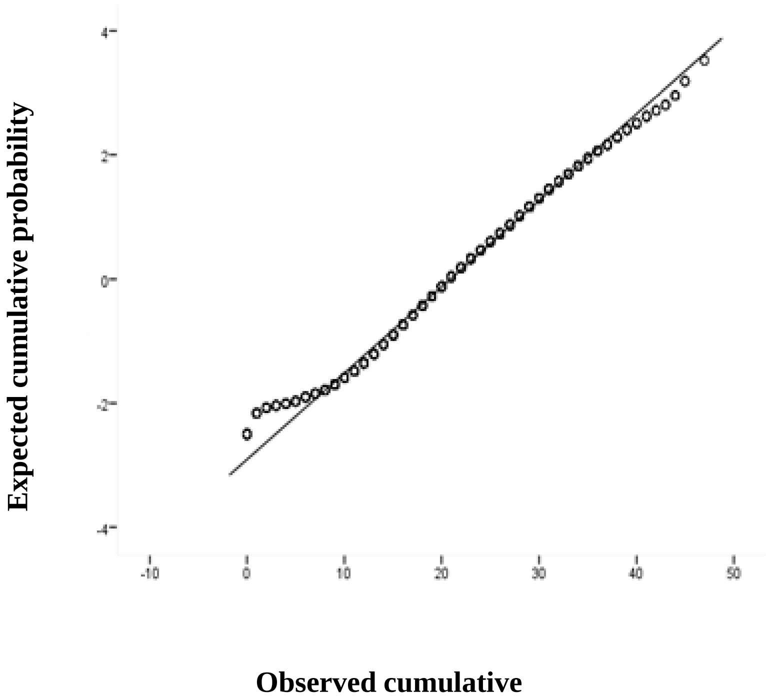
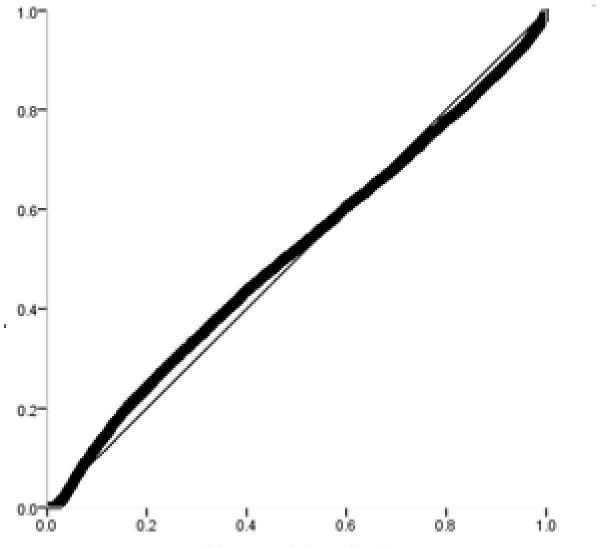


Figure 4. Probability plots of verbal fluency of both wave 4 and wave 7.

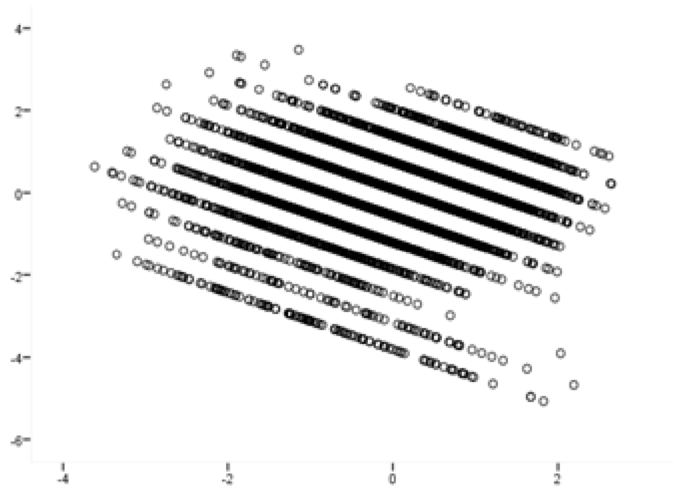
Appendix C

Expected cumulative probability



Observed cumulative

Regression standardised residual



Regression standardised predicted value

Figure 5. Testing the assumptions of Normality and Homoscedasticity for the Hierarchical Multiple Regression Predicting Immediate Recall. Including the normal probability plot of the regression standardised residual and the scatterplot of the standardised residual.

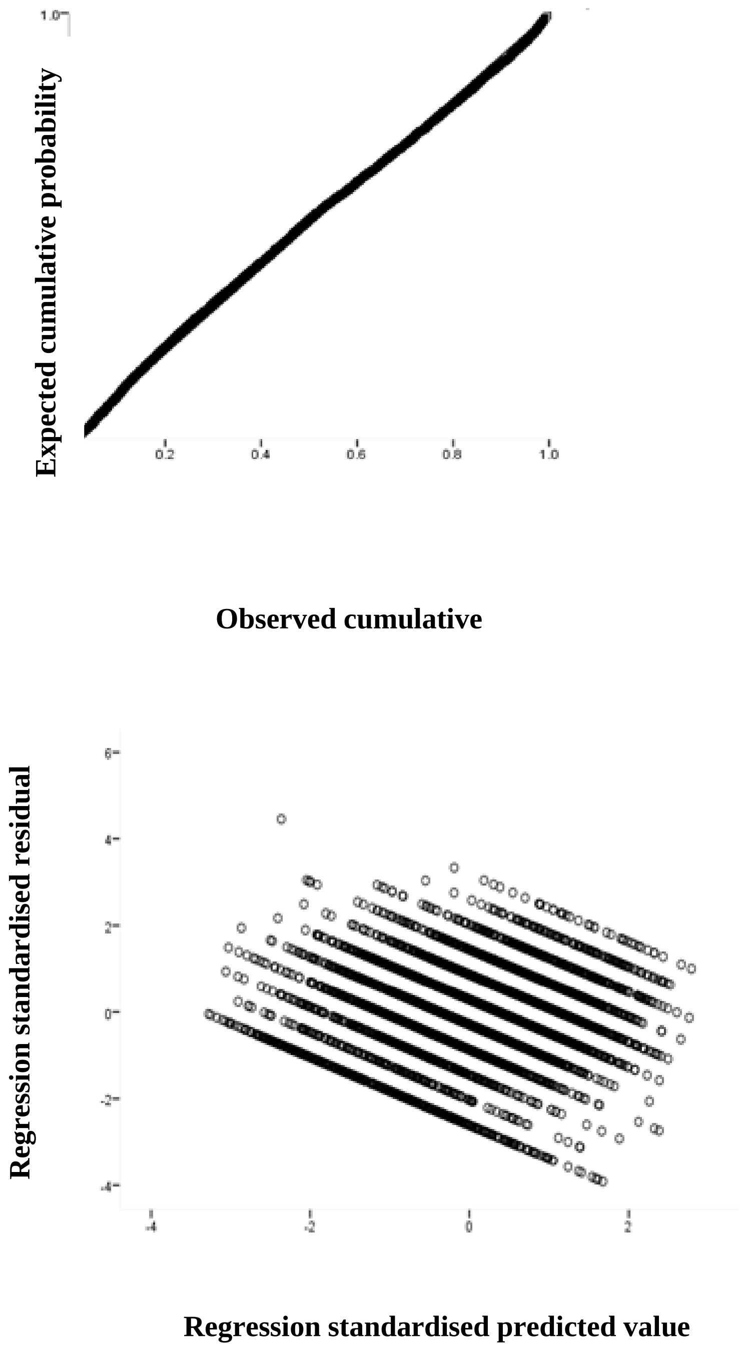
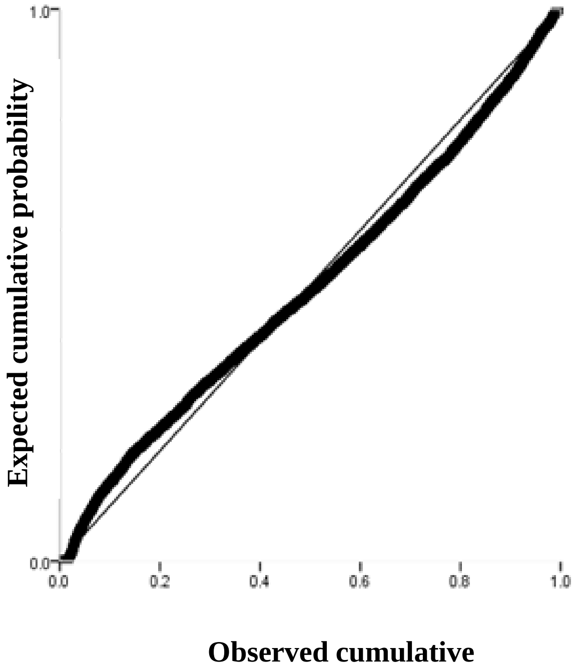


Figure 6. Testing the assumptions of Normality and Homoscedasticity for the Hierarchical Multiple Regression Predicting Delayed Recall.



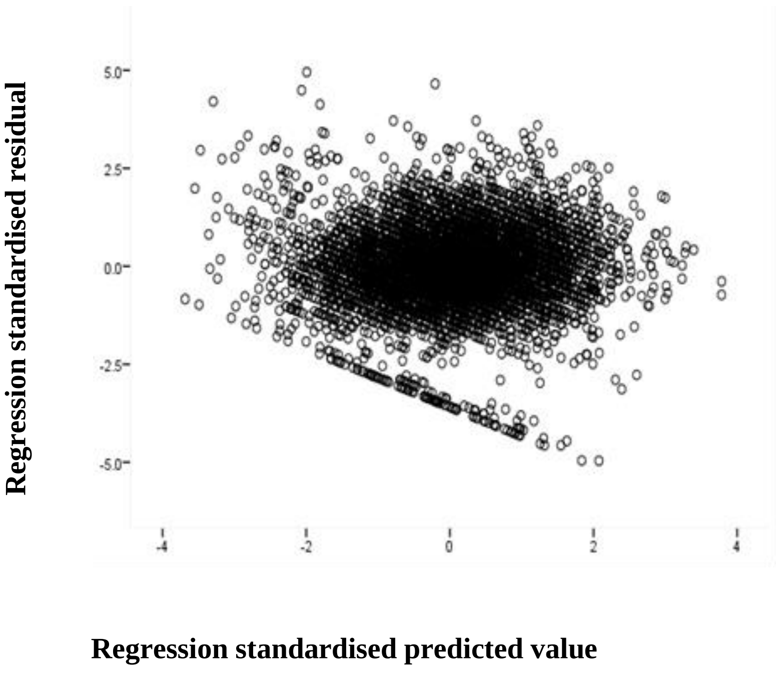


Figure 7. Testing the assumptions of Normality and Homoscedasticity for the Hierarchical Multiple Regression Predicting Verbal Fluency.