Evaluation of perceived importance of components of healthy ageing and their relationship with mortality

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Abstract

Healthy ageing (HA) research is hampered by a lack of consensus over how HA should be defined and measured. Little is known about which components of HA are important to different population groups. In addition, how components of HA relate to mortality outcomes is poorly understood.

These gaps were addressed through four studies. A systematic literature review identified elements, metrics and operationalisations of HA definitions reported in 60 papers. The outcomes of the literature review were used to design the second study in which a series of card sorting tasks (CSTs) were used to investigate how groups with different academic backgrounds and older people categorised these elements. Ten components of HA created during the CSTs were used as the basis for the third study in which surveys were used to rate and rank the importance of these ten components. The overwhelming result of the surveys was that all aspects of HA were considered important and that academics and older people ranked the components of HA in broadly similar ways. This survey was expanded to investigate age group, ethnic group and gender differences in perceptions of relative importance of the ten components of HA. Again, the main finding was one of similarity between population groups who identified independence, mood and physical function as the top three components of HA. Finally, survival analysis was performed on longitudinal cohort data from the Hertfordshire Ageing Study and Whitehall II cohorts to examine relationships between the components of HA and mortality. Brain function, health problems and physical function, and overall HA score, were associated with mortality.

These findings highlight that while a multidimensional definition of HA is important to the populations most frequently involved in HA research, future work on the measurement of HA should focus on those components of HA which can impact healthy life span.

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Abbreviations

BMI	**Body mass index**
CST	**Card sorting task**
GHQ	**General health questionnaire**
HA	**Healthy ageing**
HAP	**Healthy ageing phenotype**
HAS	**Hertfordshire Ageing Study**
MDS	**Multidimensional scaling**
SES	**Socioeconomic status**
WII	**Whitehall II Cohort**

Chapter 1. Introduction

1.1 Ageing and its impact on society

1.1.1 The process of ageing

Human ageing is a complex, gradual process (Martin-Ruiz et al., 2011, Kitani, 2007), which for many people is accompanied by functional decline, reduced independence and increased incidence of age related diseases such as stroke, dementias, movement disorders, visual problems, gastrointestinal problems, diabetes, and osteoporosis (Franceschi and Bonafi, 2003, Freedman et al., 2002). Ageing is also a heterogeneous process with a range of ageing phenotypes reported in the older population (Hadley and Rossi, 2005). Three broad ageing phenotypes have been described called survivors (who have survived with long term disease), delayers (who did not experience disease until near the end of their life span) and escapers (who did not experience major disease) (Evert et al., 2003).

1.1.1.1 Theories of ageing

There are a range of theories about why organisms age that will be touched upon briefly here but are reviewed more thoroughly in Weinert and Timiras (2003), Vina et al. (2007), and Le Couteur et al. (2014). Genetic theories of ageing include the mutation accumulation theory of ageing (Medawar, 1952) in which ageing is considered to be a result of being unable to select against genetic mutations which act later in life and the antagonistic pleiotropy theory (Williams, 1957), which suggests that ageing is caused by selection for genes which have positive effects in early life, but cause functional decline in older age (Albin, 1993). Both theories emphasise the genetic component of ageing but reviews suggest that the genetic contribution to the heritability of the adult lifespan is approximately 20% to 30% (Hjelmborg et al., 2006, Kenyon, 2010, Christensen et al., 2006), with the variation between estimates likely due to methodological differences between studies. At the molecular level, the free radical theory of ageing (Harman, 1956) was proposed based on evidence that free radicals, (unstable and highly reactive molecules with an unpaired electron (Lobo et al., 2010)), cause oxidative damage to cells and tissue and that accumulation of this damage causes ageing. However, it has since been discovered that oxidative damage is not exclusively caused by free radicals, so the theory was amended to oxidative stress theory of ageing. The oxidative stress theory predicts that accumulation of oxidative damage to the body over time can lead to DNA mutations, telomere shortening, chromosomal rearrangements, transcriptional errors and errors in protein synthesis (Kirkwood, 2008). Another theory of aging, the disposable soma theory (Kirkwood, 1977), suggests that ageing is a result of a trade-off between maintenance of the body (soma) and reproduction. The level of maintenance required to keep an organism alive and sufficiently

heathy to allow reproduction is less than is needed to keep the organism alive indefinitely, leading to an accumulation of unrepaired damage and eventually to ageing and death (Kirkwood and Austad, 2000). Overall, however, many different theories have been proposed, some of which interact adding to the complexity of this issue and lack of consensus over why exactly ageing occurs (Jin, 2010).

1.1.2 Sociodemographic change

Worldwide, population demographics are changing as lifespan increases (Stephens and Flick, 2010) and the proportion of older people in the population rapidly increases (Franco et al., 2009, Doyle et al., 2012, Dunnell, 2008). By 2040, the number of people aged over 65 years in the UK will outnumber children for the first time in recorded history (Depp et al., 2010) and will represent a large proportion of the population (McMurdo, 2000) increasing from 1.3 million in 2008 to an expected 3.3 million by 2033 (Office for National Statistics, 2009). The numbers of the oldest old (85+ years) are increasing most quickly (Young, 2002, Newson et al., 2010), with the number of people aged 90+ projected to triple by 2033 and the number of those aged 95+ projected to quadruple (Office for National Statistics, 2013). A similar pattern is predicted for the rest of Europe (Dunnell, 2008). Although relatively rare 50 years ago, the number of centenarians and supercentenarians (110+ years) will also increase seven fold (Office for National Statistics, 2009, Buckley, 2001, Willcox et al., 2010).

In the UK this major demographic change can be attributed to three main reasons: increase in lifespan, declining fertility rates and the ageing of the post-war 'baby boom' generations (Young, 2002, Dunnell, 2008, Vaupel, 2010, Carrascosa-Gil et al., 2010). Both fertility and mortality rates have fallen during the last 150 years, resulting in the increasingly aged populations of today and the fall in the proportion of children (Dunnell, 2008). Mortality rates have fallen by 38% for men and 29% for women over the last 40 years, and improvements in living conditions and childhood immunisation programmes have led to significant improvements in mortality from infectious diseases (Dunnell, 2008, Balcombe and Sinclair, 2001). In the future mortality rates will be affected by medical advances and preventative health care, the fall in the prevalence of smoking, the increase in the prevalence of obesity, higher standards of living and healthier lifestyles (Dunnell, 2008, Willcox et al., 2010, Vaupel, 2010).

Research into the expected life expectancy for different sections of society is gathering pace, with differences found between people from different socioeconomic groups (Haas et al., 2012). The effect of socioeconomic status (SES) on health outcomes begins in early life and continues across the life course (Kahn and Fazio, 2005). SES is associated with health in later life (Haas, 2008), with those in high SES groups experiencing fewer functional impairments in later life than

those from lower SES groups (Morciano et al., 2015, Sole-Auro et al., 2015). SES has impact on health through a wide range of factors including access to education about health behaviours, access to better healthcare, use made of available health care and engagement with health promoting behaviours (Pampel et al., 2010, Charlton and White, 1995, Marmot, 2005, Marmot and Allen, 2014). Occupational status can also affect health with lower status manual labouring jobs, often physically demanding, with increased risk of exposure to harmful environments while higher status jobs are often sedentary. These SES-related physical activity patterns tend to reverse after retirement (Haas et al., 2012).

1.1.3 Societal implications

These demographic changes have the potential for far reaching effects on society, particularly for health care systems and the economy (e.g. Restrepo and Rozental, 1994). Vaupel and Gowan (Vaupel and Gowan, 1986) provide an interesting commentary on the changes increased lifespan may bring about, and suggest ways for society to adapt to this new demography. While a longer lifespan is, for most, desirable, an increase in years of life does not necessarily equate to an increase in years of good health. Rather, an increase in lifespan can often mean a longer period of disease or disability before death (Franco et al., 2009). Therefore, it is important to make a distinction between lifespan and health span (Barron, 2016). Lifespan refers to the total number of years of life, whereas health span refers to the total number of years of good health. Increase in lifespan is giving rise to new social, medical and economic challenges, while increasing health span has been identified as a key policy priority (Franco et al., 2009).

In response to demographic change and the disparity between lifespan and health span, policy makers are concerned with the implications of an ageing population, made more difficult as the implication of these changes are not yet fully understood (Peel et al., 2004, Willcox et al., 2010). As older people will form a larger proportion of the population, as well as of the voting population, future policies will need to address the ambition of people to age well and to have a good quality of life (Bowling and Iliffe, 2011). As most people now anticipate a longer life, they may increase the amount of time spent in different phases of life such as in education, employment and retirement (Vaupel, 2010, Oxley, 2009). The profile of people's lives has also changed with fewer children and fewer marriages lasting (Roberts, 2012), both of which have implications for informal care provision. For example, 14% of women born in 1931 had no children, while 21% of women born in 1964 have no children, leading to a mismatch between the rise in demand for care and the ability of families to provide it. Care provision will also be affected by the fragmentation of family life through increasing rates of separation and divorce which can lead to loneliness impacting on wellbeing and resilience (Roberts, 2012). Unless increase in lifespan is accompanied by a simultaneous increase in health span, the higher

prevalence of age related disease will put increasing pressure on health care resources (Franco et al., 2009, Restrepo and Rozental, 1994, Glatt et al., 2007). Over the last century, typical causes of mortality have changed from infectious disease to age-related chronic illnesses such as cardiovascular disease, cancers and stroke (Depp et al., 2010), which will require new health care strategies.

When the NHS was established, the management of most health problems was hospital based, but a growing proportion of older people will require the provision of care at home for long term health problems and personal care needs (Roberts, 2012). This will necessitate putting resources into ensuring that the design and layout of the home environment is suitably adapted to overcome declining physical function and maintain independence (Oswald et al., 2007) in the same way that architecture and design have been used to maintain independent living for individuals with dementia (e.g. van Hoof and Kort, 2009, Hadjri et al., 2015). Further, approximately 90% of health care for older people is now provided by GPs, so future training for primary care physicians should include a greater focus on geriatric medicine (Futurage, 2010). To keep health care costs to a minimum, and to help people maintain good health into old age, health care services such as the NHS need to focus on prevention rather than treatment (Bowling, 1993), contrary to the current increase in medicalisation of older people with increased hospitalisation and polypharmacy (Melzer et al., 2014). Research is beginning to focus on healthy ageing (HA) and to examine ways in which health span can be improved to keep pace with lifespan, and there is new interest in developing integrated care systems (NHS, 2014).

As the size of the older population grows, demand for, and costs of, health and social care services will increase (Dunnell, 2008), placing growing pressure on public finances as long term health care costs rise (Oxley, 2009, Willcox et al., 2008). This is likely to become a focus for government as the current demographic change is adding large sums to NHS costs at a time when a reduction in spending is being sought (Roberts, 2012, Davey and Glasgow, 2006). There will also be an increased pensions burden which will impact on the economy and on those still in the workforce as the ratio of working age to pension age people falls (Dunnell, 2008). To decrease the impact of an ageing population on society, methods to decrease age related ill health and increase quality of life for older people will need to be developed (Fiocco and Yaffe, 2010), However, it is difficult to design and to deliver interventions to keep the ageing population healthy while the concept of HA remains ambiguous, and while research tends to focus on the negative aspects of ageing rather than what older people have to contribute to society (Peel et al., 2004, Hansen-Kyle, 2005).

1.2 The concept of healthy ageing

1.2.1 What is healthy ageing?

There is currently increasing interest in how to define, measure and promote HA arising from the ongoing demographic changes, associated health care costs and the higher expectations which people now have of later life (Bowling and Dieppe, 2005, Bowling and Iliffe, 2006, Fiocco and Yaffe, 2010). Recently there has been a shift in the emphasis of research away from focusing on negative aspects of ageing towards how to age well (Peel et al., 2004, Depp and Jeste, 2009, Franco et al., 2007, Phelan and Larson, 2002). Age related decline is an important area of work, but not the only important facet of ageing (Baltes and Carstensen, 1996, Fernandez-Ballesteros, 2011). Unfortunately, there is a lack of consensus about the definition of HA and achieving a better definition of HA is an objective for my PhD. The idea that ageing can be positive has been around since the time of Cicero (Depp et al., 2010) but HA has only emerged as an area of research in more recent years with the recognition that ageing as a process is heterogeneous and plastic (Fiocco and Yaffe, 2010, Kivimaki and Ferrie, 2011) and does not necessarily always involve a decline in function and quality of life. Further, people are also now more informed about their healthcare and want to find ways to age well (Phelan and Larson, 2002). There is considerable interest among the public in the idea that there are factors which can improve health span alongside lifespan (Depp and Jeste, 2006).

Unfortunately for the progress of HA research, there is little agreement on what HA is, how it should be defined or how it can be measured (Depp and Jeste, 2006). Most research agrees that HA is more than long lifespan, with greater quality of life and compression of morbidity (so that years of life free from age-related frailty, disability and disease are as large a fraction of maximum lifespan as possible) being viewed as important as length of life (Balcombe and Sinclair, 2001). To address this gap in literature, part of this thesis will examine definitions of HA and their importance to different population groups.

1.2.2 Synonymous terms for healthy ageing

One main point of confusion in the literature concerns whether HA is the most appropriate term to use or whether others descriptors such as ‘optimal ageing’, ‘successful ageing’, ‘active ageing’, ‘positive ageing’, ‘productive ageing’ or ‘ageing well’ (Fernandez-Ballesteros, 2011, Strawbridge et al., 2002), would be more advantageous. Successful ageing is the term most frequently mentioned in the literature (Peel et al., 2004, Hank, 2011), perhaps because it was popularised in the Rowe and Kahn model (1987, 1997) (see Section 1.3.1). However, the term “successful ageing” is problematic because it suggests two outcomes; success or failure, rather than the reality of a continuum of ageing outcomes (e.g. a person may be classified as an “unsuccessful”

ager because they have been diagnosed with an age-related disease but their quality of life could be high because that disease is well-managed). Success is a subjective term (Phelan and Larson, 2002) and is measured differently across cultures, with a focus on material and economic success in Western cultures (Hung et al., 2010, Peel et al., 2004). HA is ageing arguably the most useful umbrella term (Hung et al., 2010) and was used by World Health Organisation in the 1980s when promoting a focus on reducing age related diseases through medical advances. This was followed by an emphasis on 'active' and 'productive ageing' as the economic implications of population ageing gained more focus (Davey and Glasgow, 2006). HA is the term which will be used throughout this thesis, as recognised by the general population, represents a wide range of outcomes and has the advantage of capturing the relationship between health and quality of life (Peel et al., 2004). Further problems with terminology in the HA literature are discussed in Chapter 2 Section 2.1.1 and changes in terms used over time are described in Chapter 2 Section 2.4.3.

1.2.3 Prevalence of healthy ageing

Studies that estimate the prevalence of HA often provide very different estimates, highlighting the detrimental effect for research that a lack of consensus on a definition can create. By defining HA in different ways, studies are using different criteria by which to judge the percentage of their sample that has achieved HA and by using differing criteria it is not clear that they are examining the same concept. For example, Depp and Jeste (2006) found that the proportion of healthy agers ranged from 0.4% to 95% across the studies that they reviewed, while a review by Peel et al. (2004) reported a range of 3% to 80%.

Bowling and Dieppe (2005) examined the rates of self-reported HA. In a survey of 854 British people, 75% rated themselves as ageing very well or well. When comparing the rates of self-reported HA to the number of people achieving HA according to theoretical models, Strawbridge et al. (2002) found that 50.3% of the 867 individuals in their sample rated themselves as achieving HA but only 18.8% met Rowe & Kahn's (1987) criteria for HA. Of all those who met Rowe & Kahn's criteria, 36.8% did not rate themselves as successfully ageing. Rowe and Kahn's definition excludes those with chronic conditions, but 42.7% of those surveyed with one condition said they were achieving HA as did 35% with two conditions and 16.7% with three or more conditions (Strawbridge et al., 2002).

1.3 Models and predictors of healthy ageing

1.3.1 Models of healthy of ageing

As yet, there is no single accepted model of HA. However, one of the most influential biomedical models of HA (Depp and Jeste, 2006), was proposed by Rowe and Kahn. In 1987, Rowe & Kahn

made a distinction between two groups of older people who remained free of disease: usual agers who were currently free of disease, but at high risk of developing disease, and successful agers with a high level of functioning and low risk of disease (Rowe and Kahn, 1987). In 1997, this idea was further developed into a model of HA. This model has three main components: 1) relatively low risk of disease and disease-related disability, 2) relatively high mental and physical function, and 3) active engagement with life, including close relationships with others and continued participation in productive activities (Rowe and Kahn, 1997). This model of evaluating successful ageing was among the first to shift from focusing on age related decline to recognise the considerable heterogeneity of ageing trajectories and was the first to make the distinction between older people who experience age related decline and those who maintain functional ability and suggested that extrinsic factors such as lifestyle may play a role in age related decline (Fiocco and Yaffe, 2010).

The 'selective optimisation with compensation model', developed by Baltes and Baltes (1990) recognised the heterogeneity of ageing but included a psychosocial perspective in addition to a biomedical perspective. In this model, people, consciously or unconsciously, focus their resources onto aspects of life which are important to them and compensate for losses in these areas caused by biological, psychological and socioeconomic change over the life course (Baltes and Baltes, 1990). Ouwehand et al. (2007) provide a detailed review of empirical evidence in support of this model.

1.3.2 Predictors of healthy ageing

There has been a lot of interest in identifying predictors of HA from Guralnik & Kaplan in 1989, who focused on predictors of physical health in older populations, to more recent work by Depp and Jeste (2006), who identified as strong predictors of HA (defined as reported by four or more studies with 75% reporting significant association) younger age, good health status, hearing problems, better physical function and not smoking. Moderate predictors (defined as reported by four or more studies with 50 to 75% reporting significant association) were high physical activity level, better self-rated health, lower systolic blood pressure, fewer medical conditions, global cognitive function and absence of depression. There was limited evidence that higher income, greater level of education, current marriage and white ethnicity were predictors of HA, with less than 50% of studies reporting significant association (Depp and Jeste, 2006). Other reviews have identified similar predictors, with the addition of education, self-efficacy and social support (e.g. Phelan and Larson, 2002). Vaillant and Mukamal (2001) identified education, physical activity and freedom from illness as predictors of HA but point out that these are often used as components of the definition in other studies.

1.3.2.1 Lifestyle factors affecting healthy ageing

Some predictors of HA are under personal control to some extent (Vaillant and Mukamal, 2001). Lifestyle factors affecting ageing are important targets for research because they are potentially modifiable (Depp et al., 2007). Physical activity can contribute to HA (e.g. Kirkwood, 2008, Dam et al., 2008) by delaying the onset of age related disease and functional decline as well as improving mood, cognitive performance and independence (Penninx et al., 2001, Gill et al., 2003, Lee et al., 2010, Kramer et al., 2006). Exercise programmes for older people can improve strength, balance, aerobic capacity and physical function (Frost et al., 2010) with strength and endurance training shown to be particularly important by counteracting the loss of strength and loss in muscle mass associated with normal ageing, reducing risk of osteoporosis and improving postural stability and flexibility, thereby reducing risk of falls (Stewart, 2005).

A Mediterranean style diet, which is high in fruits, vegetables, legumes, cereals and low in red meat and some dairy products has been associated with the prevention of many age-related diseases including cardiovascular disease, neurodegenerative diseases and cancer (Martinez-Gonzalez et al., 2009, Sofi et al., 2010), and has been associated with a lower mortality rate among 70 to 90 year olds (Knoops et al., 2004, Sofi et al., 2008). Modifying diet can help to delay onset of age-related disease. For example calorie restriction been shown to reduce many risk factors for cardiovascular disease and diabetes such as body weight, blood pressure, cholesterol, triglycerides and insulin levels (Everitt et al., 2006). Conversely, obesity is increasing worldwide and is expected to accelerate the onset of age-related diseases, including diabetes, cardiovascular disease, stroke and many types of cancer (Everitt et al., 2006, Christensen et al., 2009b).

The number and quality of social interactions have also been associated with HA (Kaplan et al., 2008, Seeman et al., 2001, Frost et al., 2010). Older people living with others are less likely to show signs of depression than those living alone (Roberts, 2012). Trajectories of HA are associated with socioeconomic status (Tampubolon, 2016). Lower socioeconomic status has been associated with poor health, including increased risk of anxiety, depression and chronic illness (Roberts, 2012, Walter et al., 2012). Higher socioeconomic status has been linked with better physical and social functioning and improved ability to participate in health behaviour interventions (Jang, 2009, Park et al., 2010).

1.4 Definitions and components of healthy ageing

As interest in maintaining health into later life has grown, so has the volume of studies examining factors that may influence ageing trajectories and the feasibility of intervention studies to promote aspects of HA. Unfortunately, there is no consistency in these studies regarding how

HA should be defined and therefore measured. Individual papers present their own unique definitions of HA, typically influenced by the background of the authors and tailored towards the aims of the study. There are many ways to consider ageing, from a cellular to a social level (Balcombe and Sinclair, 2001) and individual definitions are often based on one of these aspects (e.g. biological, psychological, social, behavioural etc.) rather than taking a holistic approach. Another reason for the lack of consensus definition is the divide between academic and lay definitions. Research tends to focus on either academic or lay opinions and there is not much work on the overlap.

A small number of papers have reviewed previously published definitions of HA, although many focus on 'successful ageing' rather than on HA. In 2002, Phelan and Larson published a brief review on the topic of 'successful ageing' which aimed to identify and summarise definitions of successful ageing published since the 1960s. Seven so-called 'key' elements of definitions of successful ageing were identified from 11 papers included in the review. High/independent functioning was reported in four out of 11 papers. Longevity, mastery/growth and active engagement with life were each reported in three papers and life satisfaction, positive adaptation and freedom from disability were each reported in two papers. Five predictors of successful ageing were identified across four papers: social contact/support was mentioned in all four papers, regular physical activity was reported by three papers, freedom from chronic illness was reported twice and high educational level and high self-efficacy were each reported in one paper. Overall there was no uniform definition and little work had been done to see how relevant these definitions are to the populations to which they were being applied. However, while the search terms included 'successful ageing', 'normal ageing', 'theories of ageing' and 'centenarians', synonymous terms such as 'healthy ageing', and 'effective ageing' were actively excluded from the review under the rationale that they were distinctly separate concepts. Unfortunately, no discussion of what makes these concepts distinct was provided. Further, this review was specifically aimed at clinicians and was intentionally highly summarised; however, no criteria were offered as to how elements of definitions of successful ageing were judged to be 'key elements' and whether or not any minor/other elements were also identified. Interestingly, this review recognised that research-led definitions of successful ageing may not reflect the views of older people, that the views of older people may change over time or cross culturally and makes the assertion that future research should focus on what older people value as important.

Peel et al. (2004) searched four databases for population based studies that reported objective rather than self-reported multidimensional outcome measures of healthy or successful ageing and found 18 studies. Most studies investigated physical, mental and social functioning. All 18

studies included physical function as a domain of healthy or successful ageing with the sub-domain of absence of disease or impairment reported in five studies. Mental health was reported in 11 studies, including cognitive function in eight studies, psychiatric morbidity and life satisfaction each in four studies and positive perceived health and sense of control both reported by three studies. The domain of social functioning was present in 11 studies including social contact/participation in eight studies and environmental security and use of home care services each in two studies (Figure 1.1). Peel et al. (2004) also summarised the percentage of participants reported who achieved HA in each of the studies included in the review. This ranged from 3.4% to 79.8%. The main difference between Peel et al. (2004) and other reviews is the creation of subcategories within their domains which were separate domains in other reviews. For example, well-being came under the heading of cognitive function, whereas in Depp and Jeste (2006) well-being and cognitive function were reported as two distinct domains. An interesting point raised by Peel et al. (2004) is the use of outcome measures that assess more than one domain. For example, basic and instrumental activities of daily living are used to assess physical function exclusively even though these activities involve both physical and cognitive functioning and to an extent also measure a person's ability to function in the social environment.

In 2006, Depp and Jeste (2006) conducted a review of definitions of 'successful ageing'. This review examined studies which reported quantitative data from adults aged 6o years or over that used an operational definition of successful ageing. Twenty-nine definitions were identified and the frequency of components of HA was assessed (see Figure 1.1). Twenty-eight articles met the selection criteria from which 29 definitions were extracted, 27 of which were categorical and 2 continuous variables. Articles were published between 1978 and 2003, and mean sample size was 1984 (SD 21.61, range 155-8000). Depp & Jeste identified ten components of 'successful ageing': disability/physical functioning was found in 26 (out of 29 definitions), cognitive functioning in 13, life-satisfaction/well-being in nine, social productive engagement in eight, presence of illness in six, longevity in four, self-rated health in three, personality in two, environment/finances in two and self-rated successful ageing in two. This review was one of the first to investigate how HA had been operationalised. Disability/physical function was operationalised in 21 different ways, cognitive function in 11 ways, life satisfaction/wellbeing and social/productive engagement each in six ways, illness in four ways, longevity and self-rated health each in three ways and personality, longevity and self-rated successful ageing each in two ways. However, Depp & Jeste searched only one database with a limited number of search terms so the review they provide is not sufficiently comprehensive to allow strong conclusions to be

drawn regarding how HA has been defined and which domains should be included in future definitions.

Both of these reviews (Phelan and Larson, 2002, Depp and Jeste, 2006) also highlight the confusion in this field over the difference between definitions and predictors of healthy or successful ageing. Depp and Jeste assessed the predictive value of some of the operationalisations they identified while some predictors in Phelan (e.g. social contact, illnesses) are used as domains in Depp & Jeste.

Hung et al. (2010) published a review which went some way towards addressing the points raised by Phelan and Larson (2002), examining more closely what older people believe to be important for HA and considering differences in these opinions between cultures. Hung et al. (2010) aimed to compare views on HA of older people and academics and to compare perspectives of HA from Western and non-Western cultures. Six databases were searched for HA and five synonymous terms, 'successful ageing', 'positive ageing', 'active ageing', 'robust ageing' and 'ageing well', in the title or abstract. Thirty-four studies were identified which included operational definitions of HA and 12 components of HA were described: physical function (32 studies), cognitive function (22 studies), social function (15 studies), independence (10 studies), well-being (9 studies), life satisfaction (8 studies), longevity, family and adaptation (each in 5 studies), personal growth (4 studies) and spirituality (3 studies) (Figure 1.1). When comparing Western and non-Western cultures, physical, and social function were the most frequently reported domains in all cultures. However, while mental function was mentioned in all Western studies it was reported in fewer than half of non-Western studies.

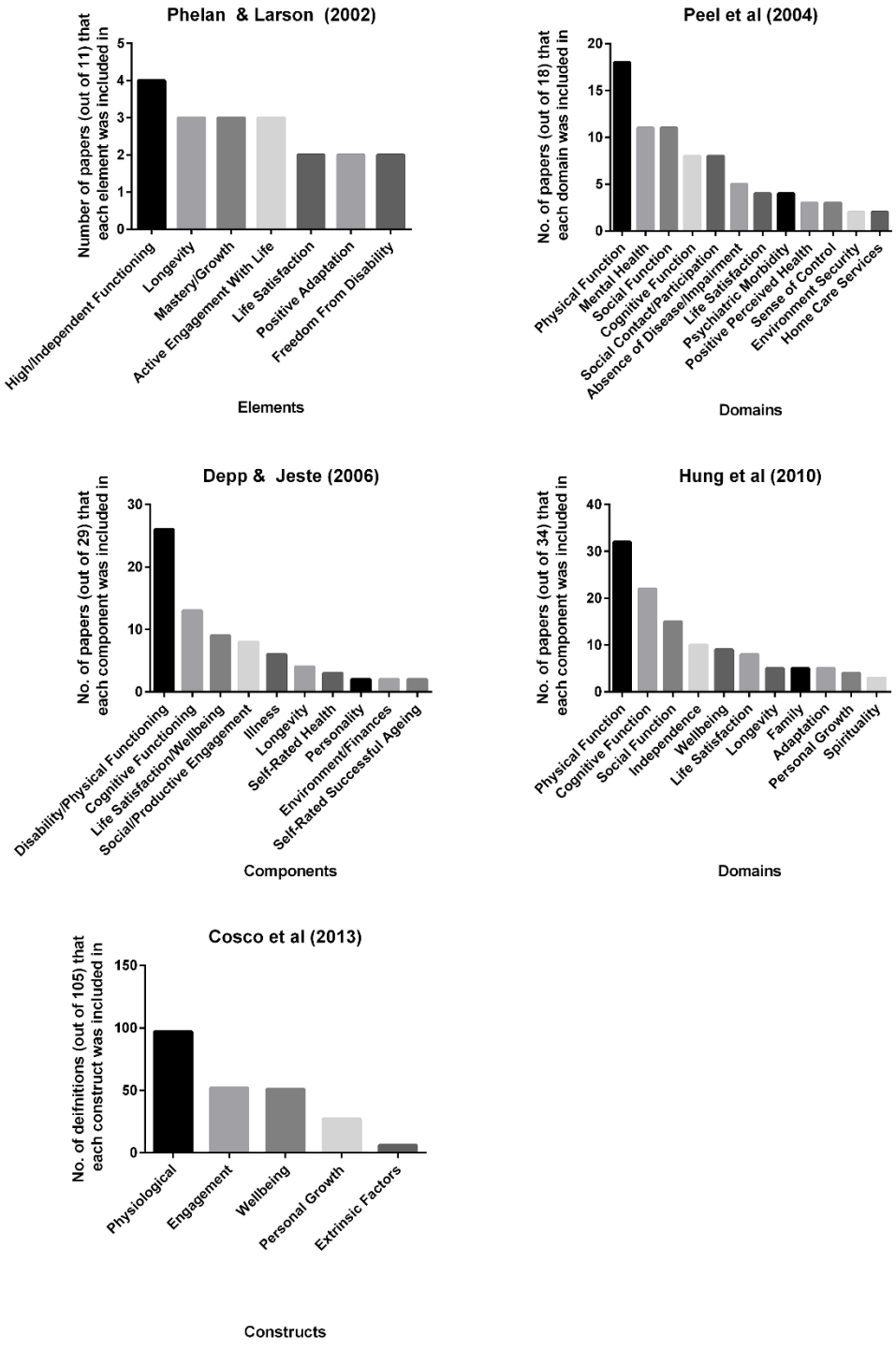

Figure 1.1. Components of definitions of HA referred to in five reviews: Phelan and Larson (2002), Depp & Jeste (2006), Peel et al. (2004), Hung et al. (2010) and Cosco et al. (2013). NB The titles on the x-axes are those used in the individual papers.

Of the 34 papers included in the review, 11 described older people's views of HA. These lay definitions included a greater variety of HA domains (mean = 7.3, range = 10) than academic definitions (mean = 2.5, range = 4). Adaptation, family, financial security, personal growth and spirituality were domains unique to lay definitions. Hung et al's review is arguably one of the most comprehensive to date, using a wide range of search terms and databases, building on the suggestions of previous work by examining academic and lay views and cross-cultural differences and, to an extent, describing how included studies have operationalised their definition of HA.

A more recent review by Cosco et al. (2013) aimed to provide an overview of definitions of successful ageing. Of the 105 definitions identified from the 84 studies included in the review, 97 included physiological constructs, 52 included engagement, 51 included well-being, 27 included personal resources and six included extrinsic factors (Figure 1.1). The constructs mentioned are simply umbrella terms for collections of related components. The components listed are physical function, cognitive function, illness, health status, longevity, mental health, affective status, life satisfaction, social engagement, support system, personal resources, autonomy and environment/finances, many of which were identified as components of HA in their own right in the earlier reviews discussed above. One criticism of this study is that these 13 components are also described as operationalisations despite having no description of the method of measurement.

Taken together, these reviews illuminate the large amount of variation and the lack of consensus about the definition of HA, how to operationalise HA and terminology used in the field. The lack of consensus definition is a major obstacle to developing successful interventions to improve HA outcomes. Similar obstacles were faced in regard to defining frailty, including a lack of a standardised definition (Fried et al., 2001) and a lack of an integrated approach with too much emphasis on the biomedical model (Gobbens, 2010). There were also challenges in operationalising frailty with no agreed markers of a frailty phenotype and uncertainty as to whether disability should be considered an outcome or an indicator of frailty (Sternberg et al., 2011). In a similar way, an operational definition of HA is important for research, for interventions in primary care and for policy planning and development. Differences in definitions of HA have also been reported between academics and older people (e.g. Hung et al., 2010), people from different age groups (e.g. Tate et al., 2013) and people of different ethnic backgrounds (e.g. Laditka et al., 2011). These differences are discussed in Chapter 4 Sections 4.1.2 to 4.1.5.

At the moment, the biggest challenge to HA research is to find a standard definition of HA, before investigating how to predict and to promote it (Depp et al., 2007, Fiocco and Yaffe, 2010, Fernandez-Ballesteros et al., 2011). Currently there is no consensus over what the definition should be (Depp et al., 2010, Futurage, 2010, Hank, 2011, Bowling, 1993) and definitions tend to depend on the discipline

of author (Bowling and Iliffe, 2006) rather than being multidimensional (Hansen-Kyle, 2005, Steverink et al., 1998).

1.4.1 Contrasts between healthy ageing and frailty?

Frailty is often defined as a decline in reserve and function across multiple systems and decreased ability to withstand stressors associated with increased risk of health problems, hospital admissions, falls and mortality (Xue, 2011, Rodriguez-Manas et al., 2013). Prevalence estimates of frailty vary, depending on the measurement used (Widagdo et al., 2015) but increase with age (Fried et al., 2001). Frailty usually presents as set of health problems including sarcopenia, very high or very low BMI with poor nutritional status, osteoporosis, poor physical function and vulnerability to infection (Franco et al., 2009). As with HA, there is no consensus about the definition or conceptualisation of measurement of frailty (Widagdo et al., 2015). However, HA is more multidimensional, encompassing more areas of life than frailty and raises interesting questions about what HA means to different populations, whereas frailty has a more clinical focus.

1.4.2 The Healthy Ageing Phenotype

Studies which have examined factors associated with healthy ageing have been limited by an incomplete phenotype (Fiocco and Yaffe, 2010). It is important to characterise the healthy ageing phenotype (HAP), the phenotype of those who reach old age in good health, in order to identify early divergence from the HAP so that interventions can be delivered early enough to have an effect, i.e. while changes are still reversible (Franco et al., 2007, Franco et al., 2009). The questions remains of what the HAP will look like. A Spark Workshop defined the HAP as having well preserved metabolic, hormonal and neuroendocrine function (Lara et al., 2013). Phelan and Larson (2002) suggest that it may be a fluid concept that varies by age, gender, birth cohort and ethnicity. Many studies rely on centenarianism to represent the HAP (Willcox et al., 2008), but cohort studies seem the most likely to lead to the identification of new intervention targets beyond those identified by disease prevention work (Kivimaki and Ferrie, 2011). However, the HAP cannot be characterised properly until there is a consensus definition of HA and agreement on how HA should be measured.

1.5 Measuring healthy ageing

There is currently no agreed way to measure HA (Peel et al., 2004), a task made more difficult by trying to measure a process rather than an outcome (Hansen-Kyle, 2005). Finding standardised ways to measure HA is vital for developing intervention studies to promote HA (Lara et al., 2013, Hilmer and Le Couteur, 2016), for comparing results across studies and to gather evidence to inform policy and planning. As HA intervention studies tend to focus on lifestyle based interventions, methods of measuring the utility of such interventions are required for use in large scale studies and therefore

need to be affordable, easy to obtain, acceptable to participants and sensitive enough to detect change in response to the intervention (Barron et al., 2015, Depp et al., 2010).

Because of the ease in collection of blood samples, blood-borne biomarkers of HA are under consideration. Biomarkers are already widely accepted tools in clinical practice and may provide useful quantitative information about biological processes of ageing (Mueller et al., 2008). According to the American Federation for Ageing Research, biomarkers must meet the following criteria: They must be able to tell where someone is in their total lifespan; they must be a better predictor of lifespan than chronological age; they must work across species so they can be tested in a laboratory setting before being validated in humans; and they must be able to be tested repeatedly without harm (e.g. blood test) (Johnson, 2006, Simm and Johnson, 2010, Barker and Sprott, 1988). For the purposes of evaluating interventions, biomarkers must also be inexpensive. It is also important to remember that biomarkers of ageing should be predictive of change (Sprott, 2010, Barzilai and Gabriely, 2010, Martin-Ruiz et al., 2011). As ageing is a multidimensional process, a panel of biomarkers of ageing may be needed because ageing is the consequence of the deterioration of more than one system (Sprott, 2010, Yashin et al., 2006, Barron et al., 2015, Lara et al., 2015). Different panels may be needed at different stages in the life course as predictive capacity can change (Hagberg and Samuelsson, 2008). Although there are many biomarkers which are widely used clinically, such as blood cholesterol and blood pressure, theoretical questions remain over the ethical implications of using biomarkers to measure HA. For example, would a poor result on a particular biomarker jeopardise prospects of securing a job or life insurance? (Simm and Johnson, 2010).

Aside from blood-borne biomarkers, the National Institutes of Health (NIH) have developed and tested a multidimensional, standardised set of measures which can be used across the life course in order to allow comparison between studies (Hodes et al., 2013). The tests included within the 'Toolbox' examine cognition (attention, executive function, processing speed, memory and language), sensation (auditory, visual, olfactory, pain), motor skills (dexterity, strength, balance and endurance), and emotion (psychological wellbeing, social wellbeing, stress and self-efficacy). Although the validity and reliability of measures included in the Toolbox have been thoroughly examined, the Toolbox was designed for use across the life course (age 3 to 85 years) rather than focusing on the older population. Therefore, some measures commonly used with older people, such as the timed up and go test, are missing from the Toolbox (Lara et al., 2013).

1.6 Thesis outline

1.6.1 LiveWell

This PhD project was supported by and embedded within the LiveWell research programme. Funded by the Lifelong Health and Wellbeing Initiative (Research Councils UK, 2011), the LiveWell programme

is a multidisciplinary research programme which aims to develop interventions based on lifestyle factors including diet, physical activity and social connectedness to promote health and wellbeing in later life. Interventions are aimed at those who are about to or who have recently retired. Retirement represents a major life transition and can have a large impact on many lifestyle factors (Bowling and Dieppe, 2005). Evidence from studies of physical activity strongly suggest that retirement is an ideal target for lifestyle based interventions (e.g. Nooyens et al., 2005, Berger et al., 2005). LiveWell also aims to identify outcome measures to assess the utility of these interventions by means of randomised controlled trials with long term follow up. Consequently, outcome measures are required that can be used in large community based samples, are cost-effective, readily measured, and can detect change in response to interventions. However, further work on the concept of HA is a prerequisite for the development of tools to measure HA (Bowling and Iliffe, 2006).

This PhD project was originally intended to characterise the HAP and to investigate ways of measuring the HAP so that measurement tools could be developed to examine the effect of interventions to promote HA for people who are close to, and just after, retirement. LiveWell focused on three main themes; physical activity, the Mediterranean diet and meaningful social roles in retirement. In conjunction with information gathered from the Healthy Ageing Phenotype workshop and MRC Biomarkers Workshop hosted by the LiveWell team at Newcastle University, the systematic review and survey work components of this thesis were intended to explore definitions of HA, identify the most important features of the HAP so that measurement tools for these features could be identified or developed (Lara et al., 2013, Lara et al., 2015). The original intention was that I would have been involved in the phase of the LiveWell project which tested these measurement tools to assess their acceptability to the age (life-stage) group of interest and to assess the ability of the tools to measure the effect of the interventions developed by LiveWell. However, as changes to the structure of the PhD were necessary (as described in Section 1.6.3) a new element was designed for the PhD project to examine further the components of HA identified in the earlier work.

1.6.2 Outline of chapters

As each subsequent chapter contains a standalone study, the rationale, aims and objectives for each piece of work are detailed in the individual chapters. To summarise, Chapter 2 explores the definitions of HA and how they have been operationalised, via a systematic review to update and expand the work of Depp and Jeste (2006). Chapter 3 uses the outcomes of the systematic review in card sorting tasks (CSTs) to examine how academics and older people perceive components of HA. Chapter 4 uses surveys to evaluate the importance of different components of HA to different groups of people, for example people of different ages, sex, and ethnic backgrounds. Chapter 5 investigates the relationship between the components of HA identified in previous chapters and mortality risk using survival analysis

in two longitudinal cohorts (Hertfordshire Ageing Cohort and Whitehall II). Finally, Chapter 6 discusses the overall findings from the project and suggestions for further research.

1.6.3 Changes to original structure

The original title of this thesis was 'Characterisation and measurement of the healthy ageing phenotype'. Following the systematic review in Chapter 2 and the initial card sorting task in Chapter 3, the next steps of the work were intended to involve a Delphi survey to develop a consensus definition of HA and to conduct a pilot study of methods of measuring the HAP. However, due to an interruption to studies caused by illness, the time frame for conducting the Delphi survey was missed so this work was reframed as the survey work described in Chapter 4 and extended to explore the importance of components of HA to different groups. The CST work in Chapter 3 was also expanded beyond its original intent as bridging work between the systematic review and the Delphi Survey. Additionally, as work on the measurement of HA as part of the wider LiveWell programme went ahead during the period of my interruption of studies, the title of the project was changed to the current title and the survival analysis of cohort data reported in Chapter 5 was included as an approach to assessing to the predictive utility of my findings about components of HA.

1.7 Overall aims and objectives

The overall aims of this project are:

1. To investigate how HA has been defined in the literature and how it has been measured.
2. To examine what different groups, in particular academics and older people, think is important for HA.
3. To explore the relationship of HA with mortality risk to determine whether components of HA, or an overall HA score, is a useful tool for measuring the utility of intervention studies designed in promoting HA.

The overall objectives of the project are to:

1. Conduct a literature review to explore previously published definitions of HA, terms used to describe HA and methods of measuring HA.
2. Explore the importance of constituent parts of the definitions of HA, identified through the literature review, to academics and older people.
3. Explore the relative importance of constituent parts of the definitions of HA, identified through the literature review, to people of different age groups, gender and ethnic groups
4. Use cohort data to examine whether HA is predictive of mortality risk.

Chapter 2. Definitions and Operationalisations of Healthy Ageing

2.1 Introduction

As detailed in Chapter 1, Section 1.4, previous review papers have examined the composition of definitions of HA. In brief, Phelan and Larson (2002) described seven components of HA from 11 papers, Peel et al. (2004) described 12 components from 18 papers, Depp and Jeste (2006) ten components from 29 definitions in 28 papers, 12 components from 34 studies were identified by Hung et al. (2010) while Cosco et al. (2013) reported 13 components within 5 overarching constructs of HA from 105 definitions in 84 papers. These reviews have been useful in showing the interest in defining HA as well as the wide heterogeneity in the nature and complexity of the proposed definitions.

It is commonly accepted that HA should translate into being socially engaged, productive and functioning independently at the physical and cognitive levels. As introduced in Chapter 1, Section 1.3.1., Rowe and Kahn's (1987) model of evaluating successful ageing was among the first to recognise the considerable heterogeneity of the ageing trajectories. This model emphasizes what individuals themselves can do to use, maintain, and perhaps even improve their physical and mental capacities. Psychosocial approaches focusing on social functioning, psychological resources and life satisfaction as the key to HA have been also proposed but these have proven to be more challenging to operationalise. For example, models with a psychosocial component such as Baltes and Baltes (1990) focus on accepting age-related losses and doing the best one can with what one has (i.e. physically, mentally, situationally). The Riley and Riley (1994) model emphasizes what societies can do (i.e. through laws, organizational policies, and customs) to provide external resources that enhance opportunities for the individual and, therefore, to facilitate behaviour change. Integration of these models is a challenge for researchers in the field (Kahn, 2002). The variety of definitions and models of HA highlights the extent to which ageing is a complex and heterogeneous process and as yet there is no single measure capable of reliably capturing HA at the level of the individual (Lara et al., 2013). Being able to consistently define and operationalise HA is important for clinical, research, and policy purposes (Mathers, 2015).

2.1.1 Terminology used in this review

The lack of consistency in published definitions of HA is discussed in Chapter 1, Section 1.4, and the variety of synonymous terms for HA used in the literature is discussed in Chapter 1, Section 1.2.2. However a second point of confusion is around the terms used to describe how definitions of HA are composed. Constructs, domains, components, operationalisations and elements were all terms used in the reviews discussed in Chapter 1, Section 1.4 to describe the various definitions of which HA is comprised. There is also the issue of what exactly an operationalisation is. Some papers, such as Depp

and Jeste (2006) present operationalisations as the score for a particular tool which indicates HA, while other reviews such as Cosco et al. (2013) use operationalisation as an interchangeable term with components and do not describe measurement tools or scoring criteria for HA. To help provide some consistency in naming conventions, 'component' will henceforth be used to describe a main constituent part of the definition of HA, and 'element' will be used to describe a building blocks of a particular component (see **Error! Reference source not found.**Figure 2.1). 'Metric' will refer to methods of measurement and 'operationalisation' will refer to the scores or cut-off points on metrics used to indicate HA.

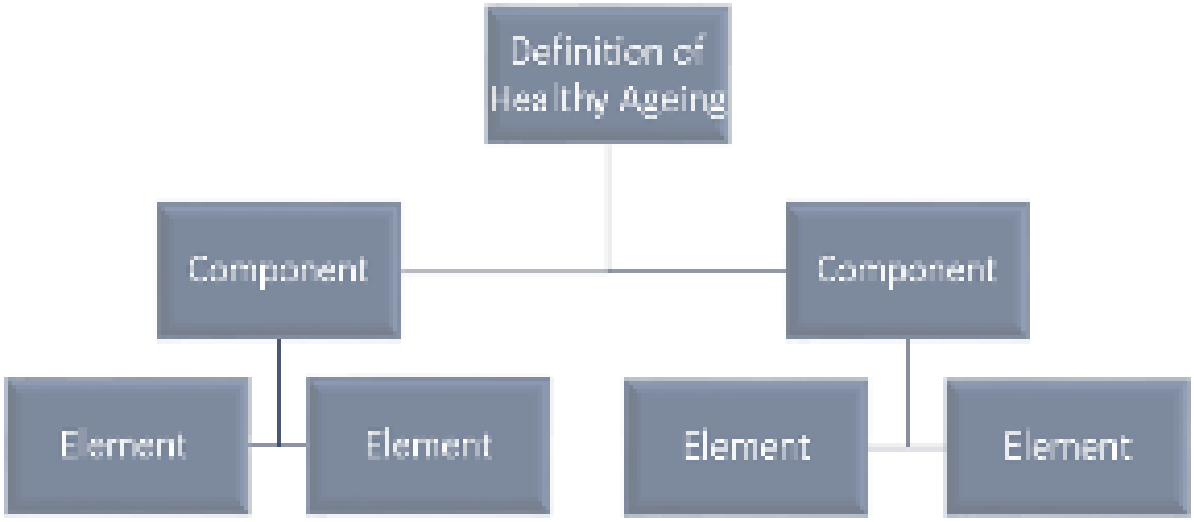

Figure 2.1. The relationships between elements, components and definitions of healthy ageing

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2.2 Rationale, hypothesis, aims and objectives

2.2.1 Rationale

Given the growing interest in measuring HA (Chapter 1, Section 1.5), this systematic review of the literature will focus on operationalised definitions of HA with an emphasis on identifying multidimensional definitions of HA. One of the main results from previous reviews of definitions of HA is the lack of consistency in the field. These problems are highlighted by the vast range of participants deemed to be achieving HA. For example, studies included in the review by Peel et al. (2004) reported 3.4% to 79.8% of participants achieving HA while for studies reported in the review by Depp and Jeste (2006) the range was 0.4% to 95%. New questions have also arisen regarding possible differences in the importance of different domains of HA between older people and academics and between different cultural groups. In the limited work which has examined these areas (e.g. Hung et al., 2010, Fernandez-Ballesteros et al., 2010), differences have been reported, raising further questions about where more differences may lie, for example between age groups across the life course. Although an important step forward in the field, the review by Depp and Jeste (2006) drew on publications from only one database so this exercise would benefit from being expanded to include more databases as

well as being updated (it is 10 years since that review was published). Similarly, Hung et al's. (2010) work could be built upon by attempting to draw together a consensus definition of HA representative of both academic and lay views as distinct from highlighting the differences between the two communities. While accomplishing these two points is not feasible by systematic review alone, conducting a new systematic review to update and expand upon Depp and Jeste (2006) would facilitate an exploration of how terminology surrounding HA has changed over time, the metrics and operationalisation of HA and how areas of measurement have changed over time. This would also provide a basis on which to examine the group differences identified by Hung et al. (2010). This review will also go into further detail by looking at the elements present in definitions of HA. Components of HA will be built up from these elements in subsequent work (Chapter 3).

2.2.2 Hypothesis

1. There will be little agreement in the literature over how HA should be defined and measured.

2.2.3 Aims

1. To expand the search strategy created by Depp and Jeste (2006) and run an updated search in multiple databases.
2. To explore the terms used to describe/ define HA.
3. To review the ways in which HA has been defined and measured in the literature.

2.2.4 Objectives

1. To identify published articles which have used HA as an outcome
2. To examine whether terms used to refer to HA, such as successful ageing, ageing well etc. have changed over time.
3. To examine the elements of HA in published definitions.
4. To identify the metrics used to measure HA and the operationalisations used in published studies.

2.3 Methods

The review was designed following guidance from the University of York Centre for Reviews and Dissemination (Centre for Reviews and Dissemination, 2009) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009). Recommended practice, as described by these sources, includes the following stages. The first is to check that a similar review has not been completed before, by searching databases of systematic review protocols such as PROSPERO International Prospective Register of Systematic Reviews (http://www.crd.york.ac.uk/PROSPERO), or the University of York Centre for Reviews and Dissemination Database (http://www.crd.york.ac.uk/CRDWeb) which includes the Database of

Abstracts of Reviews of Effects (DARE), Cochrane Database of Systematic Reviews (CDSR), and National Institute of Health Research Health Technology Assessment (NIHR HTA). Next, a study protocol should be developed which includes information about the review questions, selection criteria, search strategy, study selection, data extraction, quality assessment and data synthesis. It is also best practice to register the protocol with PROSPERO and this is now a requirement of many journals. Medline and Embase are the most commonly used databases for health-related reviews (Centre for Reviews and Dissemination, 2009), but additional sources could be searched such as the reference lists of included studies, relevant internet sources (grey literature) such as conference abstracts and reports produced by charitable trusts. Study selection should be carried out independently by at least two reviewers and agreement between reviewers should be checked. Decisions should be reported using a PRISMA diagram and, again, this is a now a requirement of most journals before a review can be published. Data extraction forms should be piloted on a small sample of studies. Quality of the studies included in the review should be assessed in provide an indication of the strength of the evidence provided by the review. There is no overall consensus on how to judge study quality but tools and guidelines are available (depending on study design), for example, Consolidated Standards of Reporting Trials (CONSORT; http://www.consort-statement.org), Strengthening the Reporting of Observational studies in Epidemiology (STROBE; http://www.strobe-statement.org) or the Mixed Methods Appraisal Tool (MMAT; http://mixedmethodsappraisaltoolpublic.pbworks.com). Data synthesis can be performed using quantitative techniques or can be done narratively where meta-analysis in not appropriate, for instance because of heterogeneous study designs.

2.3.1 Search strategy, screening and data extraction

Three electronic databases were systematically searched for published journal article literature following Cochrane guidelines (www.cocchrane.org/handbook). These searches were conducted by Linda Errington, Liaison Librarian, Newcastle University. The databases searched were Medline, Embase, and PsycInfo. Prior to searching, a small scoping search was carried out to identify and group together potentially relevant terms. Search terms were identified from key words and search strategies of the key papers identified in the scoping exercise. The search terms were then translated into a search strategy. The search strategy involved combining a range of synonymous/alternate keywords to find papers on the definition of HA. The search was limited to studies in humans and those published in the English language as resources to undertake translation work were not available. The search strategy was refined iteratively in response to emerging results. The final list of terms used for searching Medline (via Ovid) can be seen in Appendix A. Search strategy. This search strategy was then adapted as necessary to take into account differing search functionality available in the additional databases. The number of potentially relevant publications found from searches of each database is shown in Table 2.1.

Table 2.1. Number of potentially relevant publications found in each database before and after de-duplication.

Database	Date Searched	References found before de-duplication	References found after de-duplication
Medline	25.5.12	4,622	4,501
Embase	25.5.12	10,152	6,966
PsycInfo	25.5.12	1,907	1,289
TOTAL No. of refs		16,681	12,756

References of studies returned from all of the databases were exported and stored in an EndNote X4 database by Linda Errington (Liason Librarian, Newcastle University), and then duplicated references were removed. Duplicated references were deleted. Initially studies were screened by title and abstract searching then two raters (EB and JL) independently assessed full text articles identified for inclusion. Differences were resolved by discussion before data were extracted. The references of studies accepted after full text screening were cross-checked by hand in order to identify other relevant publications. These may not have been identified during the initial search as they may not have been indexed by the databases, or may have been indexed inaccurately, which cannot be anticipated by the search strategy (Centre for Reviews and Dissemination, 2009). Studies identified from reference cross-checking were subject to the same process of title and abstract screening then, if appropriate, full text screening, as other studies. Data was extracted from full papers using a standardised data extraction form, which was piloted on a small sample of papers. Reference list checks and citation searching were carried out on included publications to identify other studies which were potentially eligible for inclusion.

2.3.2 Selection criteria

The literature was searched for any type of study design reporting quantitative data and which operationalised a definition of healthy ageing as a dependent variable. Where review papers were identified, references were hand search and each included article considered for the current review individually. Studies were eligible for inclusion only if they reported quantitative data from male or female participants of any ethnic background, not recruited based on disease, and which studied HA as an outcome. No limitations were applied to the methods of measurement used to evaluate HA. Studies must have been published in a peer-reviewed journal in the English language as resources to undertake translation work were not available. There is no consensus on the methodology for assessing quality of papers of this type (Harden et al., 2004).

2.3.3 Analysis strategy

The number of results at each stage of the systematic review and the characteristics of each included study shown in Figure 2.2 and Appendix B respectively. The proportion of terms used (i.e. HA and synonymous terms) was compared graphically by decade. There was a large degree of variability in the

components metrics and operationalisations used in the studies, therefore a descriptive, narrative review is presented using the components from Depp and Jeste (2006) as a framework for presenting results and to allow comparison with that earlier review.

2.4 Results

2.4.1 Included studies

Medline, Embase and PsycInfo were searched up to May 2012. These searches found 4,622, 10,152 and 1,907 references respectively (Figure 2.2). After the references were imported into EndNote and duplicates removed, the total number of references reduced from 16,681 to 12,756. After screening by title and abstract, 274 potentially relevant papers were obtained in full text. After screening the full papers, 214 did not meet the inclusion criteria and were excluded from the review. In total 60 papers were included in the review.

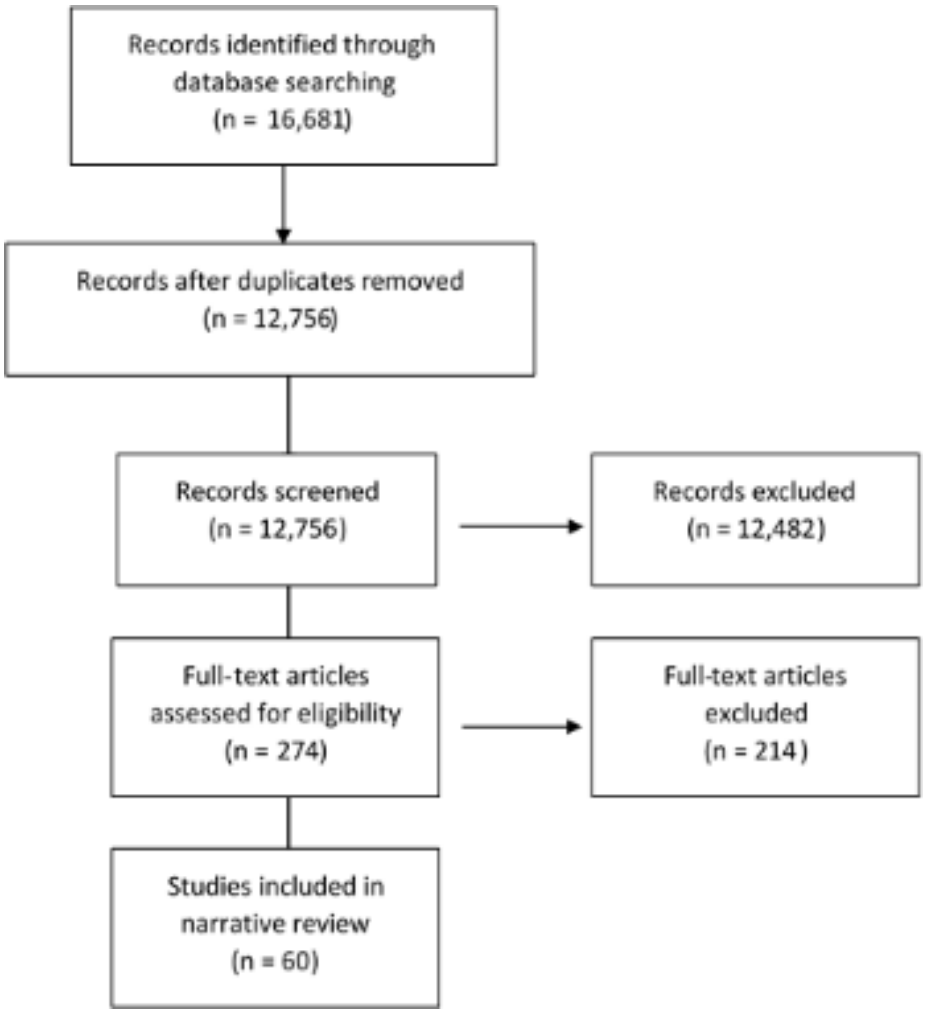


Figure 2.2. Flow diagram showing the number of papers at each stage of the review. Adapted from (Moher et al., 2009).

2.4.2 Characteristics of included studies

The characteristics of the included studies are presented in Figure 2.2. The greatest number of studies were conducted in the USA (46.7%) followed by Europe (21.7%), East Asia (11.7%), Australia (8.3%), Canada (6.7%), South America (3.3%) and Africa (1.6%). The most frequently reported study design was longitudinal cohort (48.4%) followed by cross-sectional (24.2%), prospective (19.4%), retrospective (4.8%), clinical study (1.6%) and community-based randomised trial (1.6%). Thirteen percent of studies included participants in some form of residential care. Sample sizes ranged from 24 to 13,297 (mean=1,858) and mean age of participants ranged from 44 to 86.4 years.

2.4.3 Prevalence of terms

Successful ageing was the most frequently used term (70%) followed by healthy ageing (HA) (11.7%), health and ageing (3.2%), longevity (3.2%) and active life, ageing well, perceived age, positive ageing, quality of extended life years, robust ageing and wellbeing each with 1.7%. Focussing on the two most frequent terms, HA and successful ageing, Figure 2.3 shows the change in use over the decades. There was a gradual rise in the use of HA between the 1970s and the 1990s followed by a steeper increase after the turn of the millennium. For successful ageing there was a steep rise in the use of the term between 1980 and 2000. However, these rises most likely just reflect the increasing numbers of studies published on HA, so the main finding here is that successful ageing is a much more widely used term than HA.

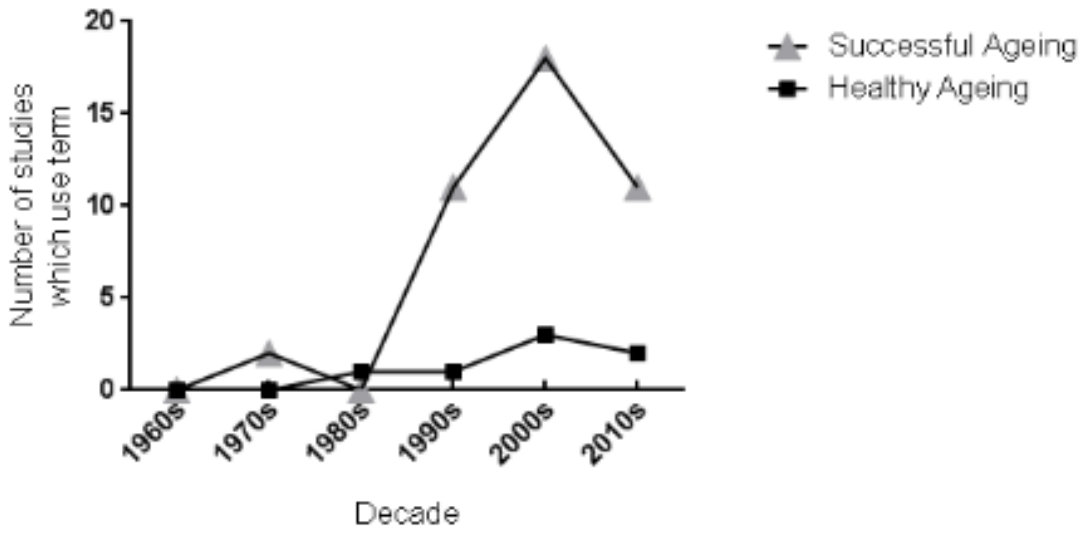


Figure 2.3. The number of studies which use the terms healthy ageing and successful ageing separated by decade.

2.4.4 Citations, elements, metrics and operationalisations of HA

A summary of the elements, metrics and operationalisations extracted from the 60 publications is included in Appendix C. In total 280 elements of HA were identified. Figure 2.4 shows the number of elements of HA identified by this review that were mapped onto the ten components created by Depp and Jeste (2006). The remaining elements found in this review, which could not be accommodated within those ten components, were grouped together as 'other' and included ethnicity, gender and smoking status. These were cited by 32 papers and were measured by 16 with 62 operationalisations. 'Disability/physical function' was the most widely cited (n=50) component containing 102 elements of HA, followed by 'life satisfaction/wellbeing' (40 citations, 34 elements), 'illness' (38 citations, 27 elements), 'cognitive function' (36 citations, 34 elements), 'social and productive engagement' (35 citations, 19 elements), 'environment/finances' (25 citations, 11 elements), 'self-rated health' (21 citations, 3 elements), 'personality' (15 citations, 28 elements), 'self-rated healthy ageing' (6 citations, 1 element) and 'longevity' (4 citations, 1 element).

This review also found 269 unique metrics and 396 separate operationalisations of HA. Some metrics were used in more than one component so that the total number of unique metrics is fewer than the total number of metrics shown in Figure 2.4 (n=289).

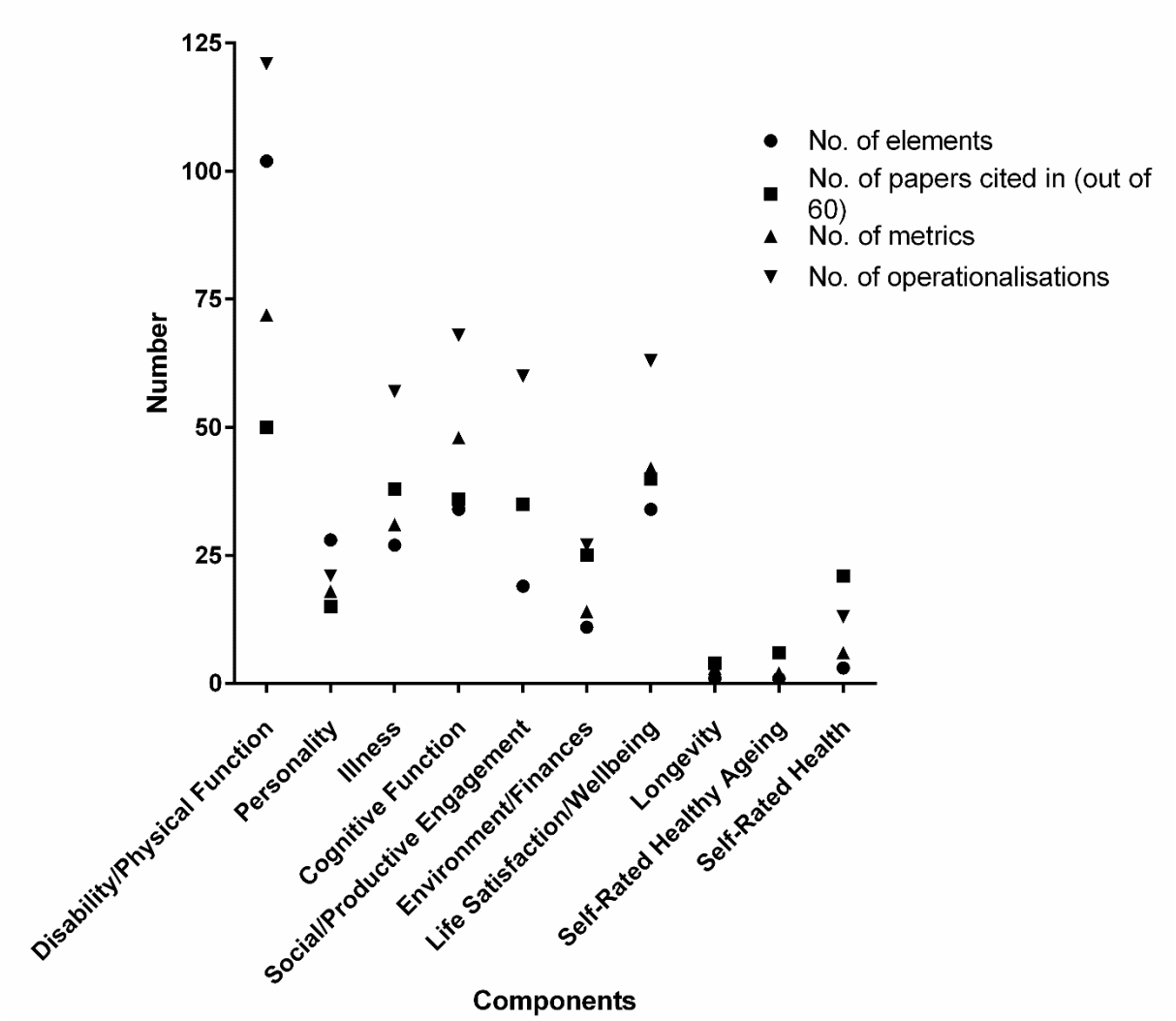


Figure 2.4. The number of elements, citations, metrics and operationalisations of HA per Depp and Jeste (2006) component.

'Disability/physical function' had the largest number of metrics (n=72) and operationalisations (n=121), followed by 'cognitive function' with 48 metrics and 68 operationalisations. 'Life satisfaction/wellbeing' had the third highest number of metrics (n=42) and operationalisations (n=63) followed by 'social/productive engagement' (48 metrics, 68 operationalisations). 'Illness' had the fifth largest number of metrics (n=31) and the fifth largest number of operationalisations (n=57). 'Personality' had the sixth largest number of metrics (n=18) but the seventh largest number of operationalisations (n=21), while 'environment/finances' had the seventh largest number of metrics (n=14) but the sixth largest number of operationalisations (n=27). 'Self-rated health' had the third smallest number of metrics and operationalisations (6, 18 respectively), while 'longevity had the second smallest number of metrics (n=3) and the lowest number of operationalisations (n=4) and 'self-rated healthy ageing' had the lowest number of metrics (n=2) and the second lowest number of operationalisations (n=6). For all ten components the number of metrics was roughly two thirds of the number of operationalisations.

2.5 Discussion

2.5.1 Principal findings

This review identified 60 papers which operationalised a definition of HA and has highlighted the large degree of variation in published descriptions/definitions of HA. The majority of studies were from the USA. Successful ageing was the most frequently used term which gained in popularity during the 1980s and 1990s. This latter finding highlights the problem of inconsistent nomenclature in the field, with the dichotomous nature (i.e. success or failure) of the term failing to reflect the continuum of ageing outcomes and having unnecessarily negative connotations for individuals who experience less desirable ageing outcomes. Compared with other terms such as optimal ageing and robust ageing, HA has the advantage that it is more familiar and therefore acceptable term to the general population. HA also represents a continuum with which the general public are already familiar - it is widely understood that there are different degrees of health at all stages of the life course. Similarly, in common with perceptions of general health, whilst individuals can contribute towards their own HA through appropriate lifestyle choices general health, as well as health during ageing, is not completely under the individual's control.

Two hundred and eighty elements of HA were found which were measured by 269 unique metrics and operationalised in 396 ways. When these elements of HA were mapped onto the ten components reported by Depp and Jeste (2006), 'disability/physical function' was the most widely cited and was associated with the greatest numbers of metrics and operationalisations, in line with the prevalence of Rowe & Kahn's (1987) biomedical model of ageing. In general, components which were mentioned in higher numbers of papers had more elements included within them. However, this was not always the case. For example the component 'personality' was unusual in that it contained more elements (n=28) than the number of papers in which it was cited (n=15). Components which were measured by greater numbers of metrics tended to have greater numbers of operationalisations. A similar trend was observed between number of elements within components and number of metrics.

2.5.2 Strengths and limitations

The aims of i) updating and expanding upon Depp and Jeste (2006) and ii) examining the elements of which components of HA are built were achieved in this review. As this review went into a greater level of detail than previous reviews by looking at elements instead of components, it was necessary to find a way to summarize the results in order to be able to present them. Using the Depp and Jeste (2006) paper as a framework allowed comparison between studies and aided in the presentation of findings. However, the decision of which elements should be grouped under the heading of which components was subjective. Ideally, it would have been preferable to have had two or three independent raters

make these decisions. For example, anxiety is often associated with personality type (e.g. Kupper and Denollet, 2014) but here it was placed under 'illness' because it is a recognised disorder in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV). A further problem with following the components set out by Depp and Jeste was their failure to separate emotion and mood from life satisfaction and wellbeing. Although the work of Depp and Jeste (2006) was expanded upon here by searching three databases as opposed to one.

The components of HA presented in previous reviews have been described using several different names such as components, domains and elements. An advantage of this review is that definitions of HA were examined in a greater level of detail than previous reviews by investigating the elements which form components of the definition of HA rather than simply describing components. By focussing on individual elements of components, this review has paved the way for future work examining the components that would be created from the elements identified by academics and by lay people, in line with suggestions made by Phelan and Larson (2002) and Hung et al. (2010). This would avoid the shortcoming of reviews in which the authors imposed their own opinion about what constitutes a component of HA. Similarly this review has highlighted disparity between how the terms metric and operationalisation are used in different papers, a disparity which needs to be corrected for work in this field to progress. This review has the advantage of including studies which have given operational definitions of HA alongside studies which have operationalised the measurement of HA without defining it, broadening the scope of the review.

Although one of the aims of this review was to examine how terms used to refer to HA have changed over time, the sample size is too small to draw firm conclusions. The results in Figure 2.3 appear to show a decline since 2010, however this is most likely an effect of the search ending in 2012 so there were not as many articles available in the two years since 2010 compared to the full decade since 2000. It is therefore unfair to draw a direct comparison between a two year and ten year time period. This review had deviated slightly from accepted guidance on conducting systematic reviews. Although the development of the protocol and piloting of data extraction forms was carried out in line with the guidance described in Section 2.3, grey literature was not included in the search and quality assessment was not undertaken. Further, as touched upon in earlier in Section 2.5.2, study selection was only carried out by one reviewer.

It would have been preferable to have at least two reviewers screening studies to eliminate potential bias and to improve the overall quality of the review. Unfortunately due to time constraints within the larger LiveWell project it was not possible to recruit either experienced reviewers to help with screening or to train people to help who had no previous experience of systematic reviews. Including grey literature would have broadened the scope of this review as would searching additional databases.

Whilst two additional databases were originally searched, it was not deemed practical within period of time available to include and screen the additional 39,121 studies (after deduplication) retrieved from Scopus and Web of Science. Assessing the quality of studies included in the review would also have been desirable, as had been done in previous work (Barron et al., 2015). Considering these limitations, this piece of work would perhaps better be described as a systematic literature search with narrative synthesis

2.5.3 Conclusions

Several descriptors such as successful ageing and positive ageing are used for HA in the literature. In addition, there is no consensus definition of HA and there is no agreement about how it should be measured. This lack of consistency in how to define and to operationalise HA is an impediment for clinical, research and policy purposes. As the majority of studies included in this review were published in the USA or Europe it is uncertain whether the results of the review can be generalised to other cultures. Further work will be required to explore this issue and to create a consensus.

2.5.4 Future research

The initial search included papers available up to May 2012 which was subsequently updated for publication up to October 2015. Stricter selection criteria were included for this new review which was limited to cross-sectional and cohort studies. A narrower list of synonyms for HA was also used resulting in the removal of four papers that were included in the current review; Christensen et al. (2009a) and Hogan et al. (1999) were removed based on the terms they used for HA while Robare et al. (2011) and Wahlund et al. (1996) fell outside of the selection criteria for study design.

Successful ageing emerged as the most prevalent term used for HA in the published literature. Given the idea of success or failure that such a term creates, debate within the field of HA should be initiated so that a more appropriate term (preferably HA) can be agreed upon and used consistently in the literature. The under-representation of non-Western definitions of HA in this review suggests that more work is needed to confirm whether definitions of HA produced by research which is, for the most part from the USA and Europe, are applicable cross-culturally. More work on the definitions of HA in different cultures could be pursued by examining the elements included in HA definitions in studies from different cultural backgrounds to build on work by Hung et al. (2010). Unfortunately, the number of papers using the terms HA as distinct from successful ageing was not high enough to allow a comparison of the elements of definitions used for HA and for successful ageing. In addition, potential disciplinary bias could be investigated by considering the academic backgrounds of the research groups producing definitions of HA. If such research confirmed that academic background influences the definition of HA, it would make an argument for more inter-disciplinary working on such a

multidimensional topic. Previous work (e.g. Hung et al., 2010) has suggested that there are differences in definitions of HA between academics and lay people. While such differences were not the focus of the review reported in this chapter, this line of enquiry is examined further in Chapters 3 and 4.

Chapter 3. Categorisation of Elements of Healthy Ageing

3.1 Introduction

In the previous chapter, 280 aspects of HA were identified via systematic review. To investigate possible between group differences in opinions about what is important for HA, these data needed to be summarised into a more manageable number of categories for participants. To reduce the amount of information for participants, categories of elements which shared some similar characteristics or features were created. This was accomplished through a card sorting task (CST), which is a type of categorisation task. Categorisation tasks have long been used in cognitive and social psychology to sort information into groups (Courcoux et al., 2015).

3.1.1 Introduction to card sorting tasks (CSTs)

Card sorting, also referred to as free sorting, requires participants to sort information written on cards (stimuli) into groups. It is a relatively straightforward task for which participants require no prior training. It is also useful for comparing different groups of participants (Courcoux et al., 2015). Card sorting is based upon personal construct theory (Rugg and McGeorge, 2005). Developed in the 1950s by George Kelly (1955), personal construct is based on the central idea that people understand the world through their experiences of it. As every individual has different experiences in life, each individual creates their own model of reality (Cridland et al., 2014). Individuals construct categories to reflect their understanding of the world. The way in which individuals create these categories is a reflection of their internal representation of the world and will differ from person to person based on their past experiences (Fincher and Tenenerg, 2005).

3.1.2 Uses of CSTs

CSTs are used widely in industry to assess the usability of designs, particularly in product development and web design to ensure they meet end user needs (Courcoux et al., 2015, U.S. Department of Health and Human Services, 2015). Recent example of the use of CSTs in industry include testing visualisation software to assess consumer purchases of plants (Garbez et al., 2015), examining cultural differences in perceptions of mineral content in Sauvignon wines (Parr et al., 2015) and a comparison of guitarists perception of electric guitars with either ebony or rosewood fingerboards (Pate et al., 2015).

There are very few peer reviewed articles on the utility of CSTs in research on ageing, therefore using CSTs to investigate how different population groups categorise elements of HA was a novel approach. Searches for journal articles which used CSTs in ageing research revealed that the Dimensional Change Card Sort Test (Frye et al., 1995) and the Wisconsin Card Sorting Task (Berg, 1948), which measure set-shifting executive functions and cognitive flexibility respectively have been used widely in studies of cognitive changes during ageing.

3.1.3 Expert and novice categorisation

As performance in a CST is influenced by experience, we could expect differences between people who are experts or novices in a particular topic. Experts have accumulated more experience of a given topic than a novice and therefore may categorise information relating to their area of expertise in different ways from novices (Nielsen and Sano, 1994, Fincher and Tenenerg, 2005). In general, novices sort information by superficial domain and context while experts sort by common causal structure and conceptual features independent of domain (Rottman et al., 2012, Smith et al., 2013). For example, novices sorted fish by appearance while fishermen grouped them by behavioural similarities (Shafto and Coley, 2003). In addition, wine connoisseurs (quantified via Rasch analysis) grouped wine glasses by function and technical specification while non connoisseurs grouped them by description of shape and design (Faye et al., 2013).

There are different levels of categorisation: subordinate, basic and superordinate, with the basic category the most readily used in spontaneous classification (Rosch et al., 1976). These differences in categorisation strategy reflect how experts and novices organise their discipline specific knowledge, although this may be an unconscious process (Dreyfus and Dreyfus, 2005). Using trees as an example, 'plant' is the superordinate category, 'tree' the basic category and 'oak' the subordinate. However, an expert's basic category is the equivalent of a novice's subordinate category leading to experts creating a much wider range of categories for stimuli in their subject area than novices (Rota and Zellner, 2007). There is also evidence that people with the same level of expertise, but from different academic backgrounds, categorise differently (Bussolon, 2009). Similarly, literature reviews and survey work have reported differences in what academics and older people think is important for HA (e.g. Hung et al., 2010, Phelan et al., 2004). This is discussed further in Chapter 4, Section 4.1.2.

3.1.4 Age group and gender differences in Card Sorting Tasks

The literature surrounding age related differences in general CST performance focuses on age related changes in cognitive functioning affecting performance speed and ability to deal with more complex information (e.g. Botwinick et al., 1960, Falduto and Baron, 1986). However, opinions about healthy ageing over the life-course have also been studied. Jopp et al (Jopp et al., 2015) examined responses to open ended questions about the meaning of successful ageing from young ($\sim$ 22 years), middle-aged ($\sim$ 46 years) and older ($\sim$ 72 years) participants from the USA and Germany. Responses were analysed for underlying themes with results that were broadly similar across age groups and cultural background. However success and wellbeing were three times more likely to be mentioned by participants from the USA while success and respect were more important to those in the older age group.

There is an absence of evidence to suggest that CST performance differs between the sexes. However the pattern and prevalence of age-related disease varies between males and females which may affect perceptions of HA (Warner and Brown, 2011).

3.1.5 Types of CSTs

CSTs can be conducted in two ways; open or closed. In an open CST, participants organise cards into groups based on their own choices and create the name for each grouping. Open card sorting is participant centred rather than researcher centred (Fincher and Tenenerg, 2005) and is a good exploratory technique when the emphasis is on finding categories (Rugg and McGeorge, 2005). In closed card sorting, participants are given grouping criteria or group names and this method is used to determine whether the grouping criteria/names are an effective way to organise the stimuli. Closed card sorting is more useful for organising information into predefined categories (Spencer, 2009).

3.1.6 Group and individual Card Sorting Tasks

CSTs can be performed by teams or by individuals. Team card sorts allow participants to arrive at a consensus via discussion of card grouping. However, dominant group members can exert a greater influence over the sort than more submissive members of the group (Spencer, 2009). Individual card sorts remove the influence of group dynamics (Wilson, 2010) and can also be performed online (Spencer, 2009).

3.1.7 Group size for CSTs

In the field of design, it is becoming more common for CSTs to be performed by individuals online and to determine group consensus via statistical analysis (Mueller, 2012). In larger groups, CST performance tends to decline (Mueller, 2012) because of diminishing motivation and increasing conflict and communication problems (Staats et al., 2012).

Previous work has found that naturally forming social groups tend to include five people on average and when asked to work together on a specific task, fewer complaints about the work and the group are reported by people in a group of five (Moreland et al., 2013). Other work has reported that, for CSTs, a group size of three to five participants is optimal (Spencer, 2009, Nielsen, 2004, Tullis and Wood, 2004).

3.1.8 Acceptability of CSTs to participants

The administration of CSTs is straightforward and the task itself places relatively little time pressure or cognitive burden on participants so this approach is suitable for use with all ages and levels/areas of expertise (Fincher and Tenenerg, 2005). Cards contain a small amount of information so there is little to distract participants from the task of categorisation. However, this means the outcome of the task relies on participants correctly understanding the meaning of what is presented to them (Rugg and

McGeorge, 2005). Overall, CSTs are engaging for participants and participants report enjoying them (Daws, 1996).

3.1.9 Comparison of CSTs with alternative approaches

3.1.9.1 Q sort methodology

CSTs are only one method of categorising information. An alternative type of categorisation task is Q-sort methodology which was developed in the 1930's as a systematic way to study individual opinions on a particular topic (Brown, 1993) and to examine the subjectivity in individual viewpoints that is typically missed by other quantitative methods (Cross, 2005). The aim of a Q sort is to show the scope of individual opinions (Cross, 2005). Similar to a CST, during a Q sort, participants are given a set of cards bearing statements about a particular topic (called the Q set) but unlike a CST they then place them in rank order, revealing their individual subjective view of relative importance (Brouwer, 1999). Once the sort is complete, participants can reflect on their finished sort and make any changes they feel to be appropriate. These viewpoints can be analysed using factor analysis, with correlation between opinions indicating which extent to which concepts are shared by participants (Brown, 1993, Courcoux et al., 2015).

Similar to CSTs, Q sorts do not require large numbers of participants. However the maximum recommended number is 100 cards (Cross, 2005) which is less than half of what was identified in the systematic review (see Chapter 2) so this approach was not suitable for use in this study. Q sort is also open to more potential sources of bias than CSTs. Both methods are vulnerable to the effects of demand characteristics and social desirability bias. Q sorts are also at more risk of experimenter bias than CSTs from the number of statements included in the sort (Brown, 1993). Q sort methodology is based on the idea that there are a limited number of possible viewpoints on particular topic. If the researcher does not include all of these viewpoints, the results will be biased towards what is included and other important factors may be missed (Brown, 1980). In contrast, with the CST used in this work, the stimuli included in the task were taken directly from the outcomes of the systematic review which minimised the risk of experimenter bias. There is also a risk during Q sort analysis that researchers can over-interpret the results by inferring reasons for the opinions presents rather than describing the opinions found (Cross, 2005). This is not the case for the CST as consensus categorisation, rather than subjective opinion, is the main outcome. The final stage in a Q sort is to analyse the similarities and differences between individual patterns of responses, but here we are interested in the consensus of a group.

It has been asserted in the literature that forcing people to rank their choices in Q sorts forces them to think more carefully about their responses (Prasad, 2001), but there is no evidence that creating categories in CSTs fails to elicit the same degree of attention. Additionally, there is discrepancy in the

literature about the retest reliability of Q sorts and this is often explained as a natural change in attitudes and opinions over time (Cross, 2005). This may also be true of CSTs. Further, it has been claimed that by forcing participants in Q sorts to sort cards into a predetermined matrix limits their ability to express their true opinions (Cross, 2005). The CST in this study does not share this limitation because an open sort was used in which participants were free to create their own groups. In CSTs and Q sorts, cards are sorted from each participants own point of view and each participant may understand a term on card in dissimilar ways (Cross, 2005). In this study, standardised definitions of terms were provided to CST participants to minimise this potential problem (Appendix F).

In summary, while Q sorts and CSTs share the advantage of being versatile methods which can be used to examine many different topics, to address the aims of this chapter a CST was considered to be the most appropriate approach to use to categorise the elements of HA derived from the systemic review (Chapter 2).

3.1.9.2 Focus groups

Focus groups are a form of group interview that have been used study a vast array of topics. The distinguishing feature of focus groups is their emphasis on communication and interaction between group members (Kitzinger, 1995, Smithson, 2000). Focus group discussions are centred around a particular topic, with a moderator to guide discussions usually using open ended questions (Kitzinger, 1995).

Focus groups usually involve between six and ten participants (Wilkinson, 1998, Rabiee, 2004). Groups are recommended to be composed of either pre-existing groups, for example colleagues, or recruited based on homogeneity of participants, for example in respect to age or socioeconomic status (Wilkinson, 1998). Group dynamics can encourage quieter members to join in (Kitzinger, 1995) but may also silence individuals who do not agree with the majority opinion (Smithson, 2000). Verbal interactions between group members, as well as interactions between the group and the moderator, are usually recorded, transcribed and then subjected to thematic analysis, content analysis (Wilkinson, 1998) or discourse analysis (Smithson, 2000).

In this study, focus groups would have provided richer data on the reasoning behind the choice of cards to be placed in particular categories and why category names were chosen. Such data are not formally available from CSTs. However, the main interest of this study was the categories of cards which were created, not the reasoning behind their creation.

As with Q sorts, focus groups are more at risk of experimenter bias than CSTs, as the direction of the groups discussions is influenced by the moderator. Focus groups are also at risk of influence from

demand characteristics and social desirability bias, especially because of the interaction with the moderator.

3.1.9.3 Online CSTs

There are several pragmatic advantages to conducting CSTs online using software such as OptimalSort (OptimalWorkshop) or WebSort (Information Architecture Tools). Once set up, online sorts can be run as many times as required, without needing participants to travel to a particular venue, many participants can be tested simultaneously and the sort data are captured by the software without the need for data entry by the researcher. However, online CSTs lack the richness of group sorts arriving at their conclusion by consensus and lose the observational data on group processes that can be recorded with traditional CSTs (Spencer, 2009). The large number of stimuli used in this CST may also have been unmanageable for participants to sort in a reasonable timescale using an online system, therefore for this particular project group sorts were the most feasible approach.

3.2. Rationale, hypothesis, aims and objectives

3.2.1 Rationale

The roots of CSTs in personal construct theory make it an appropriate method for investigating how people think about ageing. Whilst card sorting is used commonly in product design and web design, as argued above, the application of this methodology to investigate perceptions of HA is novel. This method also allows a comparison between expert and novice categorisation which could help to investigate reported differences between academics and older people in perceptions of what is important in HA (e.g. Hung et al., 2010). It could be argued that as everyone ages, everyone is an expert in ageing. However, academics who research ageing have been trained over time to think in a more formalised way about this topic, while academics in general are used to dealing with information at a detailed level so are likely to be working more at the subordinate level of categorisation (e.g. Rota and Zellner, 2007, Bussolon, 2009). In light of these differences the following groups were recruited: Academics with an interest in ageing, academics from other fields, and a group of older people without an academic background. Research on opinions about ageing across the life course has shown similar results between age groups and also between the sexes (e.g. Jopp et al., 2015), so it was not necessary here to have groups matched for gender or age.

As one of the aims of the study was to explore how elements of ageing would be categorised, open card sorting was used. As a focus of the work to this point had been on a consensus definition of ageing, group card sorts were used, but a subset of individual card sorts was also conducted for comparison with the group results and to examine the effects of group dynamics.

3.2.2 Hypothesis

1. There will be variation in how academics and older people categorise elements of HA.

3.2.3 Aims

1. To create categories of elements of HA identified in the systematic literature review (Chapter 2), to develop items for a survey of manageable size.
2. To compare how people with varying levels of expertise, specifically academics from differing backgrounds and older people, created these categorisations.
3. To compare open versus group task performance in a subset of participants in order to examine the influence of group dynamics on card categorisation.

3.2.4 Objectives

1. To run open CSTs with three groups of participants with varying levels of expertise in ageing research i.e. academics with an interest in ageing, academics without a background in ageing research and older people.
2. To compare the categories of cards created by each group of participants in terms of number of categories, categories names and cards contained within each category and to examine levels of agreement.
3. To compare outcomes from individual versus group CSTs.

3.3 Method

3.3.1 Participants

3.3.1.1 Group 1 – Academics with an interest in ageing

Participants in Group 1 were an opportunistic sample of four members of the LiveWell team, two males and two females differing in ages and levels of expertise. Participants' age was not noted. Each of the participants was from a different academic background but all were working in ageing research at the time of the task.

3.3.1.2 Group 2 – Older people

Group 2 consisted of four retired individuals recruited from a local book group. Three of the four participants were female and the average age of the group was 67 years with a range of 65 to 72 years. Before retirement, two of the participants worked in education, one was a civil servant and the fourth had worked as a sales assistant.

3.3.1.3 Group 3 – Academics without a background in ageing

Participants in Group 3 were recruited from Northumbria University. This group consisted of two males and two females with an average age of 34 years (range 27 to 47 years). The academic backgrounds of the participants were developmental disorders, fertility, genetics and sports psychology. For two

participants in Group 3, English was not their first language; one spoke Czech and the other Portuguese, but both had sufficiently high level spoken and written English skills to be employed as post-doctoral researchers.

3.3.2 Procedure

In this study, three group and four individual open card sorting tasks were undertaken as well as one closed group sort. In the open sorts, each element of HA was written on an index card. To create uniformity, all cards were white and the elements were printed on labels and affixed to the centre of the cards, with the exception of Group 1 where post it notes were used. Cards were spread out on a table in a random order in advance of participants' arrival. Participants were given standardised instructions (Appendix D) and standardised definitions of terms were available to be referred to if participants had any questions about clarification of the meaning of the terms on the cards (Appendix F). In the open sorts, participants sorted cards into different categories and then wrote the names for each category on a white envelope in which the cards could be stored. In the closed sort, participants were given category names on white envelopes at the head of the table and were asked to sort cards into these categories. All participants agreed that their photographs could be included in this thesis.

3.3.2.1 Recommended CST Procedure

Best practice from industry states that CSTs must take place in a single session (Chollet et al., 2014) and participants should be given standardised instructions. Researchers should only answer questions about clarification (e.g. a standardised definition of a term) and not classification as this could affect the outcome. All cards should be of a uniform size and design and participants should look at all the cards before they begin the task so that they are aware all of stimuli to be sorted (Rugg and McGeorge, 2005).

3.3.2.2 Group 1 – Academics from ageing-related disciplines

The card sorting task took place at the Campus for Ageing and Vitality over one session lasting two hours. Two hundred and eighty elements of HA identified via literature review (Chapter 2) were written on individual post-it notes. Six synonymous terms were removed and 49 elements which were judged by the academics to be a) vague, b) mechanisms to improve health rather than health itself, or c) mediating factors were removed from the CST (details in Appendix E). The remaining 225 post-it notes were placed in a random order on a table (Figure 3.1). Participants arranged the elements into categories. At first, each member of the team worked separately to create categories of cards. The team then discussed the categories they had created and came to a consensus over whether any of the categories could be merged. Categories were given names based on a consensus by the team and then each category was discussed in turn (Figure 3.2). Cards from each category were paper clipped together and stored in separate envelopes.

3.3.2.3 Group 2 – Older people

Group 2 completed three sorting tasks on separate occasions: One open group sort, one open individual sort and one closed group sort. In each sort the 225 elements of HA from the literature review were printed on uniform index cards and spread randomly around a table in a meeting

Figure 3.1.The early stages of the CST with participants discussing how to categorise cards.

Figure 3.2. Nearing the end of the CST, participants have separated the cards into categories and created category names.

room at either the Campus for Ageing and Vitality or the group's usual meeting place. In the open group sort, participants worked collectively to create categories of cards and to name each category (Figure 3.3). This sort took approximately two and a half hours. In the open individual sort, which took place approximately eight months later, participants worked on their own to create and to name categories of cards. On average participants completed this sort in one and half hours. In the closed group sort (Figure 3.4), which took place ten months after the open sort, participants were given the category names that the academics with an interest in ageing had created in the original open group sort, to see if the older people and academics would put the same cards in each category. This sort took two hours.

3.3.2.4 Group 3 – Academics without a background in ageing research

Group 3 completed an open group sort at Northumbria University. The procedure was the same as for Groups 1 and 2 (see Figure 3.5 and 3.6). This sort was completed in two and a quarter hours and, unlike the other two groups, this time included a ten minute break after one hour. Although breaks during CSTs are not part of best practice guidelines this sort took

Figure 3.3. During the open group sort participants kept the cards which has been sorted into categories separate from cards that remained to be sorted.

Figure 3.4. In the closed group sort participants were given category names and discussed the category to which it was most appropriate to assign each card.

place in an over-heated room with no way to turn down or turn off the radiator. After an hour a break was required for participants to get some fresh air and drinks.

3.3.3 Analysis strategy

The first stage in analysing the data was to investigate the similarities and differences in category names created by each group so that categories could be compared (Spencer, 2009). Initial analysis was performed using an Excel analysis template provided by Spencer (2015). This template was used to calculate summary information for each group including the

Figure 3.5. Participants began the sort by trying to organise cards into vague categories.

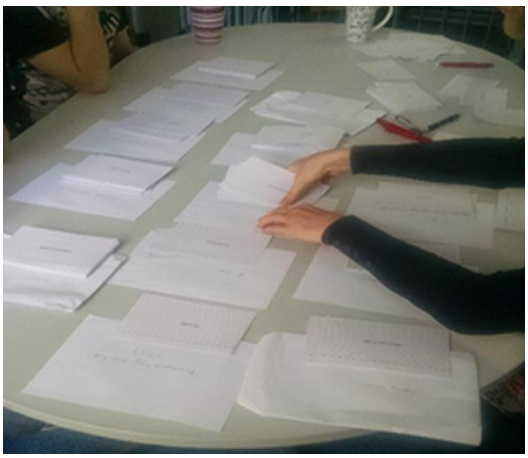


Figure 3.6. At the end of the sort participants went through all of the categories again to finalise the placement of each card.

number of participants who used a particular category, the number of cards per category and the number of unique cards per category. The number of unique cards in a category were divided by the total number of cards present in the category and multiplied by 100 to determine the percentage disagreement. This was then subtracted from 100 to give the percentage level of agreement for each category. Venn diagrams were created to provide a visual representation of the data.

The second stage in the analysis was to create co-occurrence matrices to examine which cards were placed together most often, regardless of the category in which they were placed by different groups. Each matrix provided information about the relationship between each possible pairs of cards (n=455,625) and the strength of the categories (Righi et al., 2013). A separate matrix was created each for the open group sorts, the individual open sorts and the comparison of the closed sort with the open sort by academics with an interest in ageing. These matrices were generated in Excel and manipulated using the 'R' programming language by Kile Green (PhD student in Academic Haematology, Newcastle University) with experience of running similar analyses on gene array data. The number of times each card pair appeared within a sort was then tabulated. Dendrograms based on the paired counts were generated in R using the 'hclust' package based on Euclidean distance and 'Ward' method agglomeration. The 'heatmap.2' function was then employed from the 'plots' package to populate a heat map based on the previously generated dendrograms. The heat maps were coloured based on the number of times each card was paired with another. By reflecting the dendrograms across the X and Y axis, card pairs were grouped by their similarity in relation to other pairs to form 'blocks' of similarly grouped card pairs.

3.4 Results

3.4.1 Open group sorts

3.4.1.1 Categories

Details of the categories created by each group and the cards that they contained are reported in Appendix G (Group 1), Appendix H (Group 2), and Appendix I (Group 3), respectively. The category names produced by the three groups of participants are shown in Table 3.1. Groups 1 and 3 each created 10 categories while Group 2 created eight categories.

Table 3.1. Category names given to individual piles of cards and number of cards in each category created by the academics working on ageing (Group 1), older people (Group 2) and academics without a background in ageing (Group 3) during the open CSTs.

Group 1 – Academics with an interest in ageing	N of cards	Group 2 – Older people	N of cards	Group 3 – Academics without a background in ageing	N of cards
Categories common to all groups					
Brain function	27	Brain	28	Brain function	36
Health problems	28	Health problems	32	Disease	24
Independence	17	Independence	23	Independence	28
Measuring ageing	30	Assessment	35	Measurement	34
Personality	14	Personality	41	Personality	4
Social support	14	Social	10	Social	21
Physical function	47	Physical function	40	Physical	28
Categories common to two groups					
Mood	27	-	-	Mood	17
Wellbeing	12	Wellbeing	16	-	-
Unique categories					
Fulfilling potential	9	-	-	-	-
-	-	-	-	Impairments	8
-	-	-	-	Self-perception	25

The majority of categories created by participant groups were very similar, although these were not always given identical names. All three groups created categories for ‘brain function’ (called ‘brain by Group 2), ‘health problems’ (called ‘disease’ by Group 3), ‘independence’, ‘measuring ageing’ (called ‘assessment’ by Group 2 and ‘measurement’ by Group 3), ‘personality’, ‘social’ (called ‘social support’ by Group 1) and ‘physical function’ (called ‘physical’ by Group 3). There were also two categories which were common to two groups but not present in the third, ‘mood’ in Groups 1 and 3 and ‘wellbeing’ in

Groups 1 and 2. Group 1 created one unique category called 'fulfilling potential' while Group 3 created two unique categories, 'impairments' and 'self-perception'. Group 2, however, did not create any unique categories. The overlap of categories is shown in Figure 3.7.

Table 3.1 also shows the number of cards (from a total of 225 cards) that were placed in each category. The average number of cards per category was 24.1 with a range of 43. Group 1 placed an average of 22.5 cards in each category with a range of 38, Group 2 placed 28.1 cards in each category on average with a range of 31 and Group 3 placed an average of 22.5 cards in each category, but produced a range of 32. 'Physical function' was the largest category created by Group 1 (47 cards) and Group 2 (40 cards), however the largest category created by Group 3 was 'brain function' which contained 36 cards. For categories common to all three groups, 'personality' had the fewest number of cards in Group 1 and 3 (14 and 4 respectively), whereas 'social' was the smallest category created by Group 2.

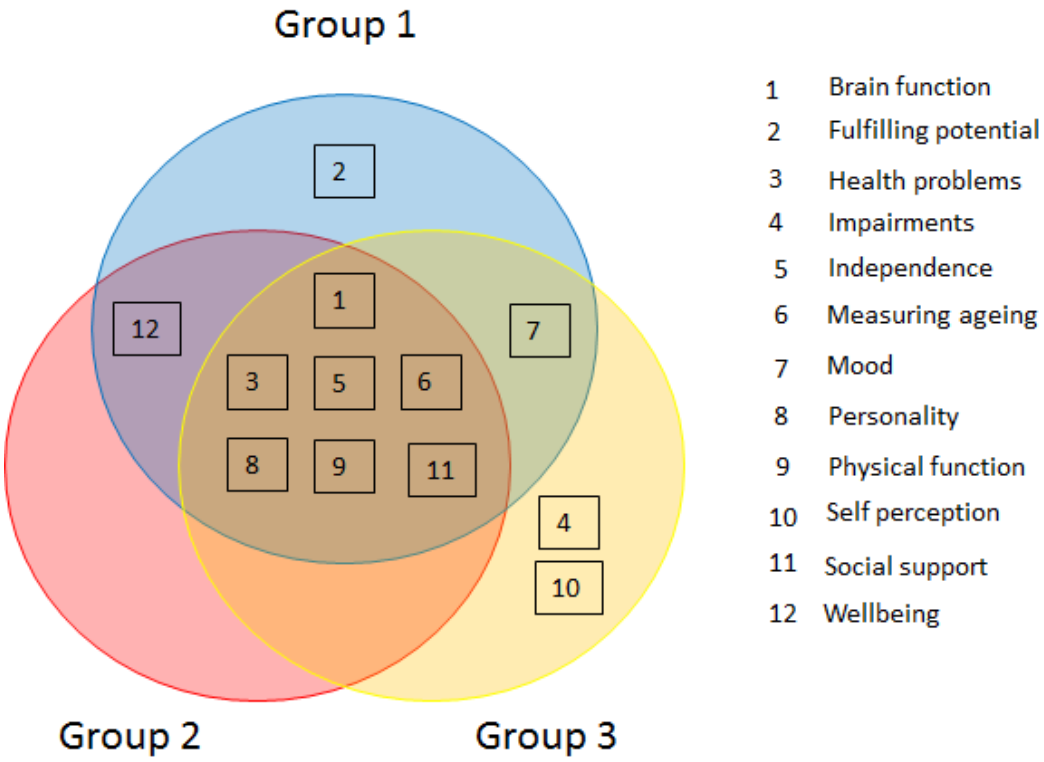


Figure 3.7. Venn diagram showing which of categories 1-12 were created by each of the participant groups. Seven categories were common to all three groups, one category was shared by Groups 1 (academics with an interest in ageing) and 3 (academics without a background in ageing), and one category was shared by Groups 1 and 2. Group 1 created one unique category and Group 3 created two unique categories. Group 2 (older people) did not create any unique categories

3.4.1.2 Level of agreement

The percentage level of agreement of card placement between all groups and between each pair of groups was calculated for each category (Table 3.2). Fulfilling potential, impairments and self-perception were not included in the table as they were present in only one group.

Table 3.2. Percentage levels of agreement of card placement between participant groups for each category created by more than one group. Categories are presented in order of highest to lowest levels of agreement.

	Group 1 & 2 (Academics with an interest in ageing & older people)		Groups 1 & 3 (Academics with an interest in ageing & academics without a background in ageing)		Groups 2 & 3 (Older people & academics without a background in ageing)	
Categories	Level of agreement (%)	N of cards in sample	Level of agreement (%)	N of cards in sample	Level of agreement (%)	N of cards in sample
Categories common to all groups						
Brain function	45.5	55	41.3	63	54.5	40.6
Health problems	41.7	60	35	42.3	58.3	39.3
Independence	35.0	40	22.2	45	17.6	51
Measuring ageing	43.1	65	46.9	64	44.9	69
Social support	37.5	24	25.8	31	28.6	35
Personality	21.8	55	0	18	6.7	45
Physical function	42.5	87	32	75	25	68
Categories common to two groups						
Mood	-		29.5		-	
Wellbeing	28.6		-		-	

For categories which were common to all three groups, 'measuring ageing' and 'brain function' showed the highest levels of agreement between groups (60.6% and 58.2% respectively) while 'independence' and 'personality' showed the least (38.2% and 27.3%). When pairs of participant groups were considered, 'measuring ageing' (65%) and 'health problems' (60%) had the highest levels of agreement between academics from ageing related disciplines and older people (Groups 1 and2), while 'wellbeing' (28.6%) and 'social support' (24%) had the lowest levels of agreement. Levels of agreement between

the two academic groups (Groups 1 and 3) were lower for every category than overall group agreement and agreement between any other pair of groups. 'Measuring ageing' and 'health problems' had the highest levels of agreement (37% and 35% respectively, while 'personality' and 'social support' had the lowest levels of agreement, with 23% and 15% respectively. Older people (Group 2) and academics without a background in ageing (Group 3) had the highest levels of agreement for 'personality' (79%) and 'independence' (65%) and whilst 'measuring ageing' and 'brain' function has the lowest levels of agreement (56.9% and 54.5% respectively) these were also relatively high.

Figure 3.8 shows the percentage levels of agreement on card placement in categories for each pair of groups for the seven categories which were common to all three groups. Overall there were similarities in the levels of agreement for most categories as well as similarities in the levels of agreement between pairs of groups. 'Measuring ageing', 'health problems' and 'brain function' had similar levels of agreement between the three pairs of groups. Levels of agreement for the category 'independence' were higher between Groups 1 and 2 than between the other two group pairs. There was a lower level of agreement for the category 'personality' between the two academic groups. Levels of agreement for the category 'social support' were similarly low for Groups 1 and 3 and Groups 2 and 3.

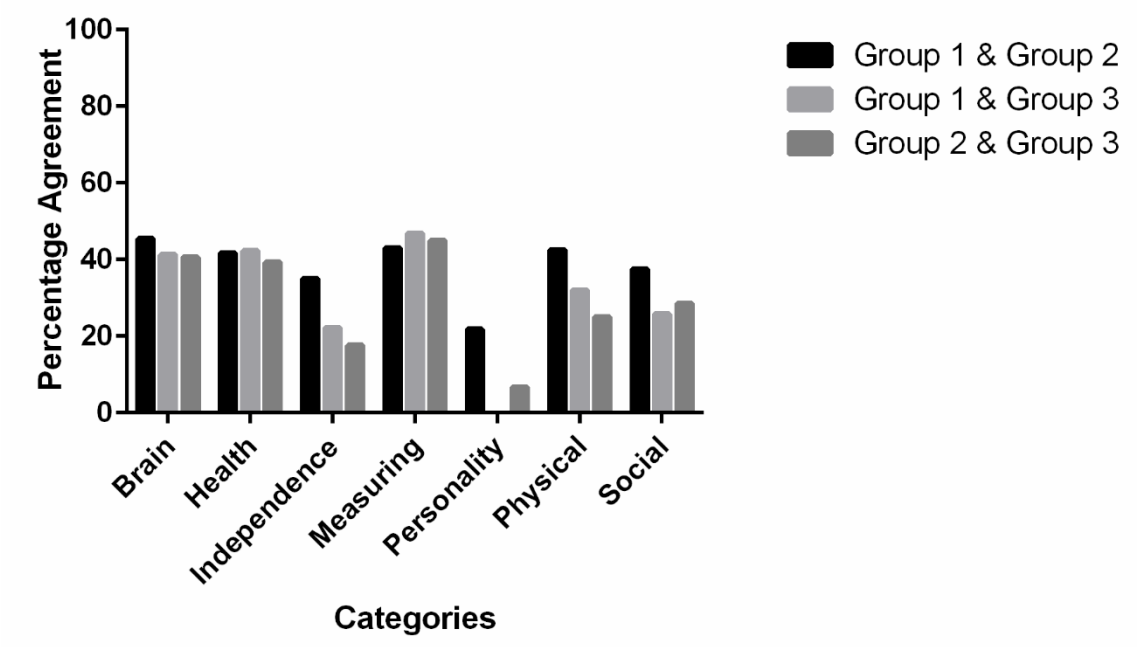


Figure 3.8. Percentage levels of agreement on card placement in categories for each pair of groups among academics with an interest in ageing (Group 1), older people (Group 2) and academics without a background in ageing research (Group 3).

3.4.1.3 Co-occurrence of cards

Across the three groups there were 151,875 possible pairs of cards, 50,625 possible pairs for each group. NB Each card corresponded to one of the 225 elements of HA derived from the systematic

review reported in the previous chapter. The number of pairs of cards which were placed in a category together in all three groups was 1,287, with 1,452 pairs of cards co-occurring in two groups and 2,816 pairs co-occurring in only one group (Figure 3.9).

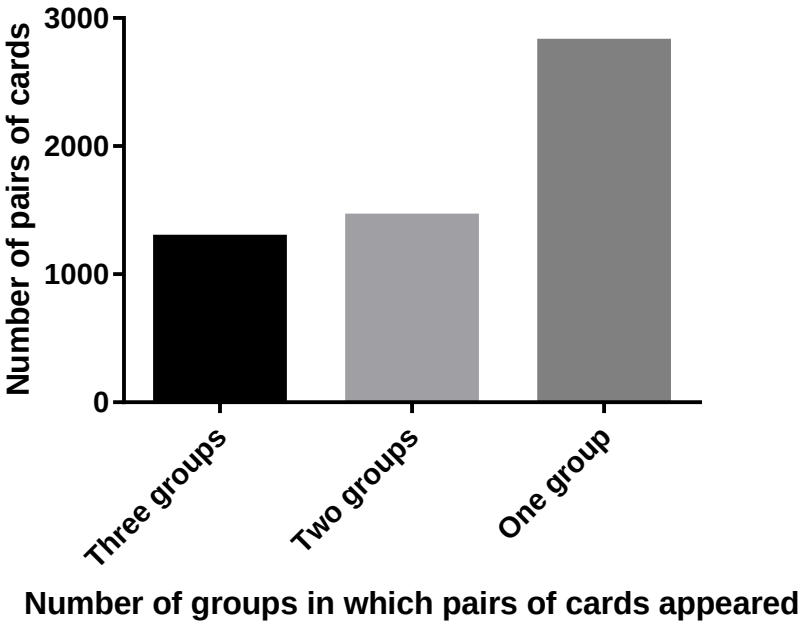


Figure 3.9. Co-occurrence of cards in the open group sort.

A heat map (Figure 3.10) was produced to show clusters of cards which were placed together by each group, irrespective of which category individual cards were placed in. A full description of the cards found in each cluster can be found in Appendix O. Card content and card numbers of each card found in each cluster on the heat map showing the co-occurrence of cards in the open group sorts. In total, 27 clusters of cards were identified (Table 3.3). Clusters 4, 7, 9, 19 and 27 were characterised by a single category, meaning that there was complete agreement between the three groups on the category in which cards within these clusters were placed. Conversely, for clusters 10-14 and 22

there was no agreement between the groups as to which categories cards in these clusters were placed.

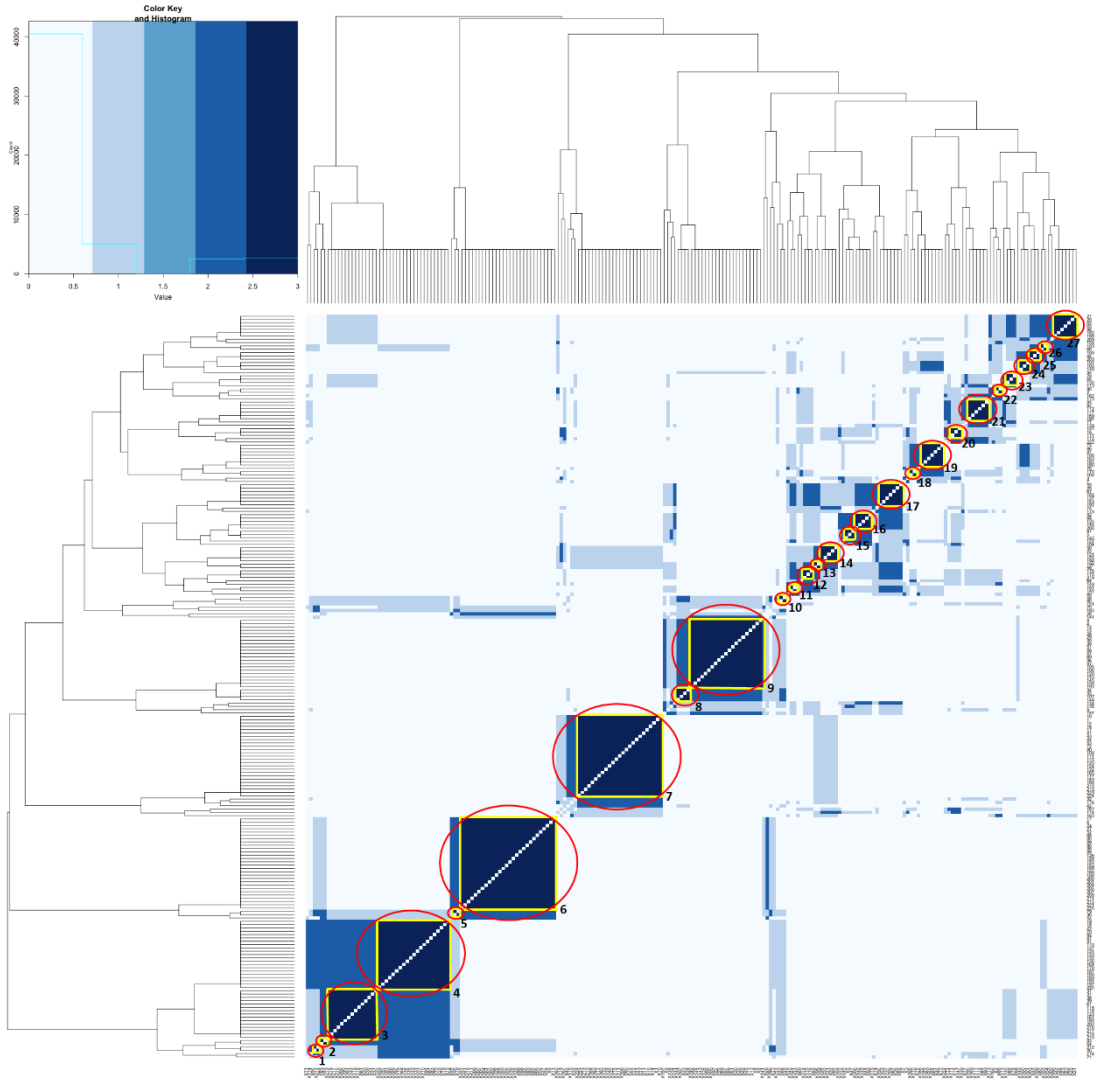


Figure 3.10. Heat map produced from co-occurrence matrix showing clusters of cards which were placed together by academics with an interest in ageing (Group 1), older people (Group 2) and academics without a background in ageing (Group 3). White space represents cards which were not paired and shades of blue represent cards which were paired, with the lightest shade representing cards paired by one group through to the darkest shade representing cards paired by all three groups.

Table 3.3. The categories cards in each cluster were placed in by academics with an interest in ageing (Group 1), older people (Group 2) and academics with no background in ageing (Group 3).

Cluster	Categories in which cards were placed by the three groups of participants
1	1 x measuring ageing, 2 x physical function
2	2 x physical function, 1 x measuring ageing
3	1 x independence, 2 x physical function
4	3 x physical function
5	2 x measuring ageing, 1 x physical function
6	3 x measuring ageing
7	3 x brain function
8	2 x health problems, 1 x physical function
9	3 x health problems
10	1x health problem, 1 x social support, 1 x physical function
11	1 x mood, 1 x psychological, 1 x social
12	1 x mood, 1 x wellbeing, 1 x self-perception
13	1 x mood, 1 x wellbeing, 1 x brain function
14	1 x brain function, 1 x personality, 1 x wellbeing
15	2 x personality, 1 x mood
16	2 x mood, 1 x personality
17	2 x mood, 1 x wellbeing
18	2 x social support, 1 x self-perception
19	3 x social support
20	2 x personality, 1 x self-perception
21	2 x wellbeing, 1 x self-perception
22	1 x fulfilling potential, 1 x independence, 1 x self-perception
23	2 x independence, 1 x wellbeing
24	1 x independence, 2 x social support
25	2 x independence, 1 x social support
26	2 x independence, 1 x physical function
27	3 x independence

The numbers in the second column of the table refer to the how many groups placed cards in each category

3.4.2 Individual open sorts

Participants from Group 2 (older people) each completed an individual open sort of the 225 cards eight months after completing the group sort.

3.4.2.1 Categories into which cards were sorted

Details of the categories derived and the cards placed in each category by each participant are given in Appendix G (Participant 1), Appendix H (Participant 2), Appendix I (Participant 3) and Appendix J (Participant 4). Table 3.4 summarises the category names created by the four participants and the number of cards placed in each category by each participant.

Table 3.4. Category names given to individual piles of cards and number of cards in each category created by the four individual participants who formed Group 2 – older people.

Participant 1	N of cards	Participant 2	N of cards	Participant 3	N of cards	Participant 4	N of cards
Categories common to all participants							
Health problems	36	Health problems	28	Health problems	32	Health problems	23
Movement	42	Movement	58	Movement	19	Movement	54
Categories common to three participants							
Blood	22	Blood	18	-	-	Blood	17
Memory	15	Memory	29	Memory	16	-	-
Traits	51	-	-	Traits	48	Traits	33
Categories common to two participants							
Mental health	21	-	-	-	-	Mental health	15
-	-	Quality of life	48	Quality of life	48	-	-
Services	17	Services	19	-	-	-	-
-	-	-	-	Tests	26	Tests	9
Unique categories							
-	-	-	-	Accomplishments	15	-	-
-	-	-	-	-	-	Brain function	38
-	-	-	-	-	-	Cardiovascular	10
Finances	5	-	-	-	-	-	-
Independence	16	-	-	-	-	-	-
-	-	-	-	Mood	21	-	-
-	-	-	-	-	-	Outside influences	12
-	-	Stress	25	-	-	-	-
-	-	-	-	-	-	Social interaction	14

All four participants created the categories ‘health problems’ and ‘movement’. There were three categories common to three participants, namely ‘blood’ (participants 1, 2 and 4), ‘memory’ (participants 1, 2 and 3) and ‘traits’ (participants 1, 3 and 4). In addition, there were four categories common to two participants, ‘mental health’ (participants 1 and 4), ‘quality of life’ (participants 2 and 3), ‘services’ (participants 1 and 2) and ‘tests’ (participants 3 and 4). Participant 1 created two unique categories, ‘finances’ and ‘independence’. Participant 2 created one unique category called ‘stress’. Participant 3 also created two unique categories ‘accomplishments’ and ‘mood’ and participant 4 created four unique categories called ‘brain function’, ‘cardiovascular’, ‘outside influences’ and social interaction’. The overlap of categories is shown in Figure 3.11.

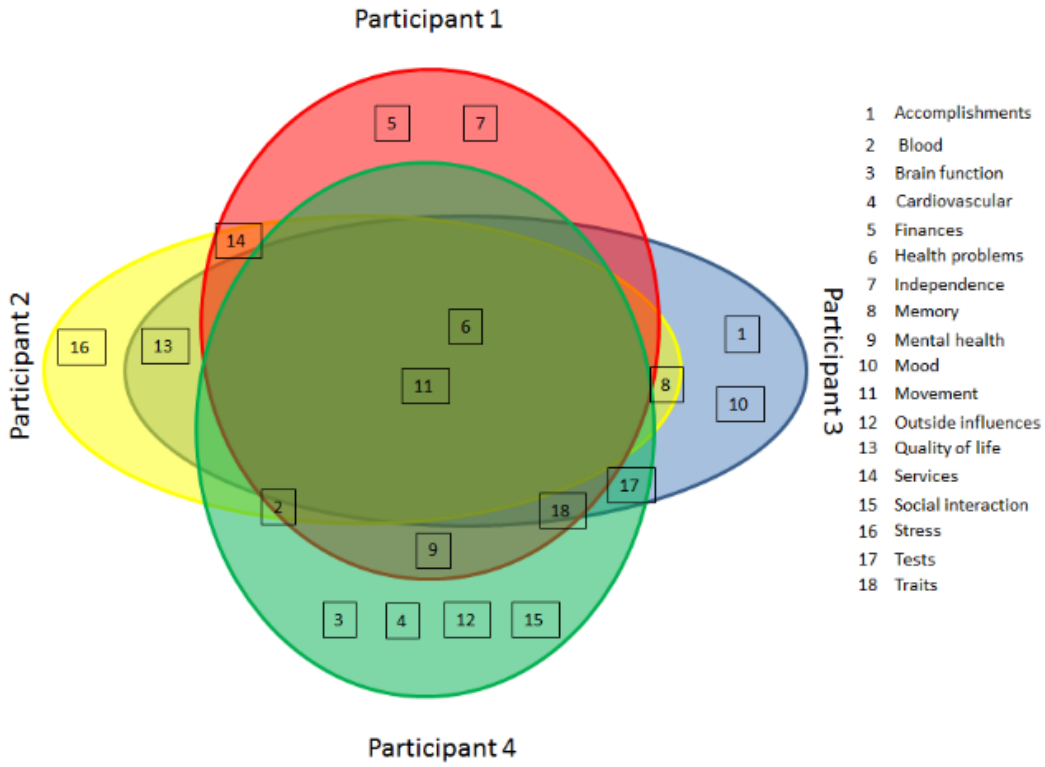


Figure 3.11. Venn diagram showing similarities and differences in categories that were created by each of the four participants. Two categories were common to all four participants, three categories were common to three participants, four categories were common to two participants and nine unique categories were created.

Table 3.4 also shows the number of cards (out of a total of 225) that were placed in each category by each participant. Categories contained an average of 26.5 cards with a range of 5 to 51. Participant 1 placed an average of 25 cards in each category with a range of 46, participant 2 placed an average of 32.1 cards in each category with a range of 40, participant 3 placed an average of 28.1 cards in each category with a range of 34 and participant 4 placed an average of 22.5 cards in each category with a range of 45. 'Traits' was the largest category created by both participants 1 and 3, with 51 and 49 cards respectively, while 'movement' was the largest category for participants 2 and 4, with 58 and 54 cards respectively. For categories common to all four participants, 'movement' contained a larger number of cards than any other category for all participants apart from participant 3.

3.4.2.2 Level of agreement

The percentage level of agreement of card placement between participants was calculated for each category (Table 3.5). Unlike for the open group sort (section 3.4.1.2), the levels of agreement between pairs of participants were not calculated. Accomplishments, brain function, cardiovascular function, finances, independence, mood, outside influences, stress and social interaction were not included in Table 3.5 as they were created by only one participant.

Table 3.5. Percentage levels of agreement of card placement between participants for each category created by more than one participant. Categories are presented in order of highest to lowest levels of agreement.

Categories	Level of agreement (%)	N of cards in sample
Categories common to all four participants		
Health problems	59.6	119
Movement	59.5	173
Categories common to three participants		
Blood	54.4	57
Memory	45	60
Traits	42.7	131
Categories common to two participants		
Mental health	25	36
Tests	22.9	35
Quality of life	18.7	96
Services	13.9	36

Both categories which were common to all participants showed similar levels of agreement. The three categories which were common to three participants had slightly lower levels of agreement with 'blood' at 54.4%, 'memory' at 45% and traits at 42.7%. In general, the four categories which were common to only two participants had fewer cards in the sample with the exception of 'quality of life' with a sample size of 96 cards. 'Mental health' had the highest levels of agreement (25%) of categories which were common to two participants, followed by 'tests' (22.9%), 'quality of life' (18.7%) and 'services' (13.9%). (participants 2 and 3) 'personality' (79%) and 'independence' (65%) were the most closely agreed upon, and 'measuring ageing' and 'brain' function showed the least agreement (56.9% and 54.5% respectively).

3.4.2.3 Co-occurrence of cards

The number of pairs of cards which were placed in a category together in all three groups was 1,287, with 1,452 pairs of cards co-occurring in two groups and 2,816 pairs co-occurring in only one group (Figure 3.12).

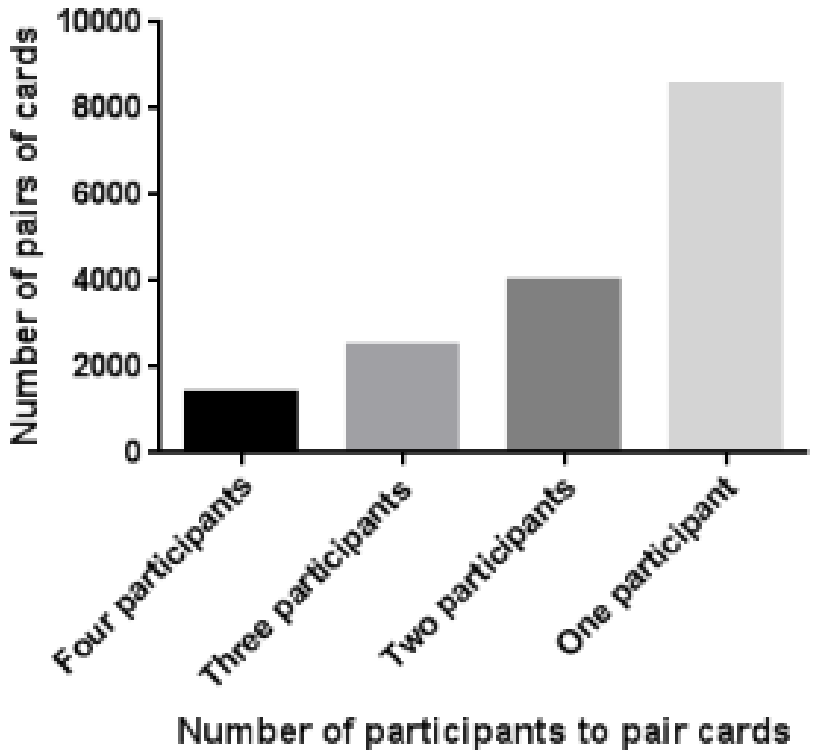


Figure 3.12. Co-occurrence of cards in the individual open sorts.

A heat map (Figure 3.13) was produced to show cards which clustered together regardless of the category into which they were placed. The content and number of the cards found in each cluster can be seen in Appendix M. In total, 33 clusters were identified. Clusters 5 and 9 ('movement' and 'health problems' respectively) (Table 3.6) were the only clusters to show complete agreement with respect to the categories into which cards in these clusters were placed . Nine clusters (clusters 10, 16, 22, 23, 25, 28, 31, 32, 33) showed no agreement between participants on categories into which cards were placed.

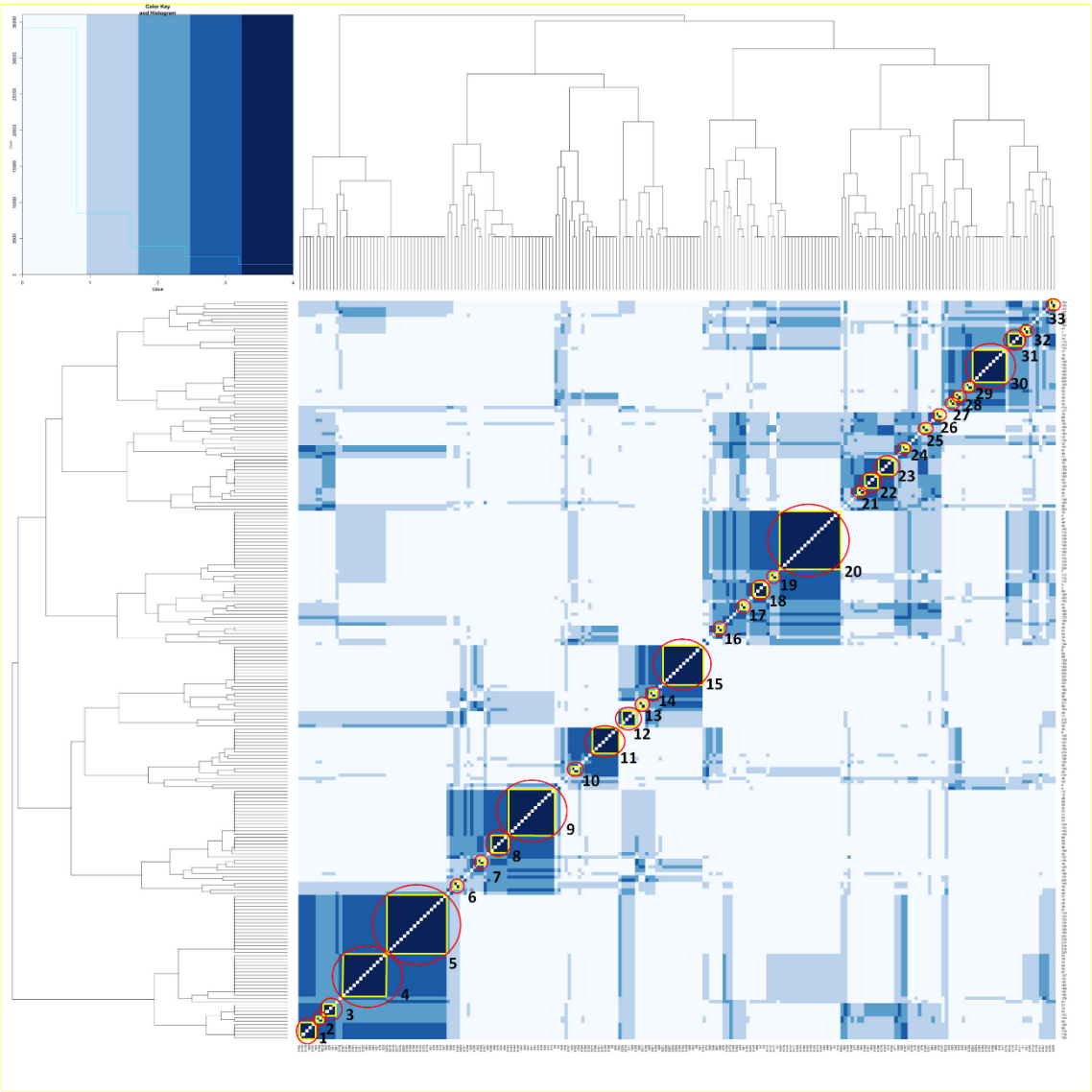


Figure 3.13. Heat map produced from co-occurrence matrix showing clusters of cards which were placed together by each of the four participants in the individual open sorts regardless of the category in which they were placed. White space represents cards which were not paired and shades of blue represent cards which were paired, with the lightest shade representing cards paired by one participant through to the darkest shade representing cards paired by all four participants.

Table 3.6. The categories cards in each cluster were placed in by the four participants in the individual open sorting task.

Cluster	Categories cards were placed in by the four participants
1	3 x movement, 1 x quality of life
2	2 x movement, 1 x services, 1 x quality of life
3	2 x movement, 1 x independence, 1 x quality of life
4	3 x movement, 1 x traits
5	4 x movement
6	2 x health problems, 1 x movement, 1 x stress
7	2 x health problems, 1 x blood, 1 x cardiovascular
8	3 x health problems, 1 x cardiovascular
9	4 x health problems
10	1 x traits, 1 x mental health, 1 x stress, 1 x mood
11	2 x mental health, 1 x stress, 1 x mood
12	1 x health problems, 1 x movement, 2 x tests
13	1 x health problems, 3 x blood
14	1 x health problems, 2 x blood, 1 x tests
15	3 x memory, 1 x tests
16	1 x traits, 1 x mental health, 1 x quality of life, 1 x mood
17	1 x trait, 2 x quality of life, 1 x social interaction
18	2 x traits, 1 x quality of life, 1 x accomplishments
19	3 x traits, 1 x services
20	3 x traits, 1 x quality of life
21	2 x services, 1 x quality of life, 1 x outside influence
22	1 x services, 1 x independence, 1 x quality of life, 1 x outside influence
23	1 x services, 1 x independence, 1 x quality of life, 1 x social interaction
24	2 x movement, 2 x quality of life
25	1 x traits, 1 x services, 1 x quality of life, 1 x social interaction
26	1 x finances, 2 x quality of life, 1 x outside influence
27	2 x memory, 1 x mental health, 1 x brain function
28	1 x memory, 1 x mood, 1 x mental health, 1 x brain function
29	2 x memory, 1 x accomplishments, 1 x brain function
30	3 x memory, 1 x brain function
31	1 x memory, 1 x traits, 1 x accomplishments, 1 x brain function
32	1 x brain function, 1 x memory, 1 x traits, 1 x accomplishments
33	1 x movement, 1 x traits, 1 x accomplishments, 1 x brain function

The numbers in the second column of the table refer to the how many groups placed cards in each category

3.4.3 Closed group sort

In the closed group sort, Group 2 (older people) sorted the cards into the categories created originally by Group 1 (academics with an interest in ageing). This sort took place ten months after Group 2 completed the open group sort. The placement of cards in categories can be found in Appendix G for Group 1 and Appendix H for Group 2.

3.4.3.1 Level of agreement

Table 3.7 Percentage levels of agreement of card placement between groups.

Categories	N of cards		N of unique cards	Level of agreement (%)
	Group 1 (Academics with an interest in ageing)	Group 2 (Older People)		
Brain function	27	35	35	43.5
Fulfilling potential	9	7	10	37.5
Health problems	28	24	28	46.2
Independence	17	34	35	31.4
Measuring ageing	30	38	38	44.1
Mood	27	22	33	32.7
Personality	14	15	23	20.7
Physical function	47	27	51	31.1
Social support	14	6	16	20.0
Wellbeing	12	17	21	27.6

Overall, the numbers of cards placed in each category by Groups 1 and 2 were similar (Table 3.7) with the largest difference (n=20) for 'physical function' followed by 'independence' (n=17). The highest levels of agreement on which cards were placed in each category was in the category 'health problems' with 46.2% of the cards selected being the same in each group, followed by 'measuring ageing' with 44.1%. The lowest levels of agreement were observed in the category 'personality' (20.7%), despite having the most similar sample sizes, and 'social support (20.0%).

3.4.3.2 Co-occurrence of cards

There were 101,250 possible pairs of cards across the two groups involved in the closed group sort with 3,604 pairs of cards placed together by both groups (Figure 3.14).

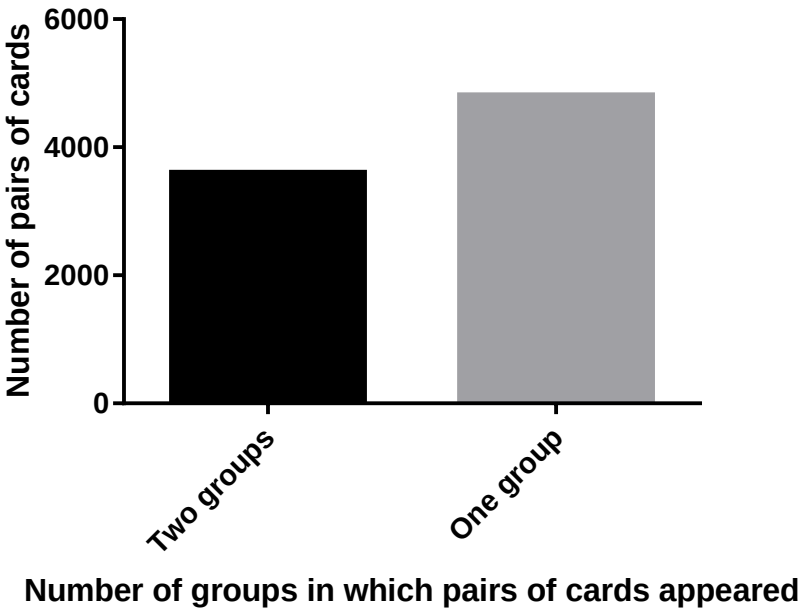


Figure 3.14. Co-occurrence of cards in the closed group sort.

Figure 3.15 shows the heat map of cluster of cards placed together in the closed group sort. Details of the cards in each cluster are in Appendix N. Twenty clusters were identified (Table 3.8) with 10 clusters showing agreement on the categories in which cards from each cluster were placed and 10 clusters showing differences. Cluster focuses on 'measuring ageing' moving on to 'physical function' (cluster 2 to 4), 'brain function' (clusters 5 and 6), 'health problems' (clusters 7 to 9), 'mood' (clusters 10 to 14) and 'wellbeing' (clusters 19 and 20).

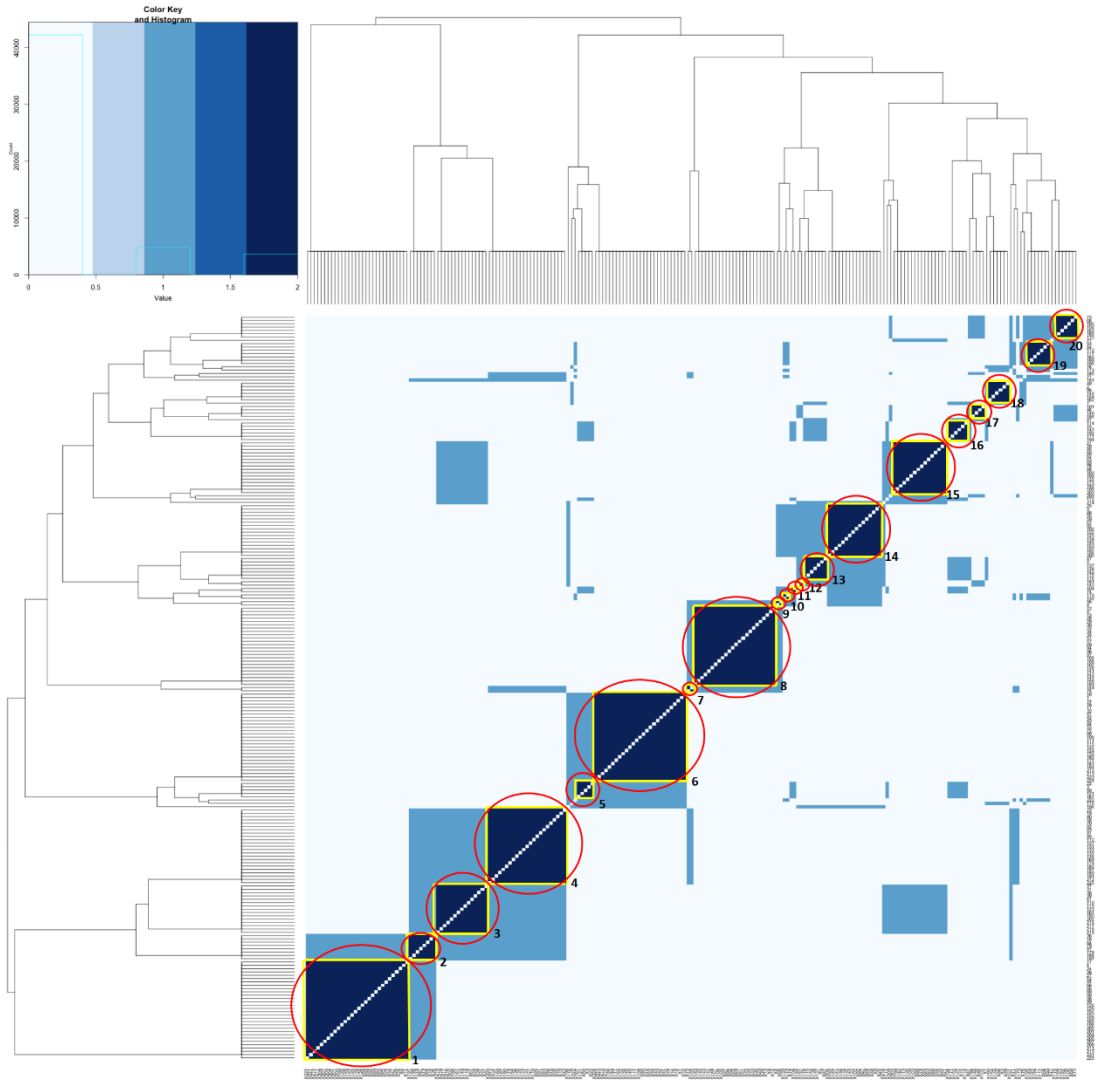


Figure 3.15. Heat map produced from co-occurrence matrix showing clusters of cards which were placed together by each of the two groups in the closed group sort regardless of the category in which they were placed. White space represents cards which were not paired and shades of blue represent cards which were paired, with the lightest shade representing cards paired by one group and the darkest shade representing cards paired by both groups.

Table 3.8. The categories cards in each cluster were placed in by academics with an interest in ageing and older people in the closed group sort.

Cluster	Categories cards were placed in by the two groups of participants
1	2 x measuring ageing
2	1 x measuring ageing, 1 x physical function
3	1 x independence, 1 x physical function
4	2 x physical function
5	I x brain function, 1 x personality
6	2 x brain function
7	1 x health problems, 1 x physical function
8	2 x health problems
9	1 x health problems, 1 x mood
10	1 x mood, 1 x wellbeing
11	1 x mood, 1 x personality
12	1 x mood, 1 x social support
13	1 x mood, 1 x personality
14	2 x mood
15	2 x independence
16	2 x personality
17	2 x social support
18	2 x fulfilling potential
19	2 x wellbeing
20	1 x social support, 1 x wellbeing

The numbers in the second column of the table refer to the how many groups placed cards in each category.

3.5 Discussion

3.5.1 Principal findings

The main aims of this work were to create categories of features of HA identified through the literature review reported in Chapter 2 and to compare how people with varying levels of expertise create these categories. Overall, these aims were achieved and the main finding was of greater agreement between the groups than was predicted by the literature (e.g. Phelan et al., 2004, Hung et al., 2010, Bussolon, 2009) and contrary to the hypothesis.

In the open group sorts and the open individual sorts, similar numbers of categories were created. Although no unique categories were created by Group 2 (older people) in the open group sorts, in the individual sorting task three of the four participants from Group 2 created seven unique categories. The categories ‘health problems’, ‘brain function’ and ‘measuring ageing’ were always among the categories with the highest levels of agreement, regardless of whether the sorting task was group or individual, or open or closed while ‘personality‘ had some of the lowest levels of agreement.

When Group 2 (older people) were asked to sort cards into categories predetermined by Group 1 (academics with an interest in ageing), the level of agreement on which cards were placed in each category was similar to that found by the open group sort. For categories created by all three groups in the open group sorts, Group 2 agreed more with Group 3 (academics without a background in ageing) on three of the seven categories ('health problems', 'measuring ageing' and 'brain function'). It is possible that on these more salient and well defined aspects of HA, the training and level of expertise of academics with an interest in ageing have caused differences in the way in which they categorise information related to HA compared with older people. However, this was not the case for the other four categories. Therefore the overall results of this work neither confirm nor support the idea that older people and researchers with an interest in ageing perceive HA very differently.

3.5.2 Strength and limitations

This piece of work has taken novel approach by adopting a technique frequently used in web design and product design (CST) and applying it to ageing research. This worked well and showed that an aspect of industry best practice can be useful in an academic setting. Further this work has shown that that the CST approach can be used to derive categories from a much larger set of stimuli (words on cards, in this instance) than is used typically in industry thus demonstrating its potential for application with larger, more complex datasets. This study also made novel use of heat maps (currently used widely in biological research to summarise and illustrate similarities/ changes in molecular abundance in different conditions) to help summarise and illustrate an unusually large social science data set.

An important strength of the CSTs used here is that the stimuli (words on cards representing elements of HA) used were based solely on the outcomes of the systematic review (Chapter 2) with no additional material added. This has the advantage of objectivity by not allowing subjectively chosen terms to be introduced by the researcher. However, as a consequence, there are several examples of included stimuli for which their counterparts are noticeably missing. Examples include "hypertension" but not "hypotension", "indoor mobility" but not "outdoor mobility", and "inductive reasoning" but not "deductive reasoning".

A possible limitation of the study design is that 49 cards describing health behaviours were removed during the first CST by Group 1 (academics with an interest in ageing) and were not included in subsequent CSTs. At this stage of the project, the CST was seen as a small stepping stone between the systematic review (Chapter 2) and the survey work (Chapter 4). As a consequence, the majority of the survey work had been completed before the CSTs were undertaken with Group 2 (older people) and Group 3 (Academics without background in ageing). The decision not to include these 49 cards in subsequent sorts with Group 2 and 3 was made on the grounds that these cards were deemed by Group 1 (experienced in ageing research) to be too vague, described mechanisms to improve health

rather than health itself, or were mediating factors. Since these 49 cards were removed during the first CST and were not included in the subsequent survey work, they were not re-introduced (because that would have created inconsistency) in the CSTs carried out by Groups 2 and 3 which took place sometime later. However, it could be argued that some of the cards which were excluded because they represented health behaviours should have remained because they are potentially measureable phenotypic traits related to HA. The content of some categories was unexpected. Using Group 1 as an example, the category 'heath problems' contains the card 'health service use'. While it is obvious that 'health service use' is not a disease, it is easy to see the logic of its placement in that category, as the category to which it is most closely related. This may be a limitation of a) using the CST methodology on a much larger data set than it was designed to be used with and b) allowing participants to create their own categories. Perhaps if participants had been presented with a large number of categories into which to sort the cards, some of the anomalous card placements may have disappeared.

There were several limitations in regard to methodology. The standardised definitions of terms presented on the cards were not used with Group 1, consequently there is a chance that different meanings were assigned to some cards by Groups 2 and 3 than were used unconsciously by Group 1. On the other hand, Group 1 was composed of researchers working in the ageing field and so would have had expert understanding of most, if not all, of the terms on the cards. Group 1 and Group 3 were both opportunity samples and so age was not controlled. No information about participant age was collected for Group 1 as the original intention was to use the data from the CSTs only for condensing information in the surveys (Chapter 4). It was not viewed as necessary to control for age as evidence from the literature suggests few differences between age groups (Jopp et al., 2015). In retrospect, gender matching these groups would have preferable to eliminate potential confounders and ensure the only differences between groups were levels of expertise. Similarly, other features of the samples of participants may have influenced the findings. The academics in Group 1 were recruited based on their expertise in the field of ageing. However, being an expert in ageing does not provide immunity from the personal experience of ageing and it is not clear the extent to which the categorisations created by participants in this group was due to their expertise or their own personal experience of ageing. Although, as the other two groups gave responses which were more similar to each other than either was to Group 1, the data suggest that expertise was the most influential factor in this case. Group processes may also have influenced the findings of the CSTs. All of the participants in Group 1 were already familiar with each other as colleagues working on the LiveWell project. It is possible that the hierarchy within this group (Principal Investigator, Research Associates, PhD student) may have inadvertently or subconsciously influenced categorisation, with the group opinion following the opinion of the more senior members (e.g. Tuyl et al., 2014). Participants in Group 2 were already known to each other from a more informal situation, a book group. It was clear during the running of

the card sorting tasks that there was one dominant member of this group. Dominant individuals are known to influence the results of other similar tasks such as focus groups (e.g. Kitzinger, 1994) and therefore this individual may have influenced the results of the group's sort. Finally, the participants in Group 3 had not met prior to completing the sorting task. Evidence from the field of organisational psychology shows that having a team of people who are familiar with each other facilitates cohesiveness, productivity and decision making but reduces negotiation within the group (see Harrison et al., 2003). Therefore the unfamiliarity of individuals in Group 3 may have increased the degree to which individuals negotiated category naming and card placement within the open group sort. Further, although standardised definitions of the terms on the cards was provided, it is possible that terms may have had different meaning to different participants. Terms that academics are familiar with may have been perceived differently by the older people. This may be reflected in particular by the cross-over of cards placed under the 'mood' and 'personality' categories by the groups and warrants further investigation.

There were some small differences in the experimental protocols implemented in the CSTs with each of the groups. Group 3 took a 10 minute break during the task because of the environmental conditions in the room used. This was not the case with the other groups and could have affected Group 3's categorisation by giving them time to reflect on the task and think in more detail about their choices. Two members of Group 3 had first languages other than English which was not the case in any other group. It is possible that this may introduced linguistic or cultural influence on how these participants categorised information. Although industry recommendations suggest five participants for each group task, here each group had four participants to maintain consistency. Gender balance was equal for Groups 1 and 3 but Group 2 consisted of one male and three females. Although there is no direct evidence that gender influences CST performance, the patterns and prevalence of various age related diseases differ between males and females (Warner and Brown, 2011). These different experiences of the ageing process may affect how males and females categorise information about HA.

Because the group CSTs sought agreement on categories within a group of participants, it is important to acknowledge the influence of group dynamics. For example, although the Group 1 were recruited because of their interest in ageing, they will bring more than that to the group. For example, personal views, seniority within the group, methodological background, previous experience of interacting with other individuals within the group and general individual differences will all influence the roles people will take on within the group (Curry et al., 2012). Although beyond the scope of the current work, it would have been interesting to have collected observational data on group processes and interactions

and to examine their influence on the outcome of the CSTs. If this work were to be repeated it would be prudent to age match participants and to include only participants whose first language was English.

3.5.3 Conclusions

The level of expertise in the academic group appears to have had a limited effect on the differences in how elements of HA were categorised in the CSTs, therefore the experience of ageing itself may be more influential than any differences between novice and expert categorisation. The differences in the number of categories produced during the group and individual CSTs suggests that there is a large degree of interpersonal variation in how categorisations about HA are made. However as individual CSTs were not repeated with Group 1 or Group 3 participants, further work would be needed to confirm this suggestion. It should be noted, however, that the results of the CST work should not be generalised to the wider population without further validation studies. Although the recommended group size for CSTs used in industry is five people, four people were included in each of the three groups. Three groups was a sufficient number to answer the questions posed at the beginning of this chapter, especially as the work was originally intended to be a piece of preparatory work for the subsequent chapter. However, although qualitative studies typically use smaller numbers of participants, within a quantitative paradigm, the sample size may too low to provide confidence in the generalizability of the findings. Similarly, the participants included in the CSTs were recruited based on pragmatic reasons (e.g. availability of individuals) and cannot be said to be representative of the wider population

3.5.4 Future research

The category names created by Group 1 in the open group sort were used to create the surveys in Chapter 4. Further analysis has also been performed on the CST data. Multidimensional scaling analysis has been used to create a spatial representation of the degrees of similarity between pairs of cards (Giguere, 2006) using the same co-occurrence matrices which were used to produce the heat maps. This additional analysis was undertaken in collaboration with Kile Green, a PhD student in Academic Haematology, Newcastle University, in preparation for publication.

It would be interesting to investigate the occurrence data in more detail, especially to examine why cards paired by two of the three groups in the open groups sorts (or by two or three of the four participants in Group 2) were not paired by all groups. Similarly with the individual data it would be interesting to see if it was always the same individual placing cards in a different category in cases where a cluster was placed in one category by three participants but not the fourth. It would also be important to go back and check retest reliability. Although the differences between group and individual performances were examined, no data were gathered on retest reliability of either group or

individual sorts. Although multiple sorts were conducted with Group 2, each was a different type of task (open group, open individual, closed group) therefore none of their data is directly comparable. If the categories created during this task are extended to other areas of research, and the results presented here from different groups are generalisable, it would be essential to investigate how stable these results are over time.

The hierarchical clusters shown on the heat maps indicate a degree of relatedness between categories and the consistent recurring groupings of certain cards despite category name, suggest that a further important question to answer is that of how categories are related to each other. A better understanding of how these categories are related could be used to improve the design and protocol for the survey work presented in Chapter 4.

Chapter 4. Importance of Components of Healthy Ageing

4.1 Introduction

4.1.1 Previous work on importance of different aspects of healthy ageing

In addition to the work described in Chapter 2 (section 2.1.2) relating to the definitions and components of HA, there is a small body of literature which has examined how people rate the importance of these components. Phelan et al. (2004) undertook a survey entitled 'Your Ideas About Growing Older' which was based on components of HA identified through a previous literature review (Phelan and Larson, 2002). While the first part of the survey consisted of open ended questions about what participants think about HA, the second part of the survey, which will be the focus here, comprised 20 statements about HA. The psychometric properties of the questionnaire are described in Fernandez-Ballesteros et al. (2008) and has been used by several subsequent studies. Phelan et al. (2004) asked 700 Japanese Americans (mean age 78) and 1,962 White Americans (mean age 79) to rate the importance of these 20 items. Thirteen were rated as important by more than 75% of the Japanese Americans. These same 13 items plus one additional attribute were rated as important by more than 75% of the White American group. These items related to physical health, mental health and social roles. Matsubayashi et al. (2006) used the same 20 item survey with 5,207 community dwelling older people aged 65+ (mean age 75) from four towns across Japan. Participants were asked to rate the importance of each item as "important", "neutral" or "not important". Fewer items were rated as important than in the Phelan et al. (2004), with eight of the 20 items considered to be important by more than 75% of participants. The attributes of HA with the highest importance ratings were related to health problems, life satisfaction and social relationships, while the least important were related to engagement in activities. Fernandez-Ballesteros et al. (2010) ran the survey with 1,189 participants (mean age 68) across Europe and Latin America using a four point rating scale. All twenty items were rated as important, with two items relating to self-care and absence of health problems achieving the highest mean importance scores; the two items receiving the lowest mean scores were 'living a long time', and 'working after retirement'. Tan et al. (2011) also reported that 13 items were rated as important by more than 75% of participants and again these items were related to physical function and health problems. Hsu (2007) used a similar 23 item survey with 584 participants in Taiwan. Participants were asked to rate each item on a five point Likert scale from least important to very important. Physical health, family relationships, social and emotional support received the highest importance ratings, while staying in employment and learning new things had the lowest ratings. Participants were also asked to rank the three most important items. Physical health was ranked in first place of importance with independence in second place and living with family in third place.

4.1.2 Differences in definitions of healthy ageing given by academics and older people

Hung et al. (2010) compared components found in definitions of HA produced by academics and lay groups in 34 papers. In total, 12 components were identified. Academic studies focused almost exclusively on physical, mental and social functioning components, while all of the lay view papers agreed that physical function was important but also gave answers across a range of 12 components including independence, wellbeing, longevity, life satisfaction, adaptation, family, personal growth and spirituality. Cosco et al. (2013) reviewed 26 studies that reported lay person definitions of HA. Lay definitions included more psychosocial components, such as social engagement and personal resources than physiological components such as longevity and physical function, distinct from biomedical models of HA (Cosco et al., 2013). However, this study examined definitions using meta-ethnography of secondary qualitative data which was already subject to the original authors' interpretations. In a later review, Cosco et al. (2014) again reported differences in conceptualisations of HA between studies of academics and lay people with components of academic definitions closely following the biomedical model, which differed from the more multidimensional lay views. However, as the studies of lay views included in the 2014 review are the same as those included in the 2013 review, the limitations of the work remain unchanged. A more general discussion of definitions of HA is given in Chapter 1, section 1.4.

4.1.3 Age group differences

There is evidence to suggest that the level of importance placed on different components of HA changes with advancing years. Cho et al. (2012) compared how well octogenarians and centenarians satisfied Rowe and Kahn's (1997) criteria for successful ageing (low probability of disease and disability, high cognitive and physical functioning, active engagement with life). A greater percentage of centenarians fulfilled the disease, disability and engagement with life criteria while a higher percentage of octogenarians had higher cognitive and physical functioning. There is similar evidence from studies investigating subjective reports of HA. Bowling (2006) compared lay definitions of HA by age group in a sample of 840 adults and found that 50 to 65 year olds were more likely than 65+ year olds to include finances in a definition of successful ageing. In contrast, those 65 years or over placed greater importance on social roles and activities. Those aged over 65 years and were more likely to categorise themselves as ageing well than their younger counterparts. More recently, Tate et al. (2013) compared definitions of successful aging given by 2,043 males at five time points between 1996 and 2006. As participants got older their focus moved from leisure time, productivity, happiness, health and social relationship to coping and acceptance. Other studies have reported different trends. Knight and Ricciardelli (2003) reported no differences in importance ratings on various aspects of HA or beliefs about what successful ageing is in a sample of 60 adults aged from 70 to 101 years. However, the sample size in the latter study was very low compared to the other studies reported about which limits

the generalisability of the findings. Further, Adams-Price et al. (1998) found that while young adults talk about ageing in a negative way, older adults talked about ageing in a positive way and reflected more on experience, mentioning aspects of ageing the younger group did not consider. In a list of 20 statements about HA, Fernandez-Ballesteros et al. (2010) found no differences in importance ratings for the majority of statements (n=19) between participants in the 50 to 64 year old age group and the 65+ age groups, with the exception of 'continuing to learn new things' which was rated as significantly more important ($p<0.001$) by the younger age group.

4.1.4 Sex differences

Although there is no direct evidence for differences in importance ratings of components of HA between men and women, other sex differences have been noted. Women tend to outlive men but are reported to have a higher incidence of chronic health problems, poorer functioning, make more use of formal services than men and spend longer living with disability (Gorman and Read, 2006, Russell, 2007, Warner and Brown, 2011, Chandola et al., 2007, Laditka and Laditka, 2002, Chung and Park, 2008, de Moraes and Azavedo Souza, 2005, Onawola and LaVeist, 1998). Despite this, women are less likely than men to rate themselves as having a poor state of health (Arber and Cooper, 1999). When examining the reported definitions of HA, women mentioned psychological support, social resources, physical appearance, spirituality and wellbeing more frequently, while men mentioned physical function more often (de Moraes and Azavedo Souza, 2005, Jopp et al., 2015).

4.1.5 Ethnic group differences

Wide disparities are reported in the health of older adults from minority ethnic backgrounds, especially in terms of chronic disease, functional limitation and mortality outcomes, with black women experiencing the largest increases in disability with age (Warner and Brown, 2011). Similarly there is evidence that opinions on what is important for HA vary cross-culturally. A literature review by Hung et al. (2010) found differences in 'key components' of HA reported in studies from different continents. For example, 'mental function' was mentioned in all European and Canadian studies but in less than half of Asian studies. Similarly, the degree to which adult children have been deemed to be successful was mentioned in interview as important component of HA for people aged 65+ in South Korea (Chung and Park, 2008). Focus group studies have found that while the different groups shared some common concerns about the ageing process, differences included greater concern over the stigma surrounding age-related disease in Asian Americans and more concern about behavioural change in Whites and African Americans (Laditka et al., 2011). Conversely, in a cross-sectional survey between 4,566 Japanese American and white Americans, both groups selected the same 13 items as important for HA with only one subsequent attribute added by the white American group (Phelan et al., 2004). However, since all participants were resident in the same county and the Japanese Americans were second generation, the cultural differences between the two groups may have been diminished. Using the

same survey, Matsubayashi et al. (2006) found that eight items were rated important by 5,207 Japanese participants. The difference in the number of items rates as important by Japanese participants in the two studies may be due to the degree of acculturation of the Japanese American group studied by Phelan et al. (2004) who had either lived in America for many years or were not first generation migrants. This also suggests that a survey based on components of HA identified in Western literature may not be relevant for all populations.

Other studies have used the survey developed by Phelan et al. (2004) to examine ratings of HA given by different ethnic groups. Fernandez-Ballesteros et al. (2010) used a survey to investigate the importance ratings of different aspects of HA by participants in seven Latin American and three European countries. As with the analysis of age groups differences, the main findings was one of consistency across countries in terms of what participants rated as important for HA, with health, social relationships and independence related items receiving higher scores and length of life items receiving lower scores. Similarly, Tan et al. (2011) found that 152 Anglo-Australians and 116 Chinese Australians rated 13 out of 20 items similarly, with differences for two items only. Anglo-Australians rated being able to cope and being able to make choices more highly than did Chinese-Australians, while a sense of peace was more important to the Chinese-Australian group. Jopp et al. (2015) also reported that what is important for HA was similar between participants from different countries (USA and Germany). Using a different 23 item survey, Hsu (2007) found that Taiwanese participants rated family support as important but maintaining employment as least important. The authors suggest the maintaining employment is viewed as something to be avoided by older people in Taiwan because having to earn money signifies that a person does not have the support of their family.

4.2 Rationale, hypothesis, aims and objectives

4.2.1 Rationale

Previous work has examined differences in the components of definitions of HA given by academics and by older people. In contrast, the present study was designed to examine possible differences in the importance rankings of components of HA by different population groups. Although the survey developed by Phelan et al. (2004) has been used by several subsequent studies (e.g. Matsubayashi et al., 2006, Fernandez-Ballesteros et al., 2010, Tan et al., 2011) it was not appropriate for use the present study because i) it was based on a literature review of 11 papers only which had been identified using limited search terms and ii) the original literature review did not include papers using terms other than successful ageing (see Phelan and Larson, 2002). The present study was aimed to develop and to implement a survey based on the outcomes of the systematic review presented in Chapter 2, which offers the advantages of incorporating data from a larger number of papers using a much wider range of terms by including HA, successful ageing and other synonyms (see Chapter 2, Section 2.3).

There is no consensus in the literature regarding possible ethnic group differences in which components of HA are reported when HA is defined by different ethnic groups. Some studies have reported inter-ethnic group differences (Hung et al., 2010, Chung and Park, 2008, Matsubayashi et al., 2006) whilst other studies have reported broad similarities between ethnic groups when looking at the importance of components of HA (Fernandez-Ballesteros et al., 2010, Tan et al., 2011, Jopp et al., 2015). However, the studies reporting similarities for the most part were based on the Phelan et al. (2004) survey and were therefore subject to the same problems as discussed above; therefore it would be prudent to re-examine the effect of ethnic group on importance ratings of HA. It is also necessary to re-examine whether opinions about what is important for HA changes with age as previous studies have provided mixed evidence. Some studies reported that the components of HA which people reported when defining HA change with age (e.g. Bowling, 2006, Tate et al., 2013), whereas others reported no age related changes in importance ratings of HA (Knight and Ricciardelli, 2003, Fernandez-Ballesteros et al., 2010). Further, as there is currently no direct evidence on the influence of sex differences in opinions about HA, the current work will also examine possible differences in importance ratings between men and women.

As studies in this field base their results on data collected at a single time point it would be prudent to see if importance rankings of HA remain consistent over time. One previous study (Tate et al., 2009) reported consistency data for themes in definitions of HA given by older people after four weeks. Tate et al's (2009) rationale for choosing this period of time was that health can be expected to stay relatively stable over four weeks and so would not influence opinions about HA. Tate et al. (2009) found that 80% of their all male sample showed consistency in themes in definitions of HA. The current study also examined the consistency of participants' responses.

4.2.2 Hypothesis

1. Based on the pattern of results in Chapter 3, fewer differences in the importance of components of HA will be demonstrated between groups than the literature predicts.

4.2.3 Aims

1. To determine the relative importance of multiple components of HA.
2. To examine possible differences in rating of statements about HA between academics and older people.
3. To examine possible differences in ranking of components of HA between academics and older people.
4. To compare rankings of components of HA between age groups, sexes and ethnic groups.
5. To examine the stability over time of a standard assessment of HA

4.2.4 Objectives

1. To create a survey based on the outcome of the systematic review reported in Chapter 2.
2. To recruit representative samples of academics and older people to take part in the survey (Survey 1).
3. To assess the relative importance of multiple components of HA by different population groups.
4. To explore possible differences in ratings of components of HA between academics and older people.
5. To create a survey based on the ten components of HA identified during the card sorting tasks (CSTs) by academics with an interest in ageing (Chapter 3).
6. To explore possible differences between academics and older people in rankings of the components.
7. To examine the consistency of these rankings after four weeks.
8. To recruit a larger group of ethnically diverse participants from across the adult age range to participate in an online survey (Survey 2).
9. To explore possible differences between age groups, ethnic groups, and males and females in ranking of the ten components of HA.

4.3 Method

4.3.1 Transition from CSTs to Survey 1

To develop a survey of a manageable size, subgroups of outcomes were created for each component of HA and one question was asked per subgroup. This led to the creation of a total of 73 questions. The creation of subgroupings for each category can be seen in Appendix R. In 'measuring ageing', 30 outcomes from the literature review (Chapter 2) were divided into nine subgroups which included bone health, kidney function, influence of genes on health, general measures of health, blood composition, heart function, blood glucose, blood lipids and adiposity. In 'health problems', 28 outcomes were divided into 12 subgroups including diabetes, dementia, bone disease, chronic pain, fatigue, cancer, obesity, degenerative brain diseases, mood disorders, lung problems, cardiovascular problems and health service use. 'Independence' comprised 76 outcomes divided into five subgroups; finances, self-maintenance, daily activities, transport and formal services. The 31 outcomes in the 'mood' were divided between eight subgroups, namely general mood, coping ability, life events, stress, anxiety, self-esteem, loneliness and personality traits. In 'personality', 14 outcomes were divided amongst seven subgroups of self-confidence, self-efficacy, sense of humour, outlook, control, coping and risk assessment. 'Brain function' comprised 26 outcomes divided into five subgroups of memory, attention, reasoning, cognitive plasticity and cognitive skills. 'Fulfilling potential' consisted of nine outcomes across five subgroups of purpose, accomplishment, contribution, personal growth and family support. 'Wellbeing' was composed of ten outcomes divided amongst six subgroups including

life satisfaction, quality of life, how well someone feels that they are ageing, energy, job satisfaction and general satisfaction with health. 'Social support' consisted of 13 outcomes divided into 5 subgroups including social activity, friendships, social relationships, home and communication and 'physical function' consisted of 47 outcomes divided into 11 subgroups of disability, sensory impairment, lung function, balance, strength, endurance, walking, movement, dexterity, sleep and self-rated health. Survey 1 was developed from the categories created by Group 1 in the CST (see Chapter 3), with ten main sections reflecting the components of HA created during the CST. Questions within each section reflected the cards placed in each of the ten categories during the CST. In Surveys 2 and 3, the ten components of HA listed to be ranked were the ten categories created by the academics with an interest in ageing (Group 1) during the CST. Only component names were ranked as the results of Survey 1 showed that each item was considered important for HA. It would have been impractical to ask participants to place over 70 items in rank order.

4.3.2. Survey development and piloting

After ethical approval was obtained from the Faculty of Medical Sciences Ethics Committee (Appendix S), Survey 1 was piloted on a group of five academics and ten older people (who participated in piloting only and not in any of the subsequent surveys) to assess feasibility and acceptability. Comments indicated that the instructions were clear to both groups and that the length of the survey was acceptable; an average time of ten minutes was taken to complete the survey. Some of the older people mentioned that it would improve the layout if there was only a single question block and rating scale on each page, rather than question blocks continuing straight after the previous block on the same page. One older person reported problems with opening the survey on an iPad. This led to the decision to send out the email based surveys in an older version of Microsoft Word so that participants using older operating systems would be less likely to experience compatibility issues.

Feedback from the academic sample resulted in the rating scale being changed from ten-point to five-point. One member of the academic sample thought that there should be separate surveys for the academics and older people. This was discussed at several meetings and decided against as it would require validation between the two questionnaires, and time constraints would not allow. Two important issues were raised through the comments of one member of the academic sample. One comment was that the rating scale should not include an option for 'not important' because the systematic review, on which the survey is based, had produced a list of items that were important for HA. However, just because the literature says that something is important for HA does not mean the survey respondents, especially the older people, would necessarily agree. The point of the survey was to assess opinions as to what is important for HA and to eliminate the ability to give a negative opinion

would have undermined the aims of the work. Several comments to the effect that certain items should be changed or moved to different sections were received but this was not possible as the survey was based upon the outcomes from the systematic review (Chapter 2) and the results of the card sorting task (Chapter 3) rather than the opinions of the researcher constructing the survey.

4.3.3 Survey 1

The questionnaire used in Survey 1 (Appendix T) consisted of 76 questions. Three questions collected demographic information about the participants and the remaining 73 questions consisted of statements which participants were asked to rate on five point scale from 'not at all important' (1) to 'extremely important' (5).

4.3.3.1 Survey 1 Participants

The academic sample were recruited from i) the list of delegates who attended a MRC-funded workshop on Biomarkers of Healthy Ageing/Healthy Ageing Phenotype held at Newcastle University and ii) academics known to the LiveWell team who had expertise in ageing and who worked in multiple locations worldwide. The latter were recruited by e-mail invitation. The disciplinary base of recruited academics is summarised in Figure 4.1.

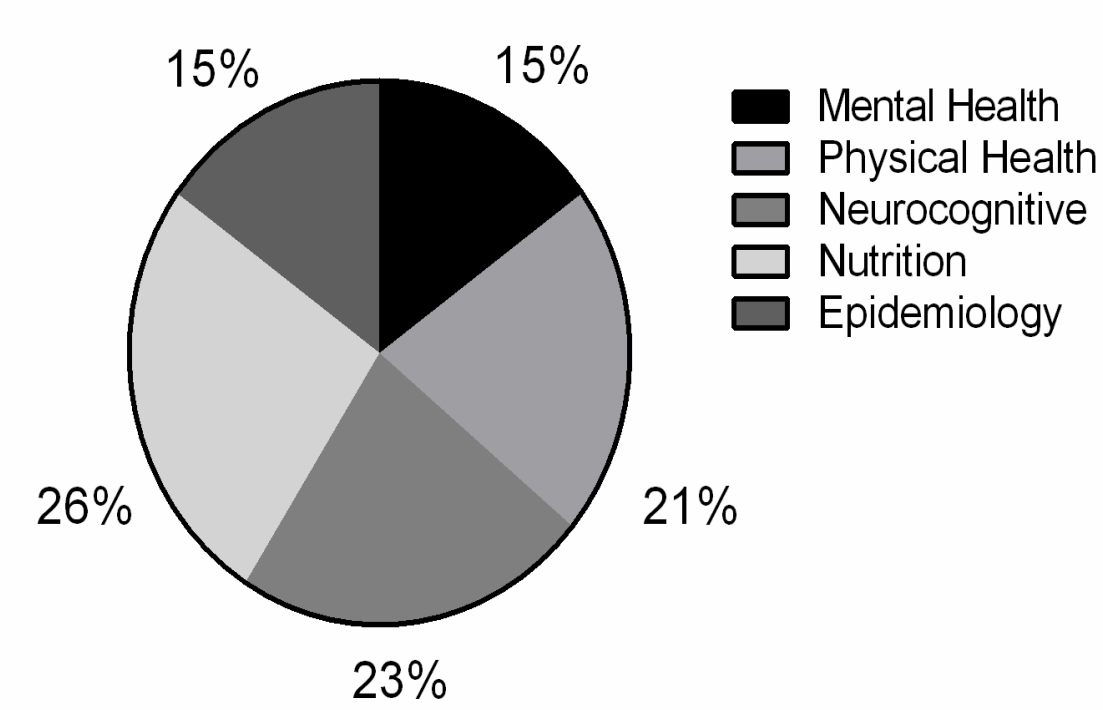


Figure 4.1. Percentage of participants from different academic backgrounds in the academic sample.

Older people, mainly based in the North East of England, were recruited through VoiceNorth (http://www.ncl.ac.uk/ageing/partners/voicenorth/), a volunteer group for people across the North East to take part in research which is organised through the Newcastle University. VoiceNorth contacted volunteers on their database with information about the survey and offered contact details for the researcher (EB) for those who wished to take part. Several older people were also recruited through a focus group at Birmingham University run by a member of the academic sample and some were recruited from the University of the Third Age (U3A) by a VoiceNorth participant who passed on the study details to their U3A branch members. Older people were offered a shopping voucher (£10) as a thank you for taking part in the study. Forty-three academics and 30 older people expressed an interest in taking part in the survey and four academics and four older people dropped out before completing the survey (Table 4.1).

Table 4.1. Characteristics of participants in Survey 1

	Academics		**Older people**	
N	39		26	
Gender	Male 17 (43.6%)	Female 22 (56.4%)	Male 12 (46.2%)	Female 14 (53.8%)
Mean Age	44.4		70.8	

4.3.4 Survey 2

Survey 2 (Appendix U) was a forced ranking exercise in which participants were asked to rank the 10 components of HA in order of importance from the least important (1) to the most important (10). Participants were instructed to give each component its own rank and to not give any two components the same rank. A subset of 15 participants (8 older people and 7 academics), were contacted again four weeks after completing Survey 2 to complete the survey again to see if rankings of HA components were maintained in the short term. Four weeks was chosen as health can be expected to remain relatively stable over this timeframe and therefore was not expected to influence importance rankings (Tate et al., 2009).

4.3.4.1 Survey 2 Participants

Participants in Survey 2 were the same participants as in Survey 1, with the loss of ten academics and seven older people to follow up (Table 4.2), slightly reducing the mean age of each group.

Table 4.2. Characteristics of participants in Survey 2

	Academics		**Older people**	
N	29		19	
Gender	Male 10 (34.5%)	Female 19 (65.5%)	Male 9 (47.4%)	Female 10 (52.6%)
Mean Age	42.8		69.6	

4.3.5 Survey 3

Survey 3 was also a forced ranking exercise of the ten components of HA, but this time completed online using SurveyMonkey. Survey 3 was conducted in two parts, one using a general email invitation containing a web link to the survey hosted on the Survey Monkey site and the other recruiting through Survey Monkey Targeted Audience. SurveyMonkey Targeted Audience allows the selection of participants based on characteristics provided by the researcher. The survey completed by all participants apart from those recruited through Targeted Audience, can be seen in Appendix V. The survey completed by participants recruited through targeted audience can be seen in Appendix W. As no ethnic group data was originally collected, some assumptions had to be made about the ethnicity of the participants not recruited through targeted audience. Data from the Office for National Statistics (Office for National Statistics, 2012) states that over 95% of the North East population is from a White British background, higher than the national 86%. As all participants not recruited through Targeted Audience were recruited from North East, it was assumed that this sample followed the trends reported by the ONS. To bring the data collected here in line with national estimates of UK ethnic mix, Targeted Audience was used to recruit participants from non-white ethnic backgrounds (from beyond the North East) so that the overall sample would be 86% white, 2% mixed/multiple ethnic background, 8% Asian/Asian British and 3% Black/African/Caribbean/Black British and 1% other ethnic group (Office for National Statistics, 2012). In this case, descriptors of ethnic groups were taken from the Office for National Statistics 2012 report on Ethnicity and National Identity in England and Wales 2011 (Office for National Statistics, 2012) in order to ensure that a sample of participants was representative of the ethnic composition of the UK. For participants recruited through Targeted Audience, the screen presented for Question 2 (regarding ethnic background) was dependent on the answer given in Question 1, therefore although four screen shots are shown for Question 2 in Appendix W, participants were presented with only one of these four options. For example, if in Question 1 a participant selected the option for 'Mixed/multiple ethnic background' Question 2 would ask for a specific answer from one of 'White and Black Caribbean', 'White and Asian', 'White and Black African' or 'Other, please specify'. However, if a participants responded to Question 1 as 'Asian/Asian British' would see options in Question 2 for 'Indian', 'Pakistani', Bangladeshi', 'Chinese' and 'Other Asian, please specify'. Participants who responded to Question 1 with option six 'prefer not to say' did not progress any further through the questionnaire as data regarding ethnicity was necessary for the analysis. Similarly, participants who answered 'White' to Question 1 were thanked for their interest in the study but were not able to progress any further. Participants were not able to advance through the survey until each screen was completed. For all participants, when asked to rank the components of HA, the survey would not allow participants to select the same rank for more than one component and would not allow advancement to the next screen until all ten ranks had been assigned. The order

in which the ten components was presented was randomised for each participant. Access to the survey was restricted by IP address (i.e. the same IP address could not access the survey more than once).

4.3.5.1 Survey 3 Participants

Five hundred and seventy six participants (Table 4.3) were recruited from a local Sixth Form college, Newcastle University staff and student email lists, the Birmingham 1000 Elders Study (www.birmingham.ac.uk/research/activity/mds/centres/healthy-ageing/elders.aspx), and SurveyMonkey Targeted Audience, (www.surveymonkey.com/mp/audience). The college students completed pen and paper versions of the survey and other participants were sent by email a web link to the survey which was hosted on SurveyMonkey. The ethnic background of participants recruited to the study was 80% white, 5% mixed/multiple ethnic background, 11% Asian/Asian British, 4% Black African/Caribbean/Black British and 1% other ethnic group. Age group data were missing for 6 participants and 570 participants were therefore included in the age group analysis.

Table 4.3 Characteristics of participants in Survey 3

Age Group (years)	**16-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**
N	209	30	209	19	96	7
Males	140 (67%)	12 (40%)	141 (67%)	8 (42%)	62 (65%)	2 (29%)
Females	69 (33%)	18 (60%)	68 (33%)	11 (58%)	34 (35%)	5 (71%)

4.3.6 Analysis strategy

Advice on various aspects of data analysis was sought from Prof John Matthews, Professor of Medical Statistics who is a collaborator in the LiveWell Programme, Dr Peter James, a statistician within the Institute of Health and Society, Dr Kim Pearce, a senior statistician within the Institute of Cellular Medicine and Dr Antoneta Granic from the Institute of Health and Society. It was deemed acceptable to use parametric tests with the Likert scale data obtained in Survey 1 as an average rating was calculated for each of the ten components of HA. According to central limits theorem, averaged scale data will follow a normal distribution. There is also evidence that analysis of five point Likert scale responses is subject to the same degree of Type 1 and Type II error using both parametric and non-parametric tests (de Winter and Dodou, 2010). A General Linear Model (GLM) approach was used to examine the differences in average importance ratings between academics and older people. Initial investigation suggested that older people and females gave higher rating and there were more females in the group of older people, a two-way ANOVA was used examine the possibility of group (academics and older people) by sex interaction.

For Survey 2 the same GLM approach was used as for Survey 1 as forced rankings meant that each response (between 1 and 10) would be given the same number of times, so data could not be skewed towards high or low rankings. As group*sex interactions were not observed in Survey 1, this analysis

was not repeated for Survey 2 data. To compare consistency of rankings, it was planned to follow the method of analysis used by Tate et al. (2009) namely contingency tables and chi-square tests. However, the analysis showed that all components had cells with expected counts less than five so an exact significance test was used for Pearson's chi-square. For this analysis, ranks were classified as low importance (1, 2 or 3), medium importance (4, 5, 6 or 7) or high importance (rank of 8, 9 or 10).

Since Survey 3 used forced ranking, a multivariate GLM approach was taken to examine the impact of age group, gender, and ethnic group on importance rankings of HA components. in addition, two step cluster analysis was conducted in SPSS as it is suitable for datasets that include categorical and continuous variables (Granic et al., 2013). Cluster membership was compared for models using two, three and four clusters. In preparation for this analysis, ranks were categorised as low importance (rank of 1 to 5) or high importance (rank of 6 to 10).

4.4 Results

4.4.1 Survey 1

Figure 4.2 shows average importance ratings for each of the ten components of HA for both academics and older people. All 10 components were ranked relatively highly (approximately 4 or greater on a scale of 1-5) by both groups of participants. Older people gave consistently higher importance ratings for each component but rankings were similar for both groups. "Independence" ranked number 1 for both groups. Figure 4.3 shows the average importance ratings for each of the ten components of HA by males and females. Females gave higher importance rating for each component of HA but the relative importance of each component was similar for both males and females.

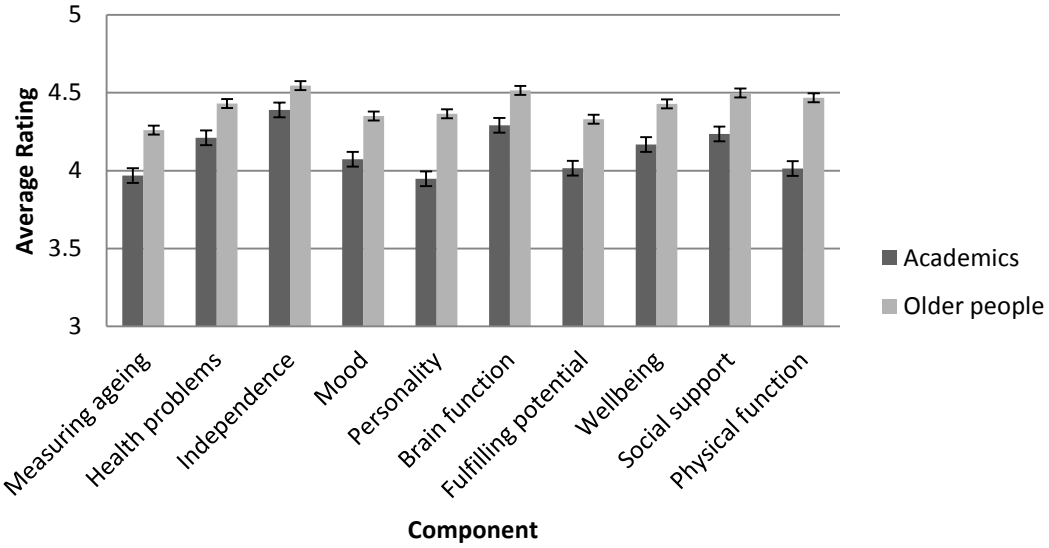


Figure 4.2. Average importance ratings by academics and older people for the ten components of HA

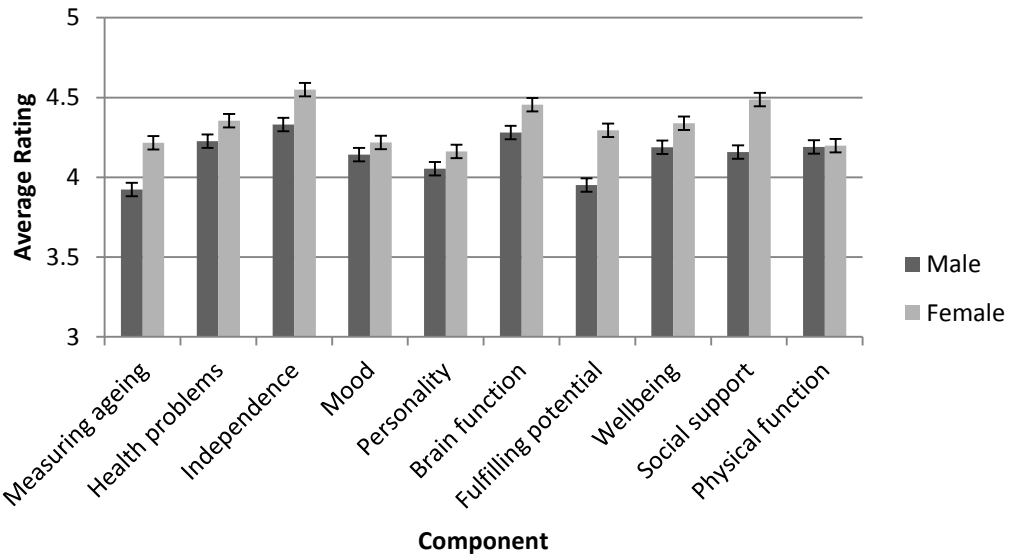


Figure 4.3. Average importance ratings by males and females for the ten components of HA.

There was a significant effect of group (academics, older people) on importance ratings of components of HA ($F_{(10,54)}$2.32, p=0.024). Although average importance ratings were broadly similar for both groups, analysis of each individual component using a Bonferroni adjusted alpha level of 0.005 showed that older people gave significantly higher importance rating than academics for 'personality' ($F_{(1,62)}$10.5, p=0.002) and 'physical function' ($F_{(1,62)}$14.5, p<0.001). There was no significant interaction between group (academics, older people) and sex for either 'personality' ($F_{(1,61)}$0.45, p=0.503) or 'physical function' ($F_{(1,61)}$0.43, p=0.513).

The question was raised of whether academic background affected the responses from the academic sample. Comparing each of the five academic backgrounds reported in Section 4.3.1.1 created very

low group sizes, therefore academics were split between those in brain/cognition related fields (mental health and neurocognition) and those from other backgrounds (physical health, nutrition and epidemiology) with group sizes of 14 and 25 respectively. This showed that both disciplinary groups gave similar ratings for the ten HA components than the other group (Figure 4.4) and there were no significant differences between the academics from brain related backgrounds and those from other backgrounds.

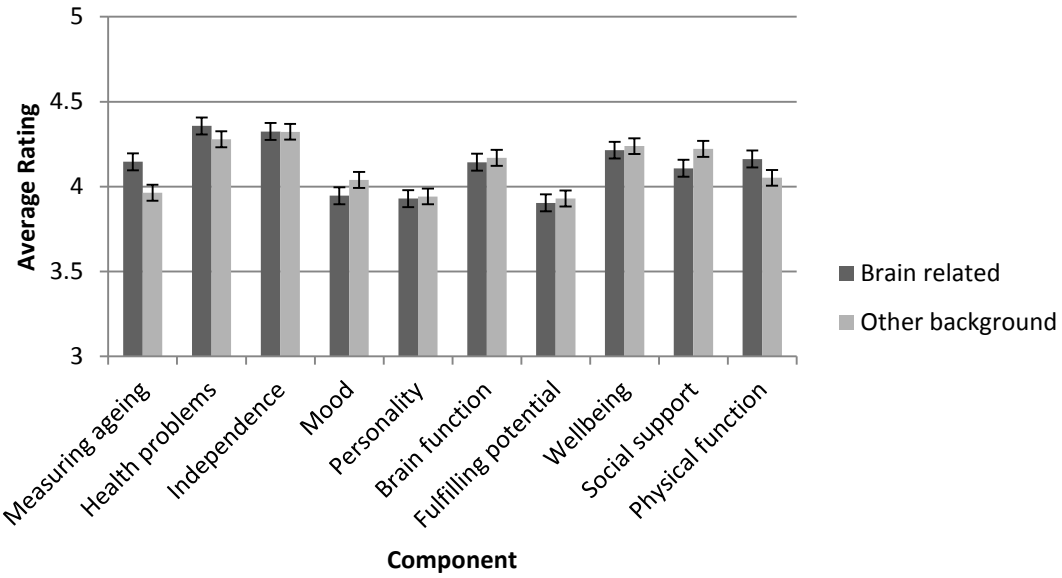


Figure 4.4. Average importance ratings for the ten components of HA by academics from brain related and other backgrounds.

4.4.2 Survey 2

In Survey 2, 48 of the participants from Survey 1, ranked the ten HA components in order of importance.

Table 4.4 shows the percentage of participants who assigning each rank for each component of HA, where one is the least important and ten the most important. Each component was ranked across the full range of possible responses except for 'brain function' which was never ranked as 10, most important. 'Independence' and 'mood' had the highest average ranking (both 6.9).

Table 4.4. The percentage of participants assigning each rank, the lowest rank, highest rank, mean and standard deviation for each component of HA in Survey 2.

Component	Rank										Lowest rank	Highest rank	Mean	SD
	1	2	3	4	5	6	7	8	9	10				
	% of participants assigning rank													
Measuring ageing	23	17	6	8	17	0	2	8	4	15	1	10	4.6	3.3
Health problems	10	17	17	19	0	13	13	2	2	6	1	10	4.4	2.5
Independence	6	4	0	12	6	10	6	17	23	15	1	10	6.9	2.7

Mood	2	4	6	12	2	15	19	0	10	15	1	10	6.9	2.7
Personality	2	6	8	4	17	4	8	19	10	21	1	10	6.8	2.7
Brain function	4	4	8	8	12	15	15	19	15	0	1	9	6.0	2.3
Fulfilling potential	19	17	25	2	12	12	4	4	4	2	1	10	3.8	2.5
Wellbeing	12	12	17	12	10	10	6	10	4	4	1	10	4.6	2.6
Social support	12	12	8	15	19	6	12	4	8	2	1	10	4.7	2.5
Physical function	6	6	2	4	6	15	15	15	19	12	1	10	6.7	2.6

NB – percentages were rounded to whole numbers therefore percentages for each component may not add up to 100%

Figure 4.5 shows the broadly similar mean rankings given by academics and older people; however older people ranked the component 'personality' a significantly higher in importance than academics ($F_{(1,45)}$8.939, p=.005).

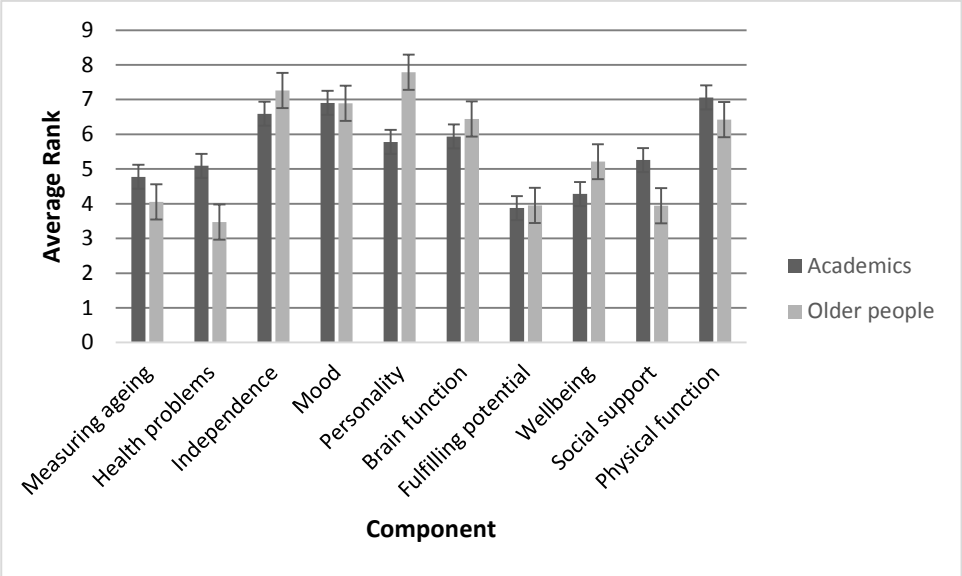


Figure 4.5. Average importance rankings for the ten components of HA by academics and older people.

4.4.2.1 Consistency

Ranking of components of HA as low, medium or high importance was compared for 15 participants on two occasions, four weeks apart. The percentage of participants who ranked each component of HA as the same level at each time point is shown in Table 4.5.

Table 4.5. The percentage of participants who ranked each component in the same way on two occasions.

Measuring ageing	60%	Brain function	53%
Health problems	60%	Fulfilling potential	80%
Independence	53%	Wellbeing	66%
Mood	53%	Social support	73%
Personality	93%	Physical function	60%

Exact significance tests for Pearson's chi-square were calculated. Only the component 'personality' demonstrated a significant difference in ranking between time points (χ=10.313, df =1, p=0.009).

4.4.3 Survey 3

In Survey 3, participants (n=570) completed a survey to rank the ten HA components in order of importance. Table 4.6 shows the percentage of participants assigning each rank, the lowest rank, highest rank, mean and standard deviation for each component of HA in Survey 3. Each component received the full range of possible responses. 'Independence' had the highest average rank (6.9) and 'measuring ageing' the lowest average rank (3.6).

Table 4.6. The percentage of participants assigning each rank, the lowest rank, highest rank, mean and standard deviation for each component of HA in Survey 3.

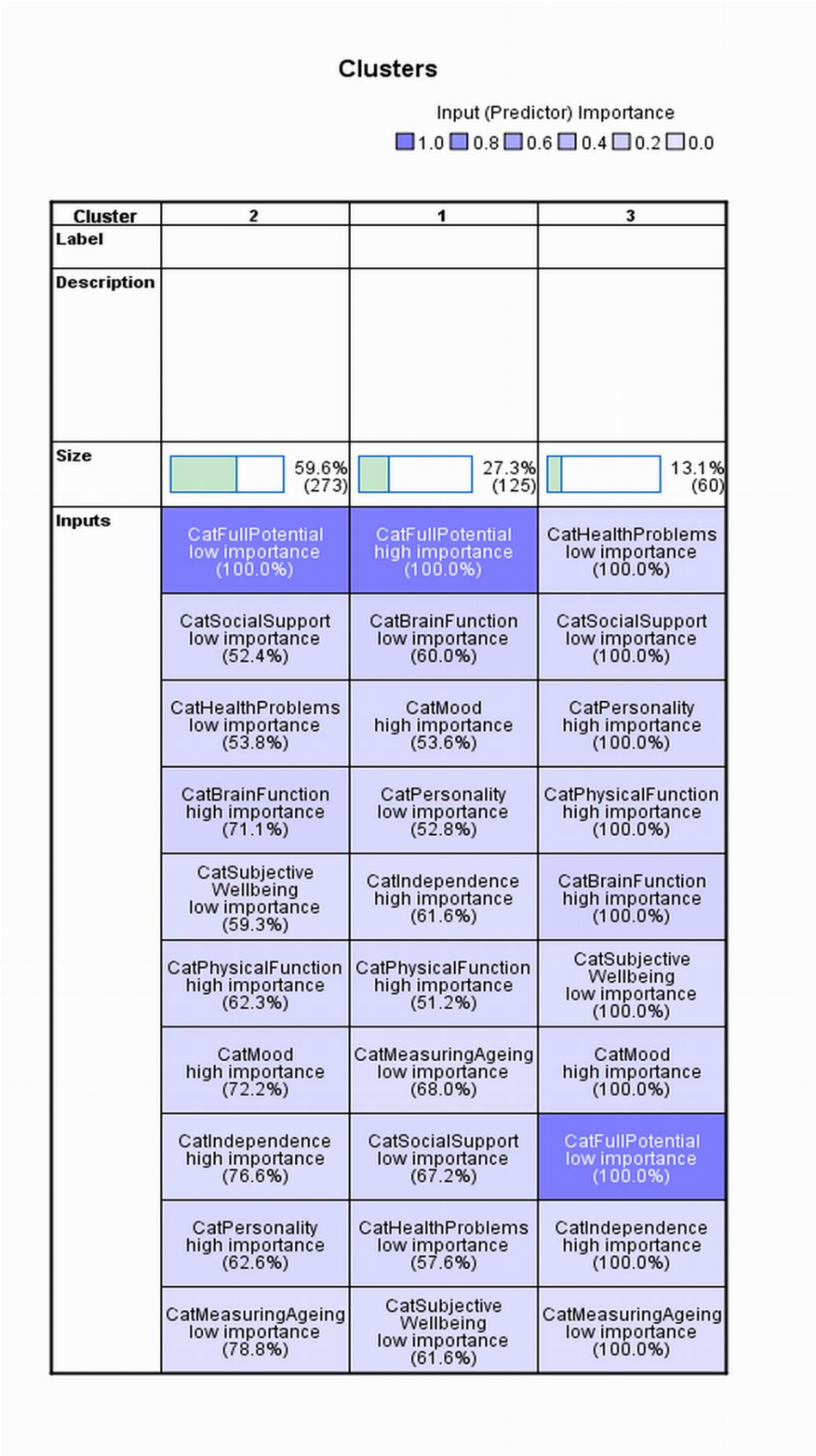
Component	Rank										Lowest rank	Highest rank	Mean	SD
	1	2	3	4	5	6	7	8	9	10				
	% of participants assigning rank													
Measuring ageing	35	16	10	7	5	7	5	3	4	6	1	10	3.6	2.9
Health problems	8	10	13	13	13	9	11	9	9	6	1	10	5.2	2.7
Independence	4	4	7	8	7	10	10	14	19	18	1	10	6.9	2.6
Mood	4	8	6	8	10	10	13	11	10	21	1	10	6.5	2.8
Personality	6	9	9	9	8	9	11	10	11	17	1	10	6.2	2.9
Brain function	4	6	5	9	10	12	14	17	15	8	1	10	6.4	2.5
Fulfilling potential	13	18	16	12	12	9	8	5	5	4	1	10	4.2	2.5
Wellbeing	13	11	12	14	12	10	9	7	8	5	1	10	4.9	2.7
Social support	9	12	15	14	14	11	9	8	5	4	1	10	4.8	2.5
Physical function	4	6	8	8	10	13	12	16	14	10	1	10	6.3	2.6

NB – percentages were rounded to whole numbers therefore percentages for each component may not add up to 100%

There was no effect of gender on importance rankings of HA components, nor were there any significant interactions between age group, gender and ethnicity. There was a significant effect of age group ($F_{(50, 2379)} = 1.75$, p=0.001 Wilks' Lambda = 0.848) and ethnicity ($F_{(40, 1977)} = 2.65$, p<0.0001 Wilks' Lambda = 0.821) on importance rankings of components of HA. Analysis of each of the ten components of HA, using a Bonferroni adjusted alpha level of 0.005, revealed a significant difference between age groups for the component 'mood' ($F_{(5, 530)} = 134$, p=0.002), and significant differences between ethnic group and 'mood' ($F_{(4,530)} = 189$, p<0.0001), 'health problems' ($F_{(4,530)} = 191$, p<0.0001), and 'personality' ($F_{(4,530)} = 202$, p<0.0001). Participants in the 31-40 year old age group ranked 'mood' as significantly more important for HA than participants in the 51-60 age group (p=0.001) and those in the 61-70 year old age group (p=0.002). Participants from a white background ranked 'mood' as significantly more important than participants from a mixed/multiple ethnic background (p=0.001), an Asian/Asian British background (p<0.0001) or Black/Caribbean/Black British background (p=0.002). Higher importance ranking of 'health problems' were given by participants from mixed/multiple ethnic backgrounds (p<0.0001) and Asian/Asian British backgrounds (p<0.0001) when compared to participants from a white background. Participants from a white background ranked 'personality' as more important for HA than did participants from an Asian/Asian British background (p<0.0001).

4.4.3.1 Cluster analysis

Two step cluster analysis was originally performed on data from participants in Survey 3 who were not recruited through Targeted Audience. The analysis identified three clusters shown in Figure 4.6. Cluster 1 was the largest (n=273), followed by Cluster 2 (n=125) and Cluster 3 (n=60). All of the participants in Cluster 1 agreed that 'fulfilling potential' was of low importance. Agreement on the importance of the other components of HA ranged from 52% to 78%. All participants in Cluster 2 agreed that 'fulfilling potential was of high importance. Agreement on the importance of the other components of HA ranged from 51% to 68%. The 60 participants in Cluster 3 ranked each component of HA in the same way. There were some similarities across all three clusters: 'social support', 'health problems', 'wellbeing' and 'measuring ageing' were ranked as having low importance, while 'physical function', 'mood' and 'independence' were given high importance. When the analysis was repeated using two- and four-cluster analyses, as a sensitivity analysis, clusters containing 60 participants who ranked clusters in the same way as participants in Cluster 3 in the three cluster analysis (see Appendix X) were apparent. When data from participants recruited from Targeted Audience was added to the analysis this cluster of 60 people remained in the three- and four-cluster analyses (see Appendix Y). Although too few data on participant characteristics were collected to examine what characterised each cluster, investigation of participant ID numbers revealed that it was the same 60 participants who were ranking components in the same way in all of these analyses.



Cluster	2	1	3
Label			
Description			
Size	59.6% (273)	27.3% (125)	13.1% (60)
Inputs	CatFullPotential low importance (100.0%)	CatFullPotential high importance (100.0%)	CatHealthProblems low importance (100.0%)
	CatSocialSupport low importance (52.4%)	CatBrainFunction low importance (60.0%)	CatSocialSupport low importance (100.0%)
	CatHealthProblems low importance (53.8%)	CatMood high importance (53.6%)	CatPersonality high importance (100.0%)
	CatBrainFunction high importance (71.1%)	CatPersonality low importance (52.8%)	CatPhysicalFunction high importance (100.0%)
	CatSubjective Wellbeing low importance (59.3%)	CatIndependence high importance (61.6%)	CatBrainFunction high importance (100.0%)
	CatPhysicalFunction high importance (62.3%)	CatPhysicalFunction high importance (51.2%)	CatSubjective Wellbeing low importance (100.0%)
	CatMood high importance (72.2%)	CatMeasuringAgeing low importance (68.0%)	CatMood high importance (100.0%)
	CatIndependence high importance (76.6%)	CatSocialSupport low importance (67.2%)	CatFullPotential low importance (100.0%)
	CatPersonality high importance (62.6%)	CatHealthProblems low importance (57.6%)	CatIndependence high importance (100.0%)
	CatMeasuringAgeing low importance (78.8%)	CatSubjective Wellbeing low importance (61.6%)	CatMeasuringAgeing low importance (100.0%)

Figure 4.6. Three clusters produced by two step cluster analysis showing a cluster of 60 participants (Cluster 3) who responded to all survey items in the same way.

4.5 Discussion

4.5.1 Principal findings

Considering the three surveys together, the main finding of this work was similarity in ratings and ranking of importance of components of HA between different population groups. Although differences were found between academics and older people in the way they rated two of the ten components (personality and physical function) of HA, there was agreement on the remaining eight components and this increased to nine in Survey 2 when components were ranked rather than rated (differences for personality only). Similarly age group differences were found for only one component (mood) and ethnic group differences for three components (mood, health problems and personality). Fewer differences between academics and older people were found than expected based on the literature (e.g. Hung et al., 2010). In each of Surveys 2 and 3, there was considerable inter-individual heterogeneity in the ranks given to each component of HA rather than a clear contrast in importance of rankings between components as reported by Phelan et al. (2004), Matsubayashi et al. (2006), Hsu (2007) and Tan et al. (2011). However, the results of Survey 1 agreed with Fernandez-Ballesteros et al. (2010) in that all items were rated as important. No evidence was found here to suggest that there are any significant sex differences in the importance of components of HA. In addition, these results are consistent with findings from work by Fernandez-Ballesteros et al. (2010), Tan et al. (2011) and Jopp et al. (2015) who found broad agreement across ethnic groups on importance of components of HA.

'Personality' was the only component of HA which showed consistent differences in importance rating/ ranking between academics and older people, age groups and ethnic groups. Measureable personality traits are reported to account for 35% of intrapersonal variation in life satisfaction (Wood et al., 2008) but personality would be of interest from an intervention study perspective only if it can be changed. Personality was considered to be fixed, especially in adulthood (Costa and McCrae, 1988), but later longitudinal work has suggested small changes can occur across the life course (Srivasta et al., 2003, Costa and McCrae, 2006). Boyce et al. (2013) examined the extent of change in personality characteristics and the relationship of these changes with subjective wellbeing in a longitudinal analysis of the Big Five personality traits (openness, conscientiousness, extroversion, agreeableness and neuroticism; also referred to as the five factor model of personality structure; see Digman 1990) and found that personality changes can affect subjective wellbeing to a comparable degree as for income, unemployment and marital status (Boyce et al., 2013). Change in personality traits has been associated with ageing, for example Field and Millsap (1991) reported an increase in agreeableness in those aged 74 to 84 years, which was maintained by those 85 years and older, and a decrease in extraversion in both groups (Field and Millsap, 1991). In a recent large scale cohort study of 20 to 80 year olds Milojev and Sibley (2014) found that with the exception of agreeableness (which showed linear decline across the life course), four of the big five personality traits showed an inverted U pattern

of rank order stability across the life course, increasing between the second and fifth decades and declining towards the eighth. Some work has also been done looking at the influence of personality traits on mortality. Mroczek and Spiro (2007) reported an association between neuroticism and early mortality in males, with the lowest survival in males who had a combination of high average levels of neuroticism and increasing levels of neuroticism over time, suggesting that both individual mean-level traits and direction of change can impact mortality (Mroczek and Spiro, 2007). In the context of the current work, LiveWell was looking to develop interventions for people in the retirement transition. One finding presented here was that older people, academics, people in different age groups and people of different ethnic groups may think about the 'personality' components of HA differently. While it is unlikely that the component 'personality' will become the target of an intervention, previous work suggests that it may be possible to tailor, or stratify, interventions to promote HA by tailoring the interventions to particular personality types (Milojev and Sibley, 2014, Chapman et al., 2014).

4.5.2 Strengths and limitations

Although used by several subsequent studies, the survey developed by Phelan et al. (2004) was based on a literature review that used very narrow search terms and did not accept any articles which used synonyms of successful ageing (Phelan and Larson, 2002). The survey used here was developed from the outcomes of a systematic review (Chapter 2) of a larger number of papers using a wide range of terms synonymous with HA, thereby capturing a wider snapshot of what is included within published definitions of HA in the literature. However, the way these outcomes were grouped together was determined by the open card sorting task performed by a sample of academics with an interest in ageing. Some of the categories created contained cards which, to those who did not take part in the task, may seem like they were not placed in the most intuitive categories, or were placed in category because there was nowhere more relevant to put them. For example some of the cards within mood related more to psychological factors. Similarly some of the cards eliminated from the task because they were either mechanisms to improve health or mediating factors rather than health itself are themselves measureable traits. If the work were to be repeated it would be desirable have the group of sorters reflect on their decisions at a later time and reconfirm their choices, before designing the survey. However, this was not possible because of the time the card sorters had available to take part in the tasks and because of the changes to the structure of the planned work necessitated by the interruption to studies. Overall, the problem was one of categorisation rather than excluding information so the final results of the survey work should not have been affected.

The development and application of an online version of the surveys allowed access to a wider pool of participant than pencil and paper questionnaire alone. The use of Survey Monkey Targeted Audience had the advantage of allowing the recruitment of a certain number of individuals from specific ethnic backgrounds in order to develop a study that could produce more generalisable results. Further, the

recruitment of younger people via local colleges allowed the examination of the importance of components of HA across a greater proportion of the life course than in previous studies. The results of Surveys 1 and 2 provide evidence that neither the background of academics nor the sex of participants affected how components of HA are rated and ranked for importance. However, the mean age of the academic group was approximately 26 years younger than the group of older people. It is possible that the differences found between academics and older people results from these age group differences but this is unlikely and Survey 3 revealed few differences between age groups. However, if this work were to be repeated it would preferable to use age matched groups to be sure that differences are solely due to being from an academic or lay background. Furthermore, the cultural or ethnic background of the participants from Survey 1 and 2 may have influenced the results. Older people were all from the North East of England while academics were spread across Europe. However, the results of the ethnic group analysis of Survey 3 data suggests that ethnic group does not have much of an impact on rankings of importance of components of HA. Additionally, the age of participants may have affected the representativeness of this survey. While the intention was to look across the life course, there were over 3.5 times more survey respondents aged below 40 years with only seven participants in the oldest age group and no one over 70 years included in the sample. It is possible that using an online survey limited the number of older respondents due to technology use barriers such as sensory decline, lack of understanding of how to use computers, mistrust of technology and cognitive decline (Wagner et al., 2010, Gatto et al., 2008). Although, internet use by people aged >75 years in the UK is considerably less that that by younger adults, such use has been rising quickly. In 2011, 19.9% of those aged ≥75 were internet users whereas in 2016, this has nearly doubled to 38.7%. For those aged 65 - 74 years (within the "target" age group for LiveWell), 74.1 % of UK adults are internet users (http://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2016). By using local groups to recruit participants and using pen and paper surveys, it may have been possible to recruit a higher number of older people, and to increase the upper age range of older people. This would have been particularly desirable to be able to compare the ranking provided by older people with the wider literature and results of the CST work.

As Survey 1 and 2 were administered in pen and paper or Word document format, counterbalancing of questions/components of HA was not possible; however, as Survey 3 was conducted online counterbalancing was used. The sample size of Survey 2 may have been too small to look at the consistency or ranks of HA at different time points. Although four weeks was chosen to be comparable to Tate et al. (2009), it would have been interesting to look at weekly intervals to examine how consistency changes over time, although this may have given rise to practice effects. As little evidence

was seen of change after four weeks, the likelihood of finding change on a weekly basis is low, and the practicalities of repeating survey at weekly intervals would have been onerous for the participants. The consistency found in this study was lower than the 80% reported by Tate et al. (2009); however, the data used here was quantitative while that used by Tate et al. (2009) was qualitative. More work is needed to see how consistency in opinions about importance of components of HA changes over time. In Survey 3 there was not an equal number of participants in each age group. Combining age groups to have three groups instead of six was considered as the numbers for the youngest two age groups would have been approximate; however, the oldest age group would still have had fewer than half the number of participants. If Survey 3 was repeated more participants in the older age groups could be targeted so that there were similar numbers of participant in each age group. In addition, as ethnic group data was not originally collected for Survey 3, assumptions had to be made about the ethnic makeup of the population that was sampled. While there is published data about the ethnic composition the North East of England (Office for National Statistics, 2012), it should be noted that the inclusion of University staff and students may have skewed the proportion of participants included from different ethnic backgrounds as Newcastle University attracts many international staff and students. Also, the proportion of people from different ethnic backgrounds sampled did not exactly meet the proportions in the English population given by the Office for National Statistics (2012), however the differences were relatively small and unlikely to have affected the overall result. If this work was repeated ethnic group data should be collected from the outset. Further, the use of SurveyMonkey Targeted Audience may have introduced some sampling bias as Targeted Audience members are a self-selecting group taking part in surveys for prize draw entries or charitable donations.

This study did not consider the independence of the ten components of HA and does not claim that the ten components are unrelated to each other. It would be possible to look at the degree of relatedness of components using correlation in the future and to see if relatedness of components was also affected by age group, ethnicity etc. Similarly, this study did not examine the psychometric properties of the surveys as the overall aim of the work was not to develop a new survey instrument.

4.5.3 Conclusions

The main finding of this work as a whole is one of similarity. There is no clear contrast in importance rankings between HA components. There are few differences between academics and older people in both ratings and rankings of the importance of HA components. This study also provides direct evidence that there are no sex differences in importance of components of HA. Overall, there are fewer differences between academics, older people, different age groups, different sexes and different ethnic groups than expected based on previous literature. Personality was the only component of HA to show differences between all groups and therefore warrants further investigation. Rankings remained stables over time.

4.5.4 Future research

There are several additional pieces of work which could be carried out with the data collected in this study in order to add more meaning to the results. Focusing on the data gathered from Survey 3, it would be interesting to look at cultural identity rather than ethnic group as previous work has shown that people tend to respond to questions about the importance of components of HA in the same as others from the culture they identify with, rather than those they share ethnicity with (Phelan et al., 2004). It would also be prudent to add in a question to the survey about current health status to examine whether health status affects opinions about HA. More information about the characteristics of the participants is needed to fully explore the results of the cluster analysis to see what characterises the group of 60 participants who responded in the same manner. Also, the robustness of clusters could be checked by rerunning the analysis on a random selection of 50% of the Survey 3 dataset to see if the same clusters and the same cluster characteristics are replicated. As the main finding of this work was similarity between groups' opinions on the importance of HA components, the next step, taken in Chapter 5, was to examine whether these components have any influence on real life ageing outcomes, such as health and mortality and, if so, whether certain components have more influence than others.

Chapter 5. The Relationship between Components of Healthy Ageing and Mortality

5.1 Introduction

Previous chapters have examined how definitions of HA are composed, how academics and older people categorise the different aspects of HA definitions and how different groups (e.g. age, sex or ethnicity group) rate the importance of the ten components of HA (see Chapter 4). This chapter seeks to assess the utility of these ten components as a measure of HA by investigating their ability to predict a well-measured ageing-related endpoint i.e. death.

5.1.1 Relationship of components of HA with ageing and mortality

5.1.1.1 Brain function

Maintenance of brain function has been included as a component in some models of HA (e.g. Baltes and Lang, 1997, Rowe and Kahn, 1997) and some cognitive functions have been shown to decline in later adulthood (e.g. Salthouse, 2010). Impaired executive and visuospatial function are associated with increased mortality risk (Johnson et al., 2007, Vazzana et al., 2010) as is a lower score on the Mini Mental State Exam (Ramos et al., 2001). Brain function was more often mentioned as an important aspect of HA by academics rather than older people but the difference was relatively small (see Chapter 4).

5.1.1.2 Fulfilling potential

Fulfilling potential and having a purpose have been reported by older people as important for achieving HA (Reichstadt et al., 2007). The role of basic factors in a person's ability to fulfil their potential have long been known, for example, if the basic needs of a good diet, adequate housing and a positive environment are not met then the ability of a person to fulfil their potential is limited (Maslow, 1954). The ability to engage in activities which an individual feels will help them to fulfil their potential can also be limited by other factors such as physical ability to take part in or travel to activities, or the local provision of appropriate activities, which in turn can impact upon quality of life (Grundy, 2006). There is as yet no direct evidence for the influence of the ability to fulfil one's own potential on mortality risk. The component 'fulfilling potential' was given the lowest overall rank of the ten HA components by academics and older people in Survey 2 (Chapter 4).

5.1.1.3 Health problems

With increased age comes increased risk of disease and disability, leading to older people having increased incidence of cardiovascular, cerebrovascular and respiratory diseases as well as cancer (Byles, 2007). Comorbidities are also common in the older population with one study of the over 70s reporting an average of seven co-morbid conditions per person (Byles, 2005) and women tend to have higher rates of disease and disability than men (Collerton et al., 2009). The literature regarding the relationship between various health problems and mortality risk is too large to describe here but the number of health problems has been reported as predictor of HA by Depp and Jeste (2006). Further, the subjective rating of the severity of one's own health problems has also been reported to predict mortality (Benyamini et al., 1999, Tigani et al., 2012). Similarly, being in good health is the most commonly mentioned reason for self-reporting as being a healthy ager (Bowling, 2006). While engaging in health behaviours (e.g. taking exercise or eating healthily) is associated with maintaining health to a later age (Burke et al., 2001a), many factors can influence the development of health problems including nutrition, socioeconomic status and social support (Marmot, 2005, Byles, 2007).

5.1.1.4 Independence

Independence is frequently included as a component of published definitions of HA (Peel et al., 2004, Peel et al., 2005), as well as definitions created by older people (Hsu, 2007, Tate et al., 2003), and is often operationalised as receiving no help, formal or informal, with activities and instrumental activities of daily living (e.g. Ford et al., 2000). Independence can be limited by a variety of factors, such as physical ability (Judge et al., 1996) and the built environment (Clarke and Nieuwenhuijsen, 2009). The component 'independence' was given the highest overall rank of the ten HA components in Survey 3 (Chapter 4). There is a lack of direct evidence regarding the relationship between levels of independence and mortality risk, with most of the related literature focussing on health problems which can lead to or be a result of nursing home admission or hospitalisation. However one study has reported that making use of formal care services can reduce mortality risk in community dwelling older people (Kuzuya et al., 2006).

5.1.1.5 Measuring ageing

The component 'measuring ageing' was given the lowest overall rank of the ten HA components in Survey 3 (Chapter 4). The ability to measure the extent to which an individual is achieving HA is often listed as a goal of future HA research. Some reviews, e.g. Peel et al. (2004), have described how previous studies have attempted to measure HA but such reviews inevitably conclude that a standard method of measuring HA is required to allow direct comparison of studies. The difficulty in developing a 'gold standard' measurements, or suite of measurements, for HA is that HA as a concept has not yet been defined satisfactorily (Lara et al., 2013). However, proposals for a suite of biomarkers of healthy

ageing have been made (Lara et al., 2015)and there is tentative evidence that it may be possible to develop a panel of blood-borne biomarkers to predict mortality risk (e.g. Barron et al., 2015).

5.1.1.6 Mood

In general, in the HA literature, mood is discussed in terms of positive mood or low mood/depression. Low mood is predictive of disability and mortality in older populations (Murphy et al., 2015) although it has been suggested that this relationship is not directly causal but instead that low mood predicts frailty and it is frailty which increases mortality risk (Almeida et al., 2015). Positive mood is reported as a predictor of survival (Engberg et al., 2013) and it has been suggested that HA can be promoted by providing psychosocial interventions to increase positive mood (Vahia et al., 2012). Mood can also predict self-rated HA (Jeste et al., 2013). However, a more recent study found that after taking into account the impact of health problems on mood, mood had no independent direct relationship with mortality risk (Liu et al., 2015). Depression is one of the most prevalent mood disorders in older adults (Blazer, 2003) and has been associated with self-rated successful ageing to the same extent as physical health (Jeste et al., 2013). The component 'mood' was given the joint highest rank of the ten HA components by academics and older people in Survey 3 (Chapter 4).

5.1.1.7 Personality

Wilson et al. (2004) compared scores on the NEO Five-Factor Inventory (Costa and McCrae, 1992) for the 'big five' personality traits (openness, conscientiousness, extraversion, agreeableness, neuroticism) and found that mortality was almost doubled in older people who scored highly (above the 90th percentile) for extraversion compared to those with low scores (10th percentile or below) while those who scored highly for conscientiousness had half the mortality risk as those with low conscientiousness scores. Similar results have been reported by subsequent studies (Mroczek and Spiro, 2007).

5.1.1.8 Physical function

Physical function was the most frequently cited component of published definitions of HA in the review by Depp and Jeste (2006) and was also the most frequently mentioned aspect of HA by both academics and older people (Hung et al., 2010). It is the most widely used outcome measure in studies claiming to examine HA (Hsu, 2007). Physical function is typically assessed using markers such as grip strength and gait speed, both of which have been shown to predict longevity (e.g. Cooper et al., 2010). Further, older people's self-assessments of their physical function was predictive of mortality (Lee, 2000). Problems with walking ability and slowing of gait speed are common in ageing (Holtzer et al., 2012). Abnormalities in walking patterns and rapid decline in gait speed are associated with increased risk of poor quality of life, dementia and mortality (Holtzer et al., 2012, White et al., 2013). Stair climbing ability is linked with independence and quality of life and poor stair climbing ability is linked to injury

or a death as a result of a fall (Hinman et al., 2014). Being able to climb a flight of stairs, along with the ability to lift and carry, have been used to operationalise freedom from disability (e.g. Jeste et al., 2010).

5.1.1.9 Social support

Social support is frequently given high priority in definitions of HA produced by older people (Hsu, 2007). Analysis of data from the Survey of Health, Ageing and Retirement in Europe (SHARE) showed that higher scores on social support variables increased the probability of older people self-reporting good health (Sirven and Debrand, 2008). There is also evidence that levels of social support may predict mortality (Blazer, 1982, Ellwardt et al., 2015, Holt-Lunstad et al., 2010). Social network size and amount of social engagement have been reported to diminish with increasing age and are associated with negative changes in life satisfaction and health (Huxhold et al., 2013). Low levels of social support, or more specifically, perceived social support, can lead to feelings of loneliness which in turn have been associated with increased mortality risk (Luo et al., 2012).

5.1.1.10 Wellbeing

Wellbeing is included in a definition of HA almost three times more often by older people than academics (Hung et al., 2010). Despite decline in physical function in later life, subjective wellbeing does not tend to follow this pattern, likely due to an individual's ability to adapt to the challenges of ageing (Baltes and Baltes, 1990). The literature reports a protective effect of wellbeing in relation to survival (e.g. Yiochi and Steptoe, 2008) with data from the English Longitudinal Study of Ageing (ELSA) showing that individuals reporting low levels of wellbeing were at almost three times higher risk of mortality than individuals reporting high levels of wellbeing (Steptoe et al., 2015). Older people who report higher levels of satisfaction with their leisure time and activities tend to report overall higher levels of wellbeing (Adams et al., 2011). Interview data from Hutchinson and Nimrod (2012) suggests that setting goals to get the most out of leisure time could be used to promote HA in older adults (Hsu, 2011).

5.1.2 Cohort studies and healthy ageing research

Longitudinal cohort research is an essential tool in the development of future HA research as it contributes to understanding of the risk factors and protective factors for achieving HA (Byles, 2007). In addition, such research allows the comparison of HA components across studies and over time and can be used to identify lifestyle factors which could be modified to promote HA (Kuh et al., 2014).

Many longitudinal cohort studies of ageing have been developed worldwide such as the US Health and Retirement Study (Juster and Suzman, 1995), the Bambui Cohort Study of Ageing in Brazil (Lima-Costa et al., 2011), the Survey of Health and Retirement in Ageing in Europe (Borsch-Supan et al., 2013) (SHARE), the Irish Longitudinal Study on Ageing (Kearney et al., 2011), and the English Longitudinal

Study of Ageing (ELSA) (Steptoe et al., 2012), the Newcastle 85+ study (Collerton et al., 2007) and the Cognitive Function and Ageing Studies (Brayne et al., 2006).

Other cohorts which were originally designed for other purposes are now taking advantage of the advancing age of their participants to study the determinants of HA, such as the French GAZEL cohort (named after *gaz* and *electricité* as participants were workers at the utility firm *Électricité de France-Gaz de France* (EDF-GDF)), (Goldberg et al., 2007) and the Newcastle Thousand Families Study (Pearce et al., 2009) which began in 1947 as a study of infant health. In the future data, new data on factors which influence HA across the life course will become available from more recent birth cohorts such as Millennium Cohort Study (Centre for Longitudinal Studies, 2016)

In the UK, the Healthy Ageing Across the Life Course Research Programme (HALCyon) brings together data from nine UK cohorts with the aim of furthering understanding of the relationship between the biology of ageing, psychological and social wellbeing and physical and cognitive function with HA (www.halcyon.ac.uk) and to examine factors across the life course which influence these processes (Kuh et al., 2014). One of the main benefits of HALCyon is that data has been standardised allowing the comparison of data collected by the different cohort studies. Similarly, the more recently established CLOSER Discovery (www.closer.ac.uk/data-resources) brings together data from another eight UK cohort studies, some older and some more recent.

5.1.2.1 Hertfordshire Ageing Study and Whitehall II

The two cohorts used in this study are the Hertfordshire Ageing Study cohort (HAS; http://www.mrc.soton.ac.uk/herts), described by Syddall et al. (2010) and Whitehall II cohort (WII; https://www.ucl.ac.uk/whitehallII), described by Marmot and Brunner (2005).

The HAS began following the rediscovery of birth weight records of live singleton births collected in North Hertfordshire between 1911 and 1948. From these records, individuals who were born between 1920 and 1930 and still lived in Hertfordshire were invited via their GPs to take part in a clinical assessment, the first HAS follow up (Syddall et al., 2010). The main aim of the HAS cohort was to examine the influence of the life course on healthy ageing. Follow-up data were collected in 1994/1995 and 2003-2005 and included ageing markers (such as grip strength, cognitive function and audiometry) and medical characteristics (e.g. blood pressure, cardiovascular symptoms and waist and hip circumferences). Information was also collected on lifestyle characteristics and socioeconomic factors. Mortality data were collected from the National Health Service Central Registry. Key findings from HAS relate to osteoporosis, sarcopenia, physical activity, physical function and diet in relation to HA (see Syddall et al., 2010).

The original Whitehall study was designed to investigate risk factors for cardiorespiratory disease and diabetes and found a link with socioeconomic status. This unexpected finding led to the creation of the WII cohort study, which was designed to examine directly the relationships between socioeconomic status and health and to investigate the influence psychosocial and occupational factors on health, to extend beyond the biomedical model of health which had been the basis of most previous cohort studies (Marmot and Brunner, 2005). Participants were 10,308 men and women aged 35 to 55 recruited from civil service offices in Whitehall between 1985 and 1988 who were followed up at five year intervals. Data were collected by questionnaire and clinical screening. Questionnaire data included socioeconomic status, psychosocial and occupational factors, health behaviours, health outcomes, subjective general health and subjective mental health. Clinical data included neuroendocrine measures, subclinical measures of cardiovascular disease, blood lipids, markers of carbohydrate metabolism, haemostatic measures and genotyping. Mortality was followed up through the National Health Service Central Registry (Marmot and Brunner, 2005). WII has produced numerous publications on cognitive ageing, cardiometabolic health, physical functioning and mental health in relation to HA (see https://www.ucl.ac.uk/whitehallII/publications/2016-publication).

5.2 Rationale, hypothesis, aims and objectives

5.2.1 Rationale

This study was designed to investigate the utility of the 10 components discussed above as a measure of HA. Findings reported in Chapter 4 showed that the ten components were rated similarly between academics and older people, people from different age groups and people from different ethnic backgrounds. The work described in this chapter was designed to investigate whether these components, in addition to being important to people for HA, are associated with mortality outcomes in longitudinal cohorts. As there is no gold standard by which to judge the utility of these components as measures of HA, mortality was used as a surrogate for HA. Pragmatic criteria were used when selecting which cohort data to include in this work. The HAS and WII cohorts were chosen because they shared some variables which aligned with the 10 components of HA and because these studies provided data from individuals within the age range of interest (50 to 70 years) at baseline or follow-up. Choosing cohorts with data which were already comparable made the analysis more manageable. An age range of 50 to 70 years was chosen to be in keeping with the peri-retirement age window focussed on by the LiveWell programme. Five years was selected as a cut-off point for early death to remove participants from the analysis who may have died from pre-existing conditions. Two cohorts were used to allow comparison of scores for the different components of HA in relation to mortality outcomes in two independent populations.

Several cohorts were considered for use in this study, including the English Longitudinal Study of Ageing (ELSA), the Survey of Health and Retirement in Ageing in Europe (SHARE), the Healthy Ageing

Across the Life Course (HALCyon) cohorts, Integrated Datasets in Europe for Ageing Research (IDEAR) and Consortium on Health and Ageing: Network of Cohorts in Europe and the United States (CHANCES). The HAS and WII cohorts were selected because they had corresponding variables which could be compared without the need to first harmonise the data. They also had shorter turnaround times between applying for, and receiving, data and they had committee meetings to approve the use of the data for this work within a short time frame, so that this study could be completed within the duration of the studentship. Both the HAS and WII are UK-based cohorts and used similar measures for the different components of HA as shown in Table 5.2. Both can be considered to be representative of the wider UK population. HAS recruited participants born in North Hertfordshire between 1920 and 1930 while WII recruited from the British Civil Service, however a full spectrum of grades were included from lower ranking support and manual staff grades to higher ranking senior executive grades. Data obtained from WII included more participants than HAS with approximately seven more years of follow up and average age of entry into the analysis was fourteen years younger than that of HAS

5.2.2 Hypothesis

1. Overall HA score will be predictive of mortality risk.

5.2.3 Aims

1. To examine whether components of HA identified Chapters 2 and 3 and used in the subsequent survey in Chapter 4 are associated with mortality outcomes.
2. To determine whether an overall score for HA is associated with mortality risk.

5.2.4 Objectives

1. To access data from two internationally-recognised cohorts investigating healthy ageing which included baseline data for participants collected within the peri-retirement age window (50 to 70 years) and also follow up morbidity and mortality data.
2. To create groups of available variables from the cohort data which correspond with the components of HA identified in previous chapters.
3. To analyse data using z-scores for individual components of HA to test the hypothesis that individuals with higher scores have more favourable outcomes, i.e. lower incidence of morbidity and delayed mortality.
4. To create a HA score variable, which will be a composite of all (ten) variables. This will be used to test the hypothesis that individuals with overall higher scores have improved mortality outcomes.

5.3 Method

5.3.1 Obtaining cohort data

Permission to gain access to data was granted by the steering committees of the WII and HAS cohorts in July 2015 and final datasets were received in November 2015.

5.3.2 Participant characteristics

5.3.2.1 HAS

Data for 560 participants were received from the HAS cohort from Follow-Up One in 1994/1995. Mean follow up was 14 years (range 6.2 to 16.7 years). The mean age of participants at baseline was 67 with a range of 63 to 73 years. 51 participants over 70 years of age at baseline, all female, were removed from the analysis. A total of 509 participants remained, 54.8% male. No participants died before the five-year cut-off point for early death.

5.3.2.2 WII

From WII, data were obtained for participants in Phases 1 to 4 of the study. At each of the phases questionnaire data was gathered, with the addition of clinical data at Phases 1 and 3 (Marmot and Brunner, 2005). The timing of each phase and the number of years of follow up between each phase and assessment of outcomes is shown in Table 5.1 .

Table 5.1. Period of data collection and number of years of follow up at each phase of the WII cohort study

	Phase 1	Phase 2	Phase 3	Phase 4
Period of data collection	1985-1988	1989	1991-1994	1995-1996
Number of years of follow up	27-24	23-22	21-18	17-16

Data from Phase 4 were not included in the present analysis as there was a low level of correspondence between variables collected at this phase and those in the first three phases. In total, data were received for 10,308 participants, 6895 (66.9%) male, 3413 (33.1%) female born between 1930 and 1952. 89.1% of the sample were white. To get the longest length of follow up data from participants was included from the earliest phase where they entered the age range for the current analysis (50 to 70 years). 5,596 participants did not reach the minimum age of 50 years at any of the phases. Of the remaining 4,712 participants, 2,700 (57.3%) were in the desired age range at Phase 1, 974 (20.7%) at Phase 2, and 1,038 (22.0%) at Phase 3. Of these eligible participants, 2,976 (63.2%) were male and 1,736 (36.8%) were female. The mean age of entry into the current analysis was 52.4 years. Date of death was compared with date of participation in the phase when participants first entered the age range for the current analysis and 82 participants died before the cut-off point for early death (i.e. within 5 years of collection of baseline data). Additionally data were missing for 12 participants and so

these individuals were removed from the analysis. 4,618 participants remained, and, of these, 2,632 (57.0%) entered the eligible age range at Phase 1, 964 (20.8%) at Phase 2 and 1,022 (22.2%) at Phase 3.

5.3.3 Variables and outcome measures

A summary of the data used from each cohort is provided in Table 5.2. A full list of variable names can be found in Appendix Z.

Table 5.2. A summary of variables and outcome measures used in the analysis for each cohort.

Hertfordshire Ageing Study	**Whitehall II Cohort**
Demographic Data	
Age	Age
Sex	Sex
Marital status	Marital status
Health Behaviours	
Smoking status	Smoking status
Components of Healthy Ageing	
Brain Function	
Alice Heim 4 score	Alice Heim 4 score
Mill Hill score	Mill Hill score
Health Problems	
Angina	Angina
High blood pressure	Diagnosis of heart trouble
Stroke	Incident dementia
Emphysema	Known dementia
Macular degeneration	Diabetes
Number of medications	Satisfaction with health in past year
	Anti-hypertensive medication
	CNS medication
	CVD medication
	Other medications
Measuring Ageing	
Skin thickness	-
Lens opacity	-
Grip strength	-
Visual acuity score	-
Mood	
-	GHQ score
Physical Function	
Walking problems	-
Walking speed	-
Ability to climb stairs	-
Able to carry loads	-

Social Support	
-	Network scale
-	Satisfaction with personal relationships
Wellbeing	
-	Life events
-	Satisfaction of standard of living
-	Satisfaction with leisure time
Outcome variables	
Length of follow up	Length of follow up
Mortality status	Mortality status
Mortality type	Mortality type

5.3.3.1 Brain function

A score for 'brain function' was calculated by combining Mill Hill and Alice Heim 4 data which was available from Phase 3 participants in WII. Mill Hill scores are markers of fluid intelligence (i.e. aspects of intelligence which are considered independent of learning such as problem solving ability and abstract reasoning) whereas scores on the Alice Heim 4 represents crystallised intelligence (knowledge accumulated through learning and experience) (Poon et al., 1992, Jeeves and Baumgartner, 2013) with more decline expected in fluid intelligence and crystallised intelligence remaining relatively stable (e.g. Horn and Cattell, 1967, Ghisletta et al., 2012). 'Brain function' data was available for 495 participants from HAS and 381 participants from WII.

5.3.3.2 Health problems

The number of health problems was assessed for all participants through combining six variables in HAS and ten variables for WII (Table 5.2). Fewer health problems are predictive of successful ageing (Depp and Jeste, 2006). 'Health problems' data was available for 197 participants from HAS and 4,618 participants from WII.

5.3.3.3 Measuring ageing

Skin structure and function becomes less stable with age resulting in decreasing skin thickness (e.g. Farage et al., 2013). Lens opacity was assessed using the LOCSIII Lens Opacity Score (Chylack et al., 1993) and visual acuity was assessed using the Bailey-Lovey logMAR chart (Bailey and Lovey, 1976). Visual impairment and lens opacity tend to increase with age (van der Pols et al., 2000), while increased mortality risk has been reported in individuals with age-related cataracts (Richer et al., 2015). Hand grip strength is a biomarker of physiological reserves during ageing (Rantanen et al., 2012). Grip strength declines at a rate of about 1% per year and higher grip strength is associated with reduced

risk of disability and mortality (Rantanen et al., 2000). Data for the 'measuring ageing' component of HA was available from HAS for 487 participants.

5.3.3.4 Mood

Mood was assessed in WII using the General Health Questionnaire (GHQ), a screening questionnaire used to detect psychiatric illness accompanying health problems. Validity and reliability of the questionnaire are discussed in McDowell (2006). Higher scores indicate greater likelihood of mood disorder (GL Assessments, 2016). Data was available for 4,479 participants.

5.3.3.5 Physical function

Physical function was measured in the HAS cohort using four variables: number of walking problems, walking speed, ability to climb stairs and ability to carry loads. Data were available for 509 participants.

5.3.3.6 Social support

The social support component was created by combining scores from two WII variables (network scale score and satisfaction with personal relationships) which were available for participants entering the study at Phases 1 and 2. Higher scores on these variables indicated larger social networks or greater satisfaction with relationships. Complete data for the 'social support' component were available for 2,858 participants.

5.3.3.7 Wellbeing

The score for wellbeing was a composite of three WII variables: life events (none, one, two or more), satisfaction with standards of living (on a seven point scale from very dissatisfied to very satisfied) and satisfaction with leisure time (on a seven point scale from very dissatisfied to very satisfied. Satisfaction with standards of living and satisfaction with leisure time variables were recoded so that higher scores equalled greater dissatisfaction, in line with direction of other variables. Data for all three variables in the 'wellbeing' component were available for 2,742 participants.

5.3.3.8 Healthy ageing score

An overall HA score was calculated for 182 participants from the HAS cohort who had data available for each component (brain function, health problems, measuring ageing and physical function). It was not possible to calculate an overall HA score for the WII data as no participants had data available for each variable in all components.

5.3.3.9 Outcome measures

For both cohorts length of follow up was calculated and mortality status and mortality type were provided in the datasets. Mortality type was reported in HAS by ICD10 classification code while WII reported mortality as either coronary heart disease, cardiovascular disease, malignant neoplasm,

respiratory disease stroke or other. To standardise mortality outcomes between the two cohorts, mortality type was categorised as all cause, cancer or cardiovascular in line with reporting conventions in previous work e.g. Barron et al. (2015) and in order to have large enough numbers in each type of mortality to allow comparison. Mortality from dementia was included with cardiovascular mortality because of the links between cardiovascular disease and dementia (e.g. Newman et al., 2005, Paciaroni and Bogousslavsky, 2013, Justin et al., 2013).

5.3.4 Preparation of datasets for analysis

Preparation of the dataset for analysis was undertaken following advice from Dr Kim Pearce, a senior statistician within the Institute of Cellular Medicine. Participants who fell outside the desired age range for analysis (50 to 70 years) were removed and participants who died within the five year cut off point for early death were removed. For HAS data, no participants died before early cut off. For WII data, participants were sorted by study phase in which the first met the age criteria and new variables for age of entry into study and length of time in study were created. To ensure that a higher score represented poorer function for each variable, variables which had a higher score representing better function were transformed. To do so, categorical variables were re-coded in the opposite direction and z-scores of continuous variables were multiplied by minus one to reverse the order of the z-scores. Composite variables for each component of HA were created (as shown in Table 5.2) by adding together standardised scores for each variable and tertiles of scores were created. Tertiles of longevity were also created. In cases where participants did not have complete data for all variables used for a component, those participants were removed from the analysis for that particular component. For HAS data, only participants who had complete data for all variables of interest were included in the analysis of the overall HA score.

5.3.5 Analysis strategy

The strategy for the analysis of the cohort data was developed with advice from Dr Kim Pearce, a senior statistician within the Institute of Cellular Medicine. Kaplan-Meier survival analysis was used to produce a survival curve for tertile groups of each component of HA using a log-rank test to examine the overall association of the three tertiles of each component with mortality. This was followed up with Cox proportional hazards modelling to compare pairs of tertiles and to adjust for demographic and health behaviour covariates which were common to both cohorts. In total three models were used: an unadjusted model, an adjusted model (adjusting for age, sex and marital status) and a fully adjusted model (adjusting for age, sex, marital status plus smoking status). In each model the top tertile (3) was used as the reference. Although a wider range of demographic and health behaviour data were available for each cohort, the covariates included in the analysis were selected because they were comparable between cohorts and are hypothesised to affect mortality risk independently of the components of HA under examination. Components where differences between tertiles remained

significant in the fully adjusted model were followed up with additional Cox proportional hazards models to assess the relationship between tertiles of the component and cancer, cardiovascular and all-cause mortality. All data preparation and analysis were performed using IBM SPSS Statistics (version 22) software.

5.4 Results

5.4.1 Participant characteristics

Table 5.3 the baseline characteristics of participants in the HAS and WII cohorts. Participants from the HAS cohort had a higher mean age of entry into the analysis (66.4 years versus 52.4 in WII) while WII participants were follow up for a longer length of time (mean 22 years) than HAS participants (mean 14.8 years). Both cohorts had a majority of male participants (54.8% HAS, 63.2% WII) while marital status and smoking status followed similar trends in both cohorts.

Table 5.3. Baseline characteristics of participants in each cohort

Characteristic	HAS cohort N=509	WII cohort N=4618
	n (%)	n (%)
Sex		
Male	279 (54.8)	2919 (63.2)
Female	230 (45.2)	1699 (36.8)
Marital status		
Single	44 (8.6)	474 (10.4)
Married/cohabiting	363 (71.4)	3449 (74.8)
Divorced	21 (4.1)	317 (6.9)
Widowed	81 (15.9)	100 (2.2)
Missing data	0	279 (6.0)
Current smoker		
Yes	77 (15.1)	822 (17.8)
No	432 (84.9)	3786 (82.0)
Missing data	0	11 (0.2)
	Mean, SD (Range)	Mean, SD (Range)
Age at entry into analysis, years	66.4, 1.7 (64.0-69.0)	52.4, 1.6 (50.0-57.9)
Follow up time, years	14.8, 2.7 (10.8)	22.0, 3.9 (21.0)

5.4.2 Brain function

Figure 5.1 and Figure 5.2 show survival curves for those in the HAS (Figure 5.1) and WII (Figure 5.2) cohorts who scored in the bottom (1) middle (2) and top (3) tertiles on the 'brain function' component, where the those in the bottom tertile had the poorest performance on cognitive tests.

For those in the HAS cohort, the estimated mean time until death was 14.4 years for those in the lowest tertile, 15.3 years for those in the middle tertile and 15.8 years for those in the highest tertile and differences between tertiles were significant ($p<0.0001$). However, for WII data there was no significant difference between the tertiles ($p=0.704$) with the estimated mean time until death as 24.6 years in the lowest tertile, 19.6 years in the middle tertile and 19.5 years in the highest tertile.

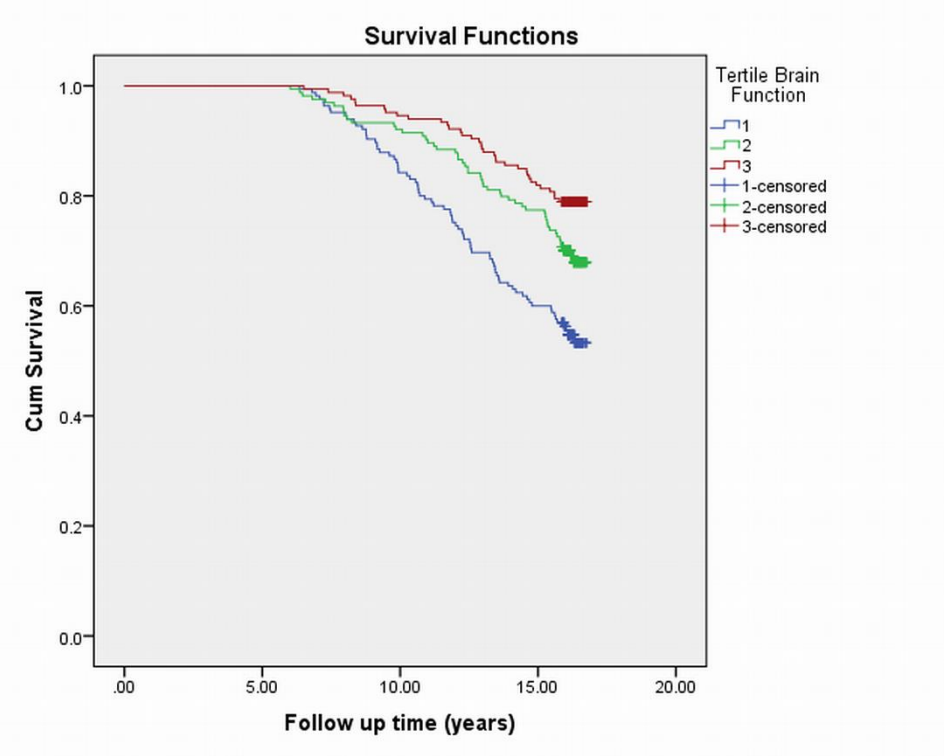


Figure 5.1. Kaplan-Meier survival curves for those in the HAS cohort in the bottom (1), middle (2) and top tertiles (3) in the 'brain function' component where the bottom tertile represents the poorest performance on cognitive tests.

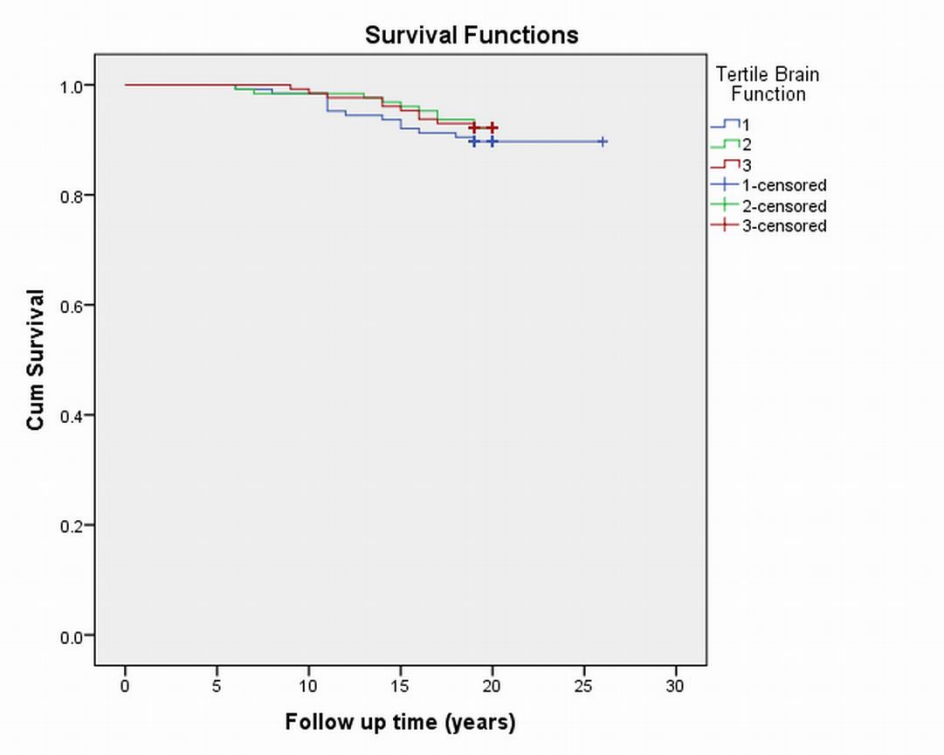


Figure 5.2. Kaplan-Meier survival cures for those in the WII cohort in the bottom (1), middle (2) and top tertiles (3) in the 'brain function' component where the bottom tertile represents poorest performance on cognitive tests.

Of the 495 participants in the HAS cohort who had data available for the 'brain function' component, 161 died during follow up. Participants in the lowest tertile and those in the middle tertile of 'brain function' scores had significantly higher all-cause mortality (unadjusted HR 2.64, 95% CI 1.77-3.94, p<0.0001; and 1.57, 95% CI 1.02-2.42, p<0.039, respectively (Table 5.4)) than those in the references group. These effects remained significant after the analysis was adjusted for age, sex, marital status and smoking status (tertile 1 fully adjusted HR 2.46, 95% CI 1.64-3.69, p<0.0001; tertile 2 fully adjusted HR 1.56, 95% CI 1.01-2.40, p=0.046; Table 5.4). This analysis was followed up with an analysis of the relationship between tertiles of brain function scores and mortality type. There were no significant differences between the bottom and middle tertiles compared with the top tertile for cancer mortality (tertile 1 unadjusted HR 0.57, 95%CI 0.29-1.14, p=0.12; tertile 2 unadjusted HR 0.54, 95%CI 0.26-1.10, p=0.09) or cardiovascular mortality (tertile 1 unadjusted HR 1.77, 95%CI 0.93-3.37, p=0.09; tertile 2 HR 1.05, 95%CI 0.53-2.08, p=0.89). In the WII cohort 8.7% of the participants who had data available for the 'brain function' component died during follow up. As shown in Table 5.4, no differences were found between tertiles of the 'brain function' component of healthy ageing and mortality in any of the Cox models for WII data (tertile 1 unadjusted HR 1.39 (95%CI 0.59-3.08, p=0.48; tertile 2 unadjusted HR 1.01, 95%CI 0.42-2.41, p=0.99)..

Table 5.4.Cox proportional hazard models for mortality risk by tertile of scores on the 'brain function' component of healthy ageing among participants in the HAS and WII cohorts.

HAS cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)*	*p* value	Fully adjusted HR (95% CI)^	*p* value
N at risk	495					
N of events	161					
Tertile 1	2.64 (1.77-3.94)	<0.0001	2.61 (1.74-3.91)	<0.0001	2.46 (1.64-3.69)	<0.0001
Tertile 2	1.57 (1.02-2.42)	0.039	1.62 (1.05-2.49)	0.03	1.56 (1.01-2.40)	0.046
Tertile 3 (Reference)	1.00	-	1.00	-	1.00	-
WII cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)	*p* value	Fully adjusted HR (95% CI)	*p* value
N at risk	381					
N of events	33					
Tertile 1	1.39 (0.59-3.08)	0.48	1.02 (0.36-2.89)	0.97	0.73 (0.26-2.06)	0.56
Tertile 2	1.01 (0.42-2.41)	0.99	1.10 (0.45-2.56)	0.84	0.97 (0.40-2.36)	0.95
Tertile 3 (Reference)	1.00	-	1.00	-	1.00	-

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.4.3 Health problems

Figure 5.3 and Figure 5.4 show survival curves for those for those in the HAS (Figure 5.3) and WII (Figure 5.4) cohorts who scored in the bottom (1) middle (2) and top (3) tertiles on the 'health problems' component, where the those in the bottom tertile reported the most health problems.

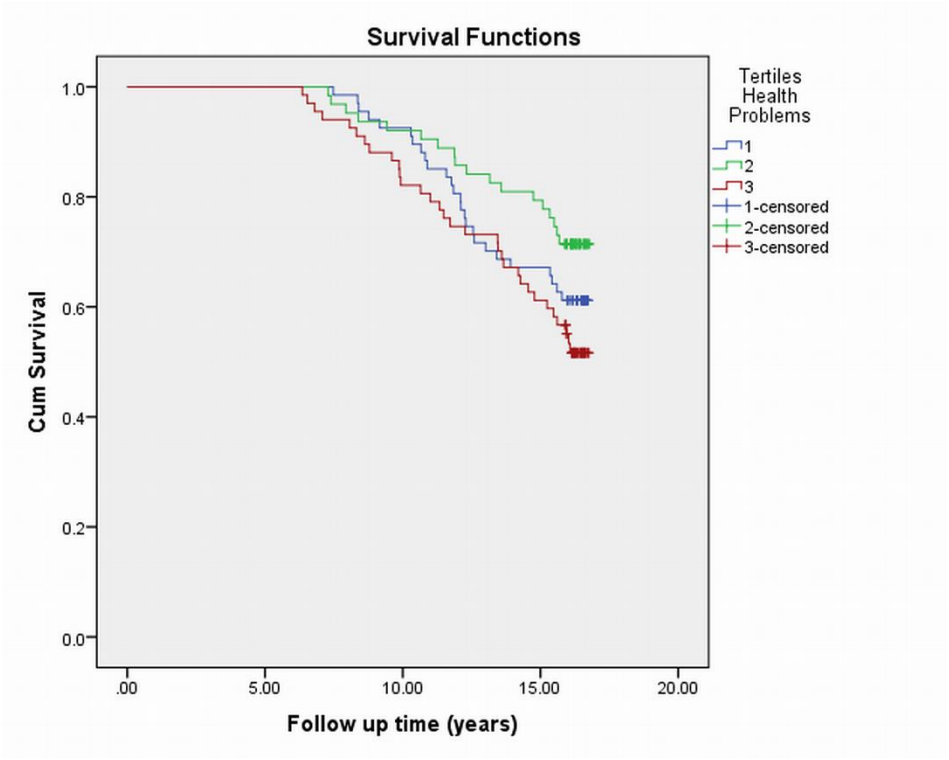


Figure 5.3. Kaplan-Meier survival curves for those in the HAS cohort in the bottom (1), middle (2) and top tertiles (3) in the 'health problems' component where the bottom tertile represents a larger number of health problems.

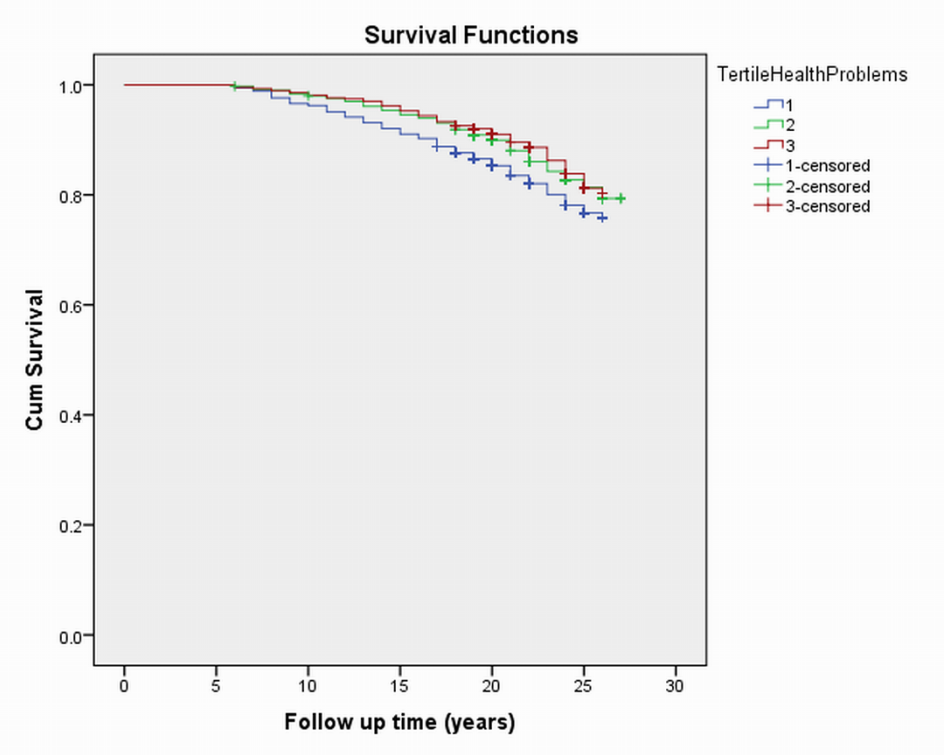


Figure 5.4. Kaplan-Meier survival curves for those in the WII cohort in the bottom (1), middle (2) and top tertiles (3) in the 'health problems' component where the bottom tertile represents a larger number of health problems.

For the HAS cohort, the estimated mean time until death was 14.3 years for those in the lowest tertile, 15.4 years for those in the middle tertile and 14.8 years for those in the highest tertile (those with the most health problems) (Figure 5.3). Of those HAS participants who had available data for the 'health problems' component, 38.6% died during follow up. There was no significant difference between the tertiles of 'health problems' and total mortality (p=.079). Similarly, there were no differences in all-cause mortality between tertiles of health problems score in either the unadjusted or adjusted models (Table 5.5). For WII there was a significant difference in time until death between tertile groups (p<0.0001); estimated mean time until death (23.9 years) was less for those with the most health problems (bottom tertile) than for those in the other 2 tertiles (25.4 and 24.7 years for those in the middle and top tertiles respectively) (Figure 5.4).

Of the 4,618 WII participants included in this analysis, 17% died during follow up. There was a significant increase in all-cause mortality risk in the unadjusted (HR 1.45, 95%CI 1.20-1.72, p<0.001) adjusted (HR 1.46, 95%CI 1.21-1.75, p<0.001) and fully adjusted models (HR 1.36, 95%CI 1.13-1.61, p=0.001) for those with larger numbers of health problems, however this trend was not repeated for those in the middle tertile (Table 5.5). There was no significant difference in mortality risk between the bottom and middle tertile compared to the top tertile for cancer mortality (tertile 1 unadjusted HR

1.77, 95%CI 0.93-3.37, p=0.09; tertile 2 HR 1.05, 95%CI 0.53-2.08, p=0.89) or cardiovascular mortality (tertile 1 unadjusted HR 1.41, 95%CI 0.85-2.34, p=0.184; tertile 2 unadjusted HR 1.23, 95%CI 0.75-2.01, p=0.41).

Table 5.5. Cox proportional hazard models for prediction of mortality risk by tertile of scores on the 'health problems' component of healthy ageing among participants in the HAS and WII cohorts.

HAS cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)*	*p* value	Fully adjusted HR (95% CI)^	*p* value
N at risk	197					
N of events	76					
Tertile 1	1.31 (0.78-2.19)	0.308	1.37 (0.81-2.33)	0.246	1.59 (0.97-2.75)	0.093
Tertile 2	0.681 (0.37-1.24)	0.210	0.654 (0.35-1.21)	0.178	0.71 (0.38-1.32)	0.28
Tertile 3	1.00	-	1.00	-	1.00	-
WII cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)	*p* value	Fully adjusted HR (95% CI)	*p* value
N at risk	4618					
N of events	789					
Tertile 1	1.45 (1.20-1.72)	<0.0001	1.46 (1.21-1.75)	<0.0001	1.35 (1.13-1.63)	0.001
Tertile 2	1.09 (0.90-1.32)	0.37	1.07 (0.88-1.29)	0.51	1.06 (0.87-1.28)	0.57
Tertile 3	1.00	-	1.00	-	1.00	-

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.4.4 Measuring ageing

Figure 5.5 shows survival estimates for those for those in the HAS cohort who scored in the bottom (1) middle (2) and top (3) tertiles on the 'measuring ageing' component, where the those in the bottom tertile performing worst on measures of HA. The estimated mean time until death was 15.2 years for those in the lowest tertile, 15.0 years for those in the middle tertile and 15.1 years for those in the highest tertile. There was no significant difference between the tertiles (p=0.339).

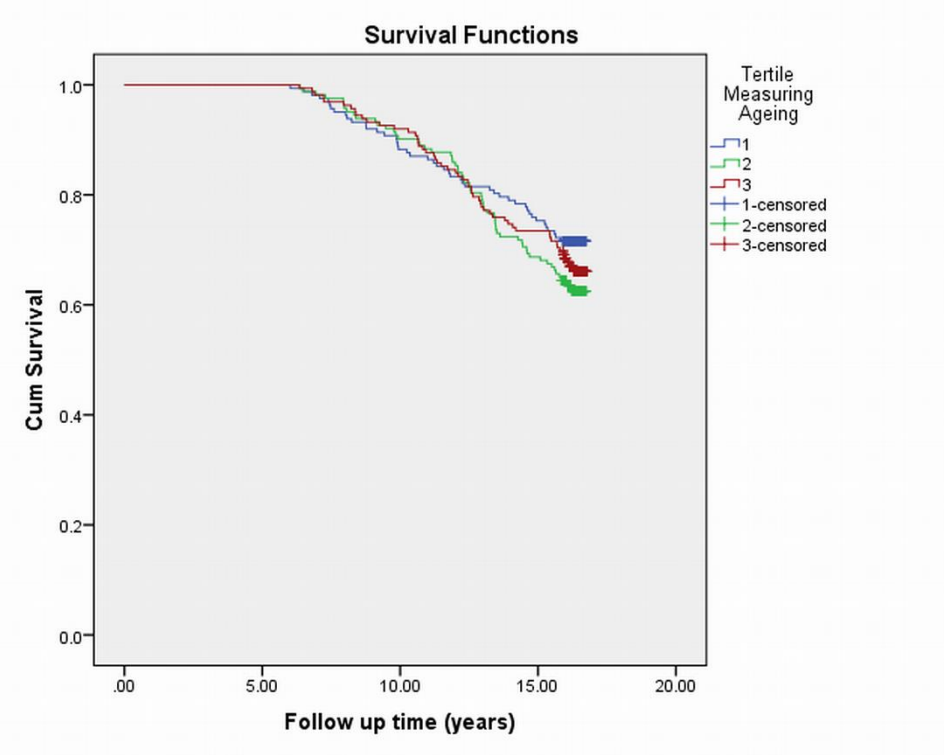


Figure 5.5. Kaplan-Meier survival curves for those in the HAS cohort in the bottom (1), middle (2) and top tertiles (3) in the 'measuring ageing' component where the bottom tertile represents poorer performance.

Approximately one third of HAS participants with 'measuring ageing' data available died during follow up. Overall, Cox proportional hazard modelling found no significant differences in mortality risk between 'measuring ageing' score tertiles in any of the models (Table 5.6).

Table 5.6. Cox proportional hazard models for prediction of mortality risk by tertile of scores on the 'measuring ageing component of healthy ageing among participants in the HAS cohort.

HAS cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)*	*p* value	Fully adjusted HR (95% CI)^	*p* value
N at risk	487					
N of events	160					
Tertile 1	0.85 (0.57-1.26)	0.412	0.89 (0.59-1.36)	0.615	0.93 (0.61-1.40)	0.723
Tertile 2	1.13 (0.78-1.63)	0.512	1.24 (0.85-1.82)	0.260	1.27 (0.87-1.85)	0.223
Tertile 3	1.00	-	1.00	-	1.00	-

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.4.5 Mood

Figure 5.6 shows survival estimates for those for those in the WII cohort who scored in the bottom (1) middle (2) and top (3) tertiles on the 'mood' component, where the those in the bottom tertile had the highest chance of mood disorder. The estimated mean time until death was 24.4 years for those in the lowest tertile, 24.2 years for those in the middle tertile and 25.3 years for those in the highest tertile. There was no significant difference between the tertiles (p=0.36).

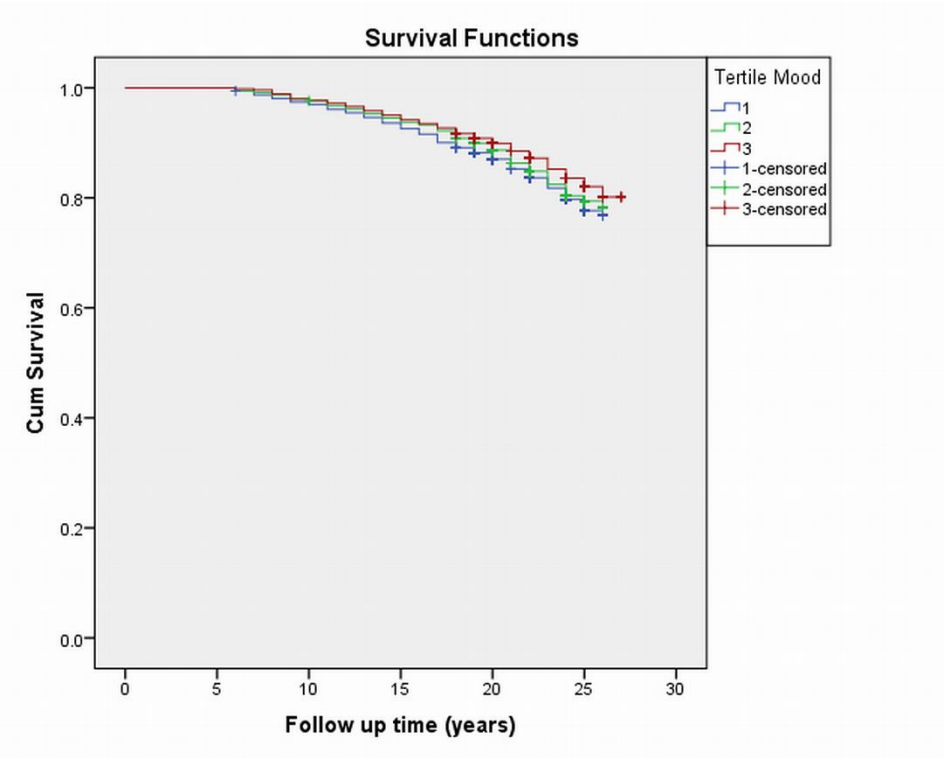


Figure 5.6. Kaplan-Meier survival curves for those in the WII cohort in the bottom (1), middle (2) and top tertiles (3) in the 'mood' component where the bottom tertile represents poorer scores on measures of mood.

Approximately 17% of WII participants with mood data available died during follow up. As shown in Table 5.7, there was no association of tertile of mood scores with mortality risk in any of the models (tertile 1 unadjusted HR 1.09, 95%CI 0.91-1.30, p=0.34, tertile 2 unadjusted HR 1.13, 95%CI 0.95-1.34, p=0.17).

Table 5.7. Cox proportional hazard models for prediction of mortality risk by tertile of scores on the 'mood' component of healthy ageing among participants in the WII cohort.

WII cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)	*p* value	Fully adjusted HR (95% CI)	*p* value
N at risk	4479					
N of events	765					
Tertile 1	1.09 (0.91-1.30)	0.34	1.06 (0.89-1.27)	0.51	1.04 (0.87-1.23)	0.64
Tertile 2	1.13 (0.95-1.34)	0.17	1.09 (0.92-1.30)	0.32	1.10 (0.92-1.32)	0.28
Tertile 3	1.00	-	1.00	-	1.00	-

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.5.6 Physical function

Figure 5.7 shows survival estimates for those for those in the HAS cohort who scored in the bottom (1) middle (2) and top (3) tertiles on the 'physical function' component, where the those in the bottom tertile performing the poorest on measures of physical function. The estimated mean time until death was 14.8 years for those in the lowest tertile, 15.2 years for those in the middle tertile and 15.3 years for those in the highest tertile. There was no significant difference between the tertiles (p=0.089).

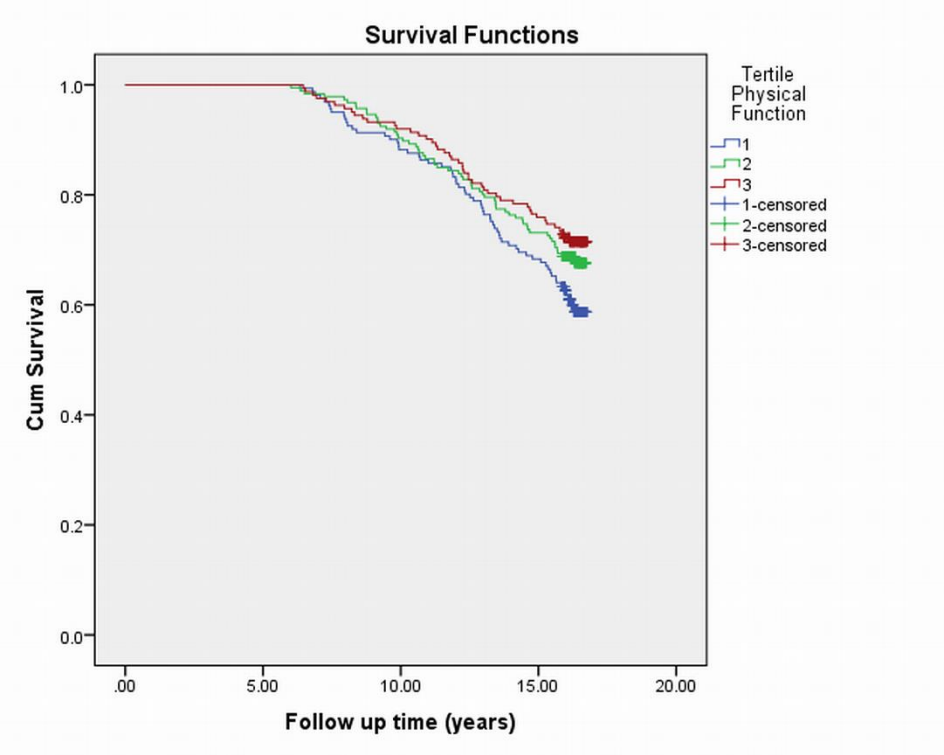


Figure 5.7. Kaplan-Meier survival curves for those in the HAS cohort in the bottom (1), middle (2) and top tertiles (3) in the 'physical function' component where the bottom tertile represents poorest performance.

As shown in Table 5.8, 33% of participants from the HAS cohort with data available for the 'physical function' component died during follow up. Participants with the poorest physical function had a 50% increased chance of all-cause mortality than participants with the best physical function scores. This increase was significant (unadjusted HR1.50, 95%CI 1.03-2.19), p=0.035) however this association became non-significant after adjusting for covariates (Table 5.8).

Table 5.8. Cox proportional hazard models for prediction of mortality risk by tertile of scores on the 'physical function' component of healthy ageing among participants in the HAS cohort

HAS cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)*	*p* value	Fully adjusted HR (95% CI)^	*p* value
N at risk	509					
N of events	169					
Tertile 1	1.50 (1.03-2.19)	0.035	1.46 (0.99-2.16)	0.055	1.43 (0.97-2.10)	0.071
Tertile 2	1.15 (0.78-1.69)	0.472	1.14 (0.75-1.65)	0.587	1.10 (0.75-1.63)	0.627
Tertile 3	1.00	-	1.00	-	1.00	-

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.5.7 Social support

Figure 5.8 shows survival estimates for those for those in the WII cohort who scored in the bottom (1) middle (2) and top (3) tertiles on the 'social support' component, where the those in the bottom tertile performing received the least social support. The estimated mean time until death was 24.4 years for those in the lowest tertile, 24.5 years for those in the middle tertile and 24.4 years for those in the highest tertile. There was no significant difference between the tertiles (p=0.626).

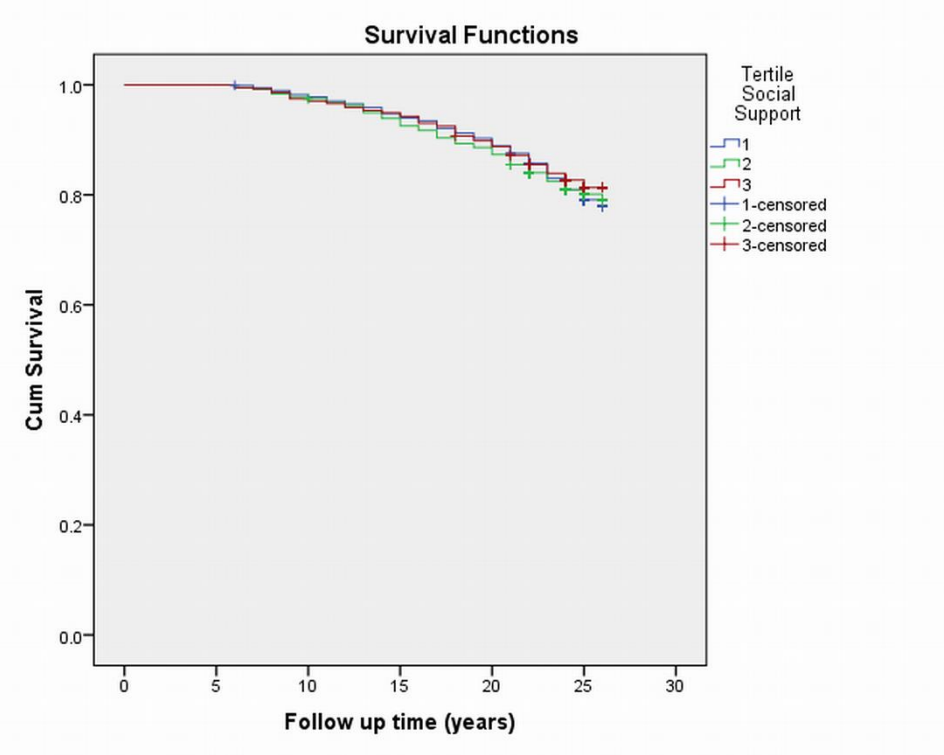


Figure 5.8. Kaplan-Meier survival curves for those in the WII cohort in the bottom (1), middle (2) and top tertiles (3) in the 'social support' component where the bottom tertile represents less social support.

Similarly there were no significant differences in all-cause mortality risk between either tertile 1 or 2 and the reference (tertile 3) in any of the model (Table 5.9).

Table 5.9. Cox proportional hazard models for prediction of mortality risk by tertile of scores on the 'social support' component of healthy ageing among participants in the WII cohort

WII cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)	*p* value	Fully adjusted HR (95% CI)	*p* value
N at risk	2858					
N of events	511					
Tertile 1	0.93 (0.75-1.15)	0.48	0.91 (0.73-1.13)	0.40	0.89 (0.72-1.11)	0.30
Tertile 2	1.02 (0.83-1.26)	0.83	1.02 (0.82-1.25)	0.89	0.99 (0.80-1.22)	0.94
Tertile 3	1.00	-	1.00	-	1.00	-

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.5.8 Wellbeing

Figure 5.9 shows survival estimates for those for those in the WII cohort who scored in the bottom (1) middle (2) and top (3) tertiles on the 'wellbeing' component, where the those in the bottom tertile reported the least wellbeing. The estimated mean time until death was 24.4 years for those in the lowest tertile, 24.5 years for those in the middle tertile and 24.3 years for those in the highest tertile. There was no significant difference between the tertiles (p=0.681).

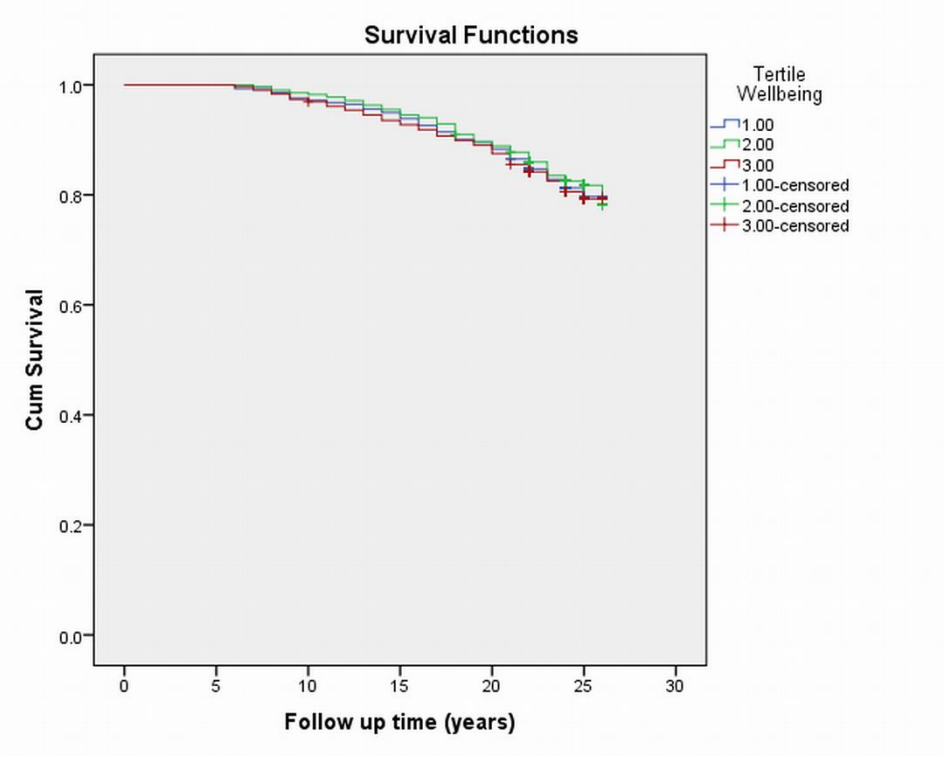


Figure 5.9. Kaplan-Meier survival curves for those in the WII cohort in the bottom (1), middle (2) and top tertiles (3) in the 'wellbeing' component where the bottom tertile represents lower wellbeing scores.

There were no significant differences in all-cause mortality risk between either tertile 1 or 2 and the reference (tertile 3) in any of the model (Table 5.10).

Table 5.10. Cox proportional hazard models for prediction of mortality risk by tertile of scores on the 'wellbeing' component of healthy ageing among participants in the WII cohort

WII cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)	*p* value	Fully adjusted HR (95% CI)	*p* value
N at risk	2742					
N of events	497					
Tertile 1	0.97 (0.79-1.18)	0.73	0.98 (0.80-1.19)	0.82	0.95 (0.78-1.16)	0.61
Tertile 2	0.89 (0.71-1.13)	0.33	0.89 (0.71-1.14)	0.37	0.87 (0.69-1.10)	0.25)
Tertile 3	1.00	-	1.00	-	1.00	-

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.5.9 Overall healthy ageing score

Figure 5.10 shows survival estimates for those for those in the HAS cohort who scored in the bottom (1) middle (2) and top (3) tertiles of the overall HA score, where the those in the bottom tertile performing the poorest overall scores of HA. The estimated mean time until death was 14.2 years for those in the lowest tertile, 14.7 years for those in the middle tertile and 15.9 years for those in the highest tertile. There was a significant difference between the tertiles (p=0.005).

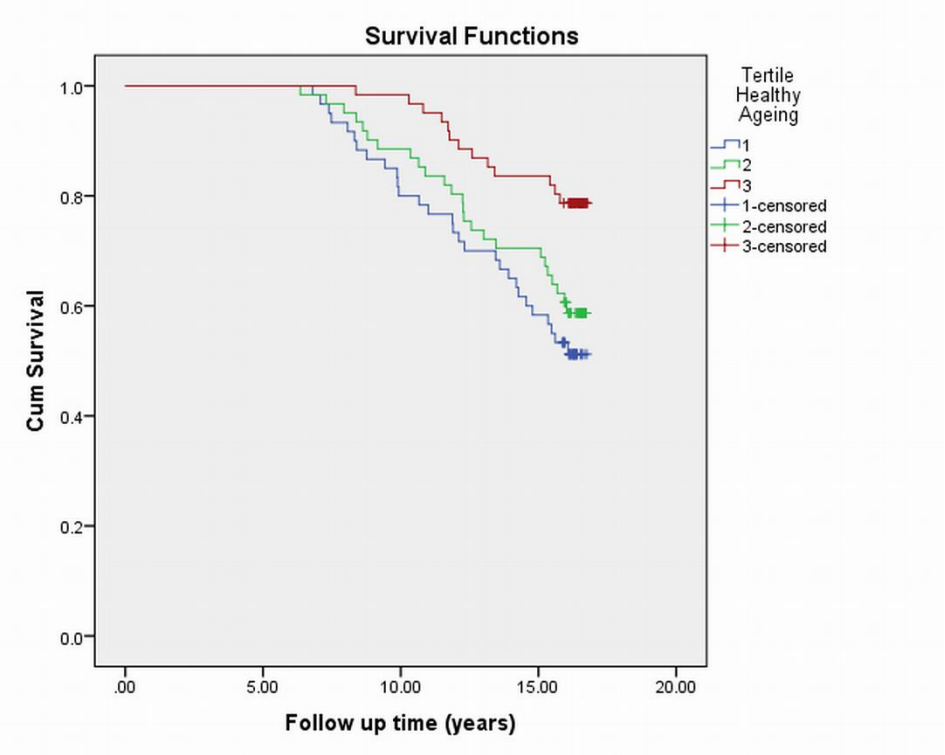


Figure 5.10. Kaplan-Meier survival curves for those in the HAS cohort in the bottom (1), middle (2) and top tertiles (3) of the overall healthy ageing score where the bottom tertile represents the lowest scores.

Of the 182 HAS participants who had data available to create a 'healthy ageing' score, 36.8% died during follow up. Cox proportional hazard models (Table 5.11) showed significantly increased mortality risk for participants in the bottom and middle tertiles of HA scores compared to those in the top tertile who had the best scores. In the fully adjusted models, this risk of all-cause mortality was 225% higher for those in tertile 1 (HR3.25, 95%CI 1.66-6.35, p=0.001) and 125% for those in tertile 2 (HR2.25, 95%CI 1.13-4.48, p=0.021).

There was no significant relationship between tertiles of HA scores and cancer mortality risk (tertile 1 unadjusted HR 1.10, 95%CI 0.33-3.68, p=0.87; tertile 2 unadjusted HR 0.99, 95%CI 0.29-3.39, p=0.99) or cardiovascular mortality risk (tertile 1 unadjusted HR 1.17, 95%CI 0.48-2.88, p=0.73; tertile 2 HR 0.89, 95%CI 0.73-2.27, p=0.82).

Table 5.11. Cox proportional hazard models for prediction of mortality risk by tertile of scores on the 'healthy ageing' component of healthy ageing among participants in the HAS cohort

HAS cohort						
Variable	Unadjusted HR (95% CI)	*p* value	Adjusted HR (95% CI)*	*p* value	Fully adjusted HR (95% CI)^	*p* value
N at risk	182					
N of events	67					
Tertile 1	2.83 (1.47-5.45)	0.002	3.01 (1.51-5.87)	0.001	3.25 (1.66-6.35)	0.001
Tertile 2	2.12 (1.13-4.33)	0.020	2.42 (1.22-4.77)	0.011	2.25 (1.13-4.48)	0.021
Tertile 3	1.00		1.00		1.00	

HR hazard ratio, *95% CI* 95% confidence intervals; * adjusted for age, sex and marital status; ^ adjusted for age, sex, marital status and smoking status

5.5 Discussion

5.5.1 Principal findings

The aim of this study was to examine the utility of components of HA identified in previous chapters by investigating associations between these components and mortality in prospective cohort studies. Composite variables corresponding to the selected components of HA were created from data collected in two cohort studies, HAS and WII. In addition, an overall HA score was calculated for HAS participants. A summary of the results is shown in Table 5.12. Participants who had the poorest brain function at baseline showed increased mortality at follow-up, an increase which remained significant after adjusting for all covariates in the HAS cohort but not the WII cohort. Similarly, participants with the greatest number of health problems in the WII cohort had increased mortality, in line with the findings of the review by Depp and Jeste (2006). However this finding was not replicated in the HAS cohort. Contrary to the available literature (e.g. Steptoe et al., 2015, Ellwardt et al., 2015, Holt-Lunstad et al., 2010), no association with mortality as found for 'measuring ageing', 'social support' or 'wellbeing'. The results for the 'physical function' component were mixed with no overall significant relationship between tertiles of the component and mortality reported in the Kaplan Meier analysis. However when pairs of tertiles were compared in the Cox proportional hazards model a significant increase in mortality risk was found for those with poorest physical function scores. This difference did not remain significant after the model was adjusted for covariates. As this study set out with an aim of examining whether there is any association between an overall score of HA and mortality, perhaps the most interesting finding was that the overall HA score created from HAS data was associated with a

225% increase in all-cause mortality for those on the bottom tertile of HA scores and a 125% increase for those in the middle tertile.

Table 5.12. Summary of the components of HA which have a relationship with mortality

Component of healthy ageing	Significance of association with all-cause mortality (unadjusted model)		Significance of association with all-cause mortality (fully adjusted model)	
Cohort	HAS	WII	HAS	WII
Brain function	Yes	Yes	Yes	No
Health problems	No	Yes	No	Yes
Physical function	Yes	N/A	No	N/A
Overall HA score	Yes	N/A	Yes	N/A

NB Components with no significant relationship with mortality are not included here

5.5.2 Strengths and limitations

This study has a number of strengths including the substantial length of follow up of participants in the relevant age range available from both the HAS and WII cohorts. Although HAS data was collected from individuals local to Hertfordshire, the mortality pattern of study participants is reported to be similar to the rest of England and Wales therefore is generalisable (Syddall et al., 2010). This study also goes further than previous attempts to quantify HA outcomes in older people by investigating more components of HA than in previous work (see Peel et al., 2004) and by creating a composite score for HA. In addition, by excluding deaths during the first 5 years of follow-up, the present study minimised possible confounding due to early deaths among those who were already ill at baseline.

However, there are also a number of limitations affecting the applicability and generalisability of these results including the difference in average age of participants between the two cohorts, with WII on average 14 years younger than HAS participants. However, this could also be viewed as a strength. The data from the two cohorts was not combined, nor was the data from one cohort used to validate the other , therefore the difference in average age between the two cohorts allowed the associations between components of HA and mortality in people towards the bottom and top of the 50 to 70 year age range at baseline to be investigated. WII data may not be as representative of the wider population as the sample was composed exclusively of civil servants, thereby not including manual workers. There was a disproportionate majority of men in the WII cohort, a problem not found in HAS, however WII has the advantage of being a much larger sample. Despite being a larger cohort, data from fewer participants were available for the analysis of brain function in the WII data compared to HAS because brain function data was only available for participants who entered the age range for this study during Phase 3 of WII data collection. Similarly, the lack of association of health problems with mortality found

in HAS data may be due to the low number of participants involved in the analysis. This relatively small number of participants with relevant data for a component and the correspondingly small number of deaths is also a more generic limitation of the work as a whole as the power of the study is limited. In line with the existing literature, no association was found between mood and mortality supporting the idea that there is no direct, independent relationship between mood and mortality (Liu et al., 2015). Another point to consider is the quality of the measurement of each HA component, specifically whether or not the instruments used in the cohort studies gave a reliable, precise measurement. However, due to practical constraints it was only possible to use the data available data. If this work were to be revisited in the future, more focus could be given to considering the quality of measurement in the cohorts. It would have been desirable to use cohorts which had an older average age to look at the association of HA components with mortality risk later in the life course. Using European and American cohorts, in addition to the two UK cohorts, would have increased the generalisability of the findings. Previous evidence suggests that there may be cultural differences in thinking about HA (e.g. Hung et al., 2010) therefore the results of this work should not be generalised outside of the UK population. Additionally, there are no data on ethnicity used in the current analysis so perhaps the results should not be generalised to the current, more diverse, UK population. Using some of the larger multi-cohort datasets would have allowed more variables, and therefore more components of HA, to be included in the analysis. However, due to the degree of harmonisation between datasets that would have been required, and the time to both obtain, clean and analyse the data, this was not practically possible.

It was only possible to partially fulfil the first aim of this study, to examine whether the ten components of HA identified in previous chapters are associated with mortality, as data was not available for three components, 'independence', 'fulfilling potential' and 'personality'. Further, data was only available from both cohort for two components, 'brain function' and 'health problems' and these components returned differing results in each cohort. Additionally, while 'brain function' was measured in the same way in both cohorts, 'health problems' was not, with more variables included in the WII analysis than in HAS. Similarly, the second aim, to examine the association between overall HA score and mortality was only partially fulfilled as the overall HA was intended to be a composite of score of all ten components. In actuality in this analysis it was the composite of four components. Possible solutions include expanding the study to more cohorts to include all ten components, or expanding the search outside of UK cohort to find cohorts which contain data relating to all ten components. Practically, however, this was not possible.

Possible explanations for the lack of an association of mortality with tertile scores of 'wellbeing', 'measuring ageing' or 'social support', contrary to the literature, include the different numbers of participants involved in each analysis, the sensitivity of tertile groupings to allow detection of differences between the 'best' and 'worst' performers on a component. With regard to covariates, it would have been preferable to include more and it would have been preferable to separate smokers in to previous, current and never rather than just current smokers or not current smokers, however these data were not available. Participants in the middle tertile of the health problems component had the longest estimated mean time until death while the survival curve for participants with the fewest health problems, in the third tertile, dropped beneath that of the middle tertile after approximately ten years of follow up. The data for the health problems component was triple checked to ensure coding of data and assignation of tertiles had been performed correctly and no errors could be found. Reasons for this difference could be postulated, for example this data relied on diagnosed health problems so perhaps individuals who did not present to their GP and therefore did not receive a diagnosis may have had a health problem which left untreated contributed to mortality rates. However the most prudent course of action would be to repeat the analysis using a time-dependent Cox model in order to examine the relationship of tertiles of health problem scores before and after changes occur at ten year follow up. One limitation unique to the analysis of the 'mood' component is that it was based on one measure, the GHQ, which has a focus on anxiety and depression. Both of these disorders can have complex aetiology involving a variety of other factors, therefore mood may not be independently or directly related to mortality as suggested by previous literature (Almeida et al., 2015, Liu et al., 2015).

5.5.3 Conclusions

The components 'brain function', 'health problems', and 'physical function' measured at 50 to 70 years are predictive of twenty-year mortality. Overall HA score also significantly predicted mortality risk. This is a significant, novel contribution to HA research.

5.5.4 Future research

Further work could be completed with the datasets used in this study. It would be interesting to repeat the Cox proportional hazards models using quintiles rather than tertiles, where sample size would allow, in order to add precision, however this would have lowered the number of participants in each group, problematic for the components with data available from fewer participants, particularly in HAS. For a more in-depth analysis, components where there is crossover between the survival curves for each tertile within a component could be re-examined using time-dependent Cox models. Using other, similar datasets it would also be interesting to repeat the analysis of relationship of 'mood' with mortality risk on data which came from more than one measurement tool. Considering the wider view of the work, it would be desirable to expand the analysis to look at more cohorts so that all ten

components and therefore an overall HA score could be examined. Comparisons with cohort data from outside the UK could be performed in order to contribute to understanding of the cultural differences in HA. A meta-analytical approach could be taken in order to pool data across a larger number of cohort studies. It would also be advantageous to include cohorts which are still following up their participants, and similarly to look back at data from younger individuals, so that it time these analyses can be performed on data from older age groups and a profile can be built up of how the association of the components of HA with mortality risk changes across the life course. Considering different approaches to investigating the utility of the HA components as predictors of mortality, once the relationship between each of the ten components of HA and mortality is fully understood, a more specific and sensitive composite score for HA could be developed based on only those components which show a relationship with mortality. Finally, with time and progression in the field of HA research, a definition of HA may have progressed to the stage that it is no longer necessary to rely on surrogates such as mortality.

Chapter 6. General Discussion

6.1 Main findings

This thesis set out to evaluate the perceived importance of components of HA and their relationship with mortality and had the following broad aims:

1. Investigate how HA has been defined and measured by expanding upon and updating a previous literature review (Depp and Jeste, 2006) to explore the terms used to describe HA in the literature and to review the way HA has been defined and measured in the past.
2. Examine whether there are any differences in what academics and older people think is important for HA. This was examined in two ways: a) by comparing how people with varying levels of expertise create components of HA from the elements of HA identified in the literature review, b) by examining the differences in ratings and rankings of components of HA between academics and older people, and between different age groups, sexes and ethnic groups.
3. Examine whether these components of HA, as well as and overall HA score, have an association with mortality risk in order to identify whether the components or the overall score could be a useful tool to measure to the utility of intervention studies designed to promote HA.

Overall, these aims have been achieved through a series of studies, each one building upon the previous. A systematic literature search and narrative review allowed elements of HA to be identified from previous literature followed by categorisation of these elements in CSTs to create components of HA to be used in the survey work and to examine how different groups (academics and older people) created these categories. This review was an update of previous review by Depp and Jeste (2006), selected because it is widely cited in the literature and, at the time the review was conducted, it was the only study to include components, metrics and operationalisations of HA in the same study. CSTs were selected over other methods because they allowed comparison of expert (academic) and novice (older people) categorisation, to elucidate whether academics and lay people thought about HA in different ways (e.g. Nielsen and Sano, 1994, Fincher and Tenenerg, 2005). The similarity of the ten components created by academics with an interest in ageing and by “novices” in the CSTs to the components identified by Depp and Jeste (2006) could suggest either support for Depp and Jeste’s components or highlight the bias created by influence of the biomedical model on Depp and Jeste’s work. By including quantitative studies only, mainly from research groups with an area of expertise based within the biomedical models (Medline and Embase have a biomedical focus while PsycInfo concentrates on behavioural sciences), the components found in Depp and Jeste’s work, and the work presented here (based on the components created by academics with an interest in ageing), may not reflect the components which would have been created if a more holistic sample was used and

warrants further investigation if a future definition of HA is truly to be a consensus definition. The components created were then used in a) survey work to examine how people of different ages, sex, or ethnic groups ranked the components of HA and b) in analyses of cohort data to examine whether components of HA could be used to predict mortality risk and therefore as a useful measure of the utility of intervention studies to promote HA. It is known from previous work that age, sex and ethnicity can affect perceptions of HA (Cho et al., 2012, Bowling, 2006, Tate et al., 2013, Jopp, 2015, Phelan et al., 2004, Hsu, 2007), however the inter-group differences which I observed were much smaller than those suggested by this literature. Assessing the utility of these components as predictors of mortality risk in cohort data was a novel approach. However, although mortality is the best surrogate endpoint of HA currently available, it is by nature the opposite of HA.

In Chapter 2, a literature review was used to examine previously published definitions and operationalisations of HA. Sixty papers were identified which contained 280 elements of HA measured by 269 unique metrics and operationalised in 396 ways. Terms used to describe HA were identified, with successful ageing as the most frequently used. Elements and operationalisations of HA were also identified, with aspects of ageing which come under the biomedical model of ageing as the most prevalent. Operationalisations of HA varied widely with no clear cut off points to represent HA for any of the metrics identified. However, only two databases were searched for studies to include in the review and study quality was not assessed so no conclusions can be drawn about the strength of the strength of the evidence presented. Similarly, grey literature was not included, nor were qualitative papers therefore the results of the review will be skewed towards quantitative paradigms. If grey and qualitative literature had been in included, the biomedical model may not have been as over-represented.

Chapter 3 built upon Chapter 2 by using CSTs to help aggregate the large number of elements of HA identified by the literature review into coherent groups which I have called components. The categorisation of elements of HA in CSTs by different population groups revealed ten components of HA: measuring ageing, health problems, independence, mood, personality, brain function, fulfilling potential, wellbeing, social support and physical function. This work has shown that there is general agreement between several population groups including academics (with and without specialist knowledge of age) and older people in the way that elements of HA are grouped. It has also shown that despite the prevalence of the biomedical model a more holistic view of HA should be considered. This chapter partially fulfilled the second overall aim of thesis by comparing how people with varying levels of expertise create components of HA from the elements of HA identified in the literature review. However, the limitations of the samples of participants included in the CST, such as age and small number of participants limit the generalisability of these findings. Nonetheless, as this work was

exploratory and originally only intended as a method of preparing the surveys (Chapter 4) from the outcomes of the literature review (Chapter 2) it has fulfilled its function.

The components of HA established in Chapter 3 were used as the basis for the survey work in Chapter 4. The survey work of importance rankings of the ten components of HA in Chapter 4 revealed overall similarity in the way that different groups rank the importance of the ten components of HA. This chapter went some way to addressing the second overall aim by examining how people of different age, sex and ethnicity ranked the ten components of HA. However, no data for the oldest old was obtained in the survey work, possibly due to the use of an online survey. Supplementary qualitative work may have had better results at obtaining the opinions of the older population.

Chapter 5 used data from two cohorts (HAS and WII) to test the utility of HA components by investigating associations between the components of HA measured in middle-age and measures of mortality. As the survey work (Chapter 4) did not reveal any clear hierarchy of importance of the ten components, all of the components were treated with equal interest in the analysis of cohort data. The work in Chapter 5 showed that, for a number of components of HA including brain function and health problems, measurements made in middle-age predicted mortality up to 20 years later. Further, those participants with the lowest overall HA score had 225% increased risk all-cause mortality in the HAS cohort. This chapter partially achieved the final overall aim, to examine the components of HA, as well as HA overall have an association with mortality risk. However, all ten components were not represented by the data obtained so their association with mortality could not be tested, nor was the overall HA score inclusive of all ten components. As the cohorts were both UK based there are issues of generalisability as addressed in the discussion section of Chapter 5.

6.2 Strengths and limitations

While the specific strengths, limitations, conclusions and suggestions for future work for each aspect of this PhD project are discussed within each experimental chapter (Chapters 2-5), there are some overall strengths and limitations of the work which should be noted.

There are several strengths of the work presented in this thesis. The work in each chapter of this thesis was informed by, and has built upon, the results of the previous chapter. Importantly, although there have been some previous reviews of the constituent parts of definitions of HA (Phelan and Larson, 2002, Peel et al., 2004, Depp and Jeste, 2006, Hung et al., 2010, Cosco et al., 2013), the limitations of these reviews, discussed in Chapter 1 Section 1.4, meant that they did not provide a sufficient basis for the CST. The new systematic review conducted here (Chapter 2) had the advantage that it provided a solid, up-to-date base for the rest of the project. In addition, the use of wider search terms and of three different databases ensured that the uncovered definitions of HA were as comprehensive as possible. The CSTs drew together a wider range of work, as well building on previous reviews by

examining definitions of HA in more detail and also raising questions about nomenclature in the area. This wider range of work allowed more stimuli to be included in the CSTs, allowing a more comprehensive piece of work on categorisation than would have been possible using only data from previous reviews. The novel approach of using a CST methodology to create categories of HA worked well and allowed comparison between different groups. Although comparisons between older lay people and academics have been made before (e.g. Hung et al., 2010), examining similarities and differences between how academics who specialise in ageing categorise elements of HA compared with academics from different specialities was a novel strategy. This strategy built on previous work by assessing whether it was the academics' expertise in ageing which was responsible for previous differences found in definitions of HA given by older lay people and academics, or whether it was the expert level of categorisation that academics employ as a result of years of training to think critically. The main finding of similarity between the components of HA created by groups in the CSTs provided confidence that the components of HA used in the subsequent survey work were representative of both academics and older people's understanding of HA. While survey work has been used previously to explicate the importance ratings of components of HA (Phelan et al., 2004, Fernandez-Ballesteros et al., 2010, Matsubayashi et al., 2006, Hsu, 2007) the survey work presented in Chapter 4 added to this area by comparing rankings given by different groups (academics, lay people, different age groups, different sexes and different ethnic groups). Having participants give rankings of all of the ten components was also an innovative approach compared to previous work. Using Survey Monkey to facilitate this work provided access to a larger number and wider range of participants than would otherwise have been available.

Although the use of different methodologies was necessary to answer the different research questions in each chapter, an advantage to using different methodologies for the studies in Chapter 2, 3 and 4 is that has allowed a wider view to be taken towards answering some of the larger questions still unanswered in HA research, such as differences between groups, and has highlighted the lack of consistency among definitions. Taken together, the main finding of the work reported in Chapter 3 and Chapter 4 was one of similarity. Replicating this finding using different methods increases confidence in the results as well as showing that these different methods have a useful role to play in future HA research. The work on the power of the components of HA measured in middle age to predict mortality up to 20 years later, described in Chapter 5, is novel. This study is one of the few attempts to determine the utility of components of HA by examining links with mortality in large longitudinal cohorts. This chapter, which came about because of enforced changes to the original structure of thesis (described in Chapter 1 Section 1.6.3), introduced an objective assessment of components of HA and.

There are also several limitations of the work as a whole which should be acknowledged. Before changes to the original structure of this PhD project became necessary, the intention was to use a Delphi survey methodology. A Delphi survey would have allowed a consensus definition of HA to be developed, using input from academics and older people, before the work in subsequent chapter was undertaken. Further, the CST was originally intended only as a short piece of bridging work between literature review and the survey work. However, due to the changes to the original structure the decision was taken to expand the CST work. By this point though, Survey 1 had already been designed using data from the first CST and had been run. Ideally, the survey work would have been based on the overall results of all of the CSTs and the tasks would have iterative, with participants having time to reflect on the categories they had created. The number of stimuli included in the CSTs was far larger than the recommended CSTs procedure and as a result it was not possible to use free analysis software. This necessitated finding new ways to analyse the CST data and therefore heat maps were used to reduce and display the data. Although widely used in the analysis of biological 'omics' data, this was a first attempt at using the heat map technique to summarise a large social science data set and seems to be a promising avenue worth developing further.

For development of future public health interventions to encourage HA, the important thing is not whether the definition of HA adopted by the intervention was made by academic or lay people, only that it is multidimensional. There appears to be little difference between different population groups and across the life course as to what is a priority to achieve HA, therefore interventions could be aimed at younger age groups in order to produce a larger impact (Fries, 2005) . The results presented in this work suggested that future interventions could be tailored by personality type in order to improve effectiveness. The development of an overall HA score could become a standardised way of measuring the utility of future HA interventions. This would also enable comparison between studies.

6.3 Conclusions

The studies reported within this thesis have updated and expanded upon previous literature reviews to highlight the inconsistency in terms used to refer to HA and the broad range of published definitions of HA. The wide variety of elements, metrics and operationalisations of HA found by the review demonstrate the need for consensus in the field over how to define and measure HA before progress can be made on a consensus definition of HA. The finding that aspects of biomedical model are most prevalent in the literature review supports previous literature which argues for a more holistic approach to HA and for a more inclusive role for the views of older people. However, through looking at cohort data no strong evidence could be found for an association between mortality risk and the components of HA ranked most highly by older people. The CSTs and survey work have shown the similarities in the conceptualisation of HA and in the perceived importance of components of HA across different groups, fewer differences than predicted by the previous literature. The component

'personality' was the only component to be ranked differently by all groups and while personality itself is an unlikely target of future HA interventions, it would be possible to tailor intervention to promote healthy ageing according to personality type or certain personality traits. An overall score of HA was significantly associated with mortality, as well as the individual components 'brain function' and 'health problems'. In particular, the overall HA score has the potential to be developed further and used in future work surrounding measuring HA and predicting mortality risk.

The overall conclusion of this thesis is that different groups perceive the importance of components of HA in a very similar way, contrary to previous literature, and it appears that there is a relationship between the broader concept of HA and mortality. The finding of similarity between academics and older people is an important one as it had been argued that imposing the views of researchers about what is important for HA would not enable the development of intervention to promote HA that were relevant to older people. Further, lessons learned from this work regarding the similarity of importance of HA components in several population groups, including younger people and ethnic minorities, provide a sound starting point for future work.

6.4 Future research

In addition to the suggestions for future work specific to each chapter, the findings of the work presented in this thesis as a whole provide several insights for the direction of future research. Further research should be undertaken in order to find consistent ways to discuss, define and operationalise HA, with a view to developing a consensus in the field. In order to achieve this, more and larger scale studies are needed rather than the small scale pieces of work which have been done in the past. In this way, studies could examine a wealth of evidence produced using different methodologies rather than choosing between different methodologies such as reviews or survey work, rather than both.

There were several questions that could not be addressed through the work presented in this thesis. Two questions relate to the systematic review. First, would inclusion of grey literature and academic qualitative literature change the outcomes of the systematic review? Second, what is the strength of the evidence included in the review and would setting a certain quality level threshold for inclusion of studies in the review have changed the number of papers included in the review and, therefore, affected the number and range of outcomes? As the subsequent studies in Chapters 3, 4 and 5 were based on the outcome of the literature review, any changes to the outcomes of the literature review could have had far reaching implications for the rest of the work. Moving on from the systematic review work, it would have been desirable to look more in depth at the cross-over between elements placed in the mood and personality categories by the three groups during the CSTs to determine whether participants' understanding of the two categories was equivalent across groups. Although ranking of importance of HA components was examined across the life-course, the survey work could

not answer how the oldest old would rank the components of HA as no data were collected from anyone over 70 years of age, potentially due to the online nature of the survey. Whilst this limits the generalisability of my findings, it is less of an issue within the context of the LiveWell Programme which focussed on the peri-retirement period. It would also be desirable in future work to examine the impact of cultural differences on perceptions of importance of components of HA, which was not examined in this thesis. There are suggestions from previous literature that such cultural differences exist (e.g. Hung et al., 2010). However, I did not collect information on the cultural background of participants in my survey so that it is not possible to support or contradict previous work using my findings. Finally, as not all ten components of HA were included in the cohort survival analysis, no conclusions can be drawn about their relationship with mortality risk or if the composite HA score incorporating all ten components would have had a different relationship with morality risk. If it was the case that adding in the additional components to the overall HA score changed the association with mortality risk, further questions would be raised about the hierarchy of the ten HA components and their independence.

Arriving at a consensus definition of HA would be a very important development for HA research. It would allow the field to move on from defining the topic to focus on finding ways to measure HA. Although work has begun to develop methods of measuring HA and the HAP (Lara et al., 2013, Lara et al., 2015). Finding a gold standard method to measure HA would allow more insightful work on the prevalence of HA in a given population to be carried out. The problem with work done on prevalence estimates this far is that they are dependent on whichever definitions of HA used in that particular piece of work, meaning that comparisons cannot be made between studies. Having prevalence estimates of HA would be helpful for policy makers and for the future planning of health care services. Finding a standard method by which to measure HA would be particularly useful for evaluating the outcomes of interventions designed to improve HA as would the development of a method to predict mortality from measures of HA.

Ten components of HA were identified in this thesis, but no claims were made about the independence of these components. A natural progression from the work on components of HA would be to examine the relatedness of the components. For example, brain function and health problems are separate components but the link between brain function and cardiovascular health is well established. Similarly, health problems and physical function are likely to involve a degree of crossover, as are wellbeing and social support. The multidimensional nature of the components identified here also raises questions about existing models of HA. The work presented here has shown that HA is more than a biomedical or psychosocial model alone can account for. A new model of HA, which takes a more holistic approach to the multifaceted nature of ageing, will require development.

Unlike frailty, HA as a field of research does not have a particularly clinical focus. An argument could be made that while frailty should be in the clinical domain because it may require attention by clinicians, promoting HA is not solely a clinical issue and non-clinical factors have bigger roles in maximising HA than do clinicians. For the outcomes of HA research to be useful for the general population, more interventions to promote HA improve HA outcomes should be developed, similar to the work of the LiveWell programme. This is an important change of direction as previously the focus has tended towards lifespan. Although extending life span is an admirable goal, at a time when the older population is growing, which has social and economic implications for society, policy makers, health care planners and researchers would perhaps better spend their efforts extending health span. By encouraging people to focus on their health in later life, it is possible that quality of life will be improved and that some of the costs associated with an ageing population will be reduced. While the advantages of having a larger proportion of older people in the population (e.g. breadth and depth of experience) are not often discussed, the economic burden of the older population is a key point for policy makers. By adopting the approach taken by the LiveWell programme and designing interventions to promote HA around what older people consider to be important for them, older people will be more engaged with these interventions and so the chances of them having a positive impact on the lives of older people, while simultaneously reducing the costs of ageing population, will be improved.

6.5. Implications for policy, practice and future work

Overall, the work produced for this thesis has highlighted the problems that can be caused by creating a definition of HA based on data mainly derived from one theoretical standpoint. Although prevalent, the biomedical model does not encompass psychosocial factors which are repeatedly demonstrated to be important to older people. However, this work has also highlighted that differences between academics and older people may be less extensive than previously thought, suggesting that the work presented here can provide a good framework with which advance the field towards a consensus definition of HA. To create a definition of HA that is important and meaningful both to the academics working within the ageing field and the older populations to whom such definition will applied, it is important to take a more holistic approach. The later results presented in this thesis suggest that an overall estimate of HA has the potential to be a useful measure for evaluating the utility of future intervention studies to promote HA. However a change in the current climate of opinion towards ageing is required before such as measure would be seen as the gold standard. In modern Western culture ageing is often viewed, and presented in the media, in a negative light with undue emphasis on the negative connotations of ageing, such as health care costs and dependency on adult children who must simultaneously provide care for their own children.

Considering the ageing population of the UK, policies are required which help to promote HA but this presents two main difficulties for policy makers. First, without a standardised definition of HA there can be no standardised way to measure it. Without a standard method of measurement, assessments of HA will not be adopted into routine clinical practice and accurately assessing the prevalence of HA will be impossible (hence the current range of 0.2 to 97% estimated prevalence of HA in previous studies using difference measures of HA). Without an accurate assessment of the prevalence of HA, policy makers will have a difficult task determining what resources should be devoted towards HA promotion. Second, as public opinion plays a role in policy development, education is required to change the public perception of ageing as a burden on the rest of the population (health care costs, pensions etc.) towards a more positive view. If older people can be helped to age in a healthy manner, health care costs and resource use will reduce, older people will be able to stay active and contribute to society for longer, perhaps contributing to child care, the voluntary sector and the economy through the rise of the so-called grey pound. At the moment, surrogate measures of HA are negative ones, for instance the use of mortality as surrogate endpoint. However, knowing how long someone survived does not provide any information about the quality of their later years. It is the job of researchers in the field to develop a consensus definition of HA to allow more positive measures of HA to be found, so that data which capture the positive aspects of ageing can be used to inform policy makers' decisions. Currently, measurements made using biomarkers are popular because of their likely cost effectiveness as well as their ease of use. Until policy makers can be convinced of the advantages of developing these positive measure they are not likely to be funded, thereby hindering the development of HA research.

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Appendix A. Search strategy

Database: Ovid MEDLINE(R)

Search Strategy:

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1 ((success$ or health$ or productive or optim$ or well or positiv$ or unimpaired or dynamic or effective or robust or exceptional) adj3 (survival or longevity or ag?ing or life span or health span or lifespan or healthspan)).mp.

2 (define or definition or predict$ or concept$ or correlat$).mp. [mp=title, abstract, original title, name of substance word, subject heading word, protocol supplementary concept, rare disease supplementary concept, unique identifier]

3 1 and 2

4 exp animals/

5 humans/

6 4 not 5

7 3 not 6

Appendix B. Papers included in the review

Author	N	Age		Gender	Country	Ethnicity of sample	Study type	Sample type	Term Used
		Mean	Range						
Achour et al. (2011)	686	72.9±1.2		M=278 F=508	France	-	Prospective cohort study	Community dwelling	Successful ageing
Albert et al. (1995)	1,011	74.27±2.72	70-79	-	USA	-	Longitudinal	Community dwelling	Successful ageing
Almeida et al. (2006)	601	-	80+	M=100% F=0	Australia	-	Prospective cohort	-	Successful ageing
Andrews et al. (2002)	1,403	-	70+	M=778 F= 625	Australia	-	Prospective cohort	Community dwelling & residential care	Successful ageing
Avlund et al. (1999)	477	75	75	M=220 F=257	Denmark	-	Cross-sectional	-	Active life
Baltes and Lang (1997)	516	84.9±8.7	70-103		Germany	-	Prospective cohort	86% community dwelling, 14% institutionalised	Successful ageing
Berkman et al. (1993)	1,354		70-79	M=603 F=751	USA	-	Prospective cohort	-	Successful ageing
Britton et al. (2008)	5,963	44	35-55	M=4,140 F=1,823	UK	-	Longitudinal	Civil service workers	Successful ageing
Burke et al. (2001b)	5,888		65+	M=1,299 F=2,043	USA	11.6% African American	Longitudinal cohort study	Community dwelling	Healthy ageing
Castro-Lionard et al. (2011)	686	79±1.2	-	M= 280 F=406	France	-	Prospective cohort	Community dwelling	Successful ageing
Cernin et al. (2011)	67	73		M= 12 F=55	USA	African American	Cross-sectional	Community dwelling	Successful ageing

Cha et al. (2011)	305	70.95	60+	M=83 F=222	Korea	Korean	Cross-sectional	Convenience sampling	Successful ageing
Christensen et al. (2009a)	1,826		70-99	M=840 F=986	Denmark	-	Prospective cohort	-	Perceived age
Costa et al. (2000)	1,606		60-95	M=642 F=964	Brazil	-	Prospective cohort	Community dwelling	Health and ageing
Day and Day (1993)	489	-	77-87	M=0 F=100	USA	100% White	Longitudinal	Community dwelling and institutionalised	Successful ageing
de Moraes and de Azevedo e Souza (2005)	400	68.43±6.66	60+	M=104 F=296	Brazil	-	Cross-sectional	Community dwelling	Successful ageing
Driscoll et al. (2008)	64	79±3.3		M=34 F=30	USA	10.9% African American	Cross-sectional	-	Successful agers and Ageing well
Dupre et al. (2008)	13,297	-	80 +	M=5454 F=7843	China	Han majority	Longitudinal	-	Longevity
Fernandez-Ballesteros (2011)	458	66.47	55-75	M=170 F=288	Spain	-	Longitudinal	Community dwelling and residential care	Positive ageing
Ford et al. (2000)	487	77.5	70+	M=145 = 342	USA	34.5% Black	Prospective cohort	Non-institutionalised	Successful ageing
Garfein and Herzog (1995)	1,644	-	60-96	M=540 F=1104	USA	90.8% white 9.2% black	Longitudinal cohort	-	Robust ageing
Gow et al. (2007)	497	79.1	-	-	Scotland	-	Retrospective cohort	-	Successful ageing

Grundy and Bowling (1999)	253	-	85+	M=41 F=212	UK	-	Longitudinal cohort	Non-institutionalised	Quality of extended life years
Guralnik and Kaplan (1989)	496	-	65-89	-	USA	19.4% Black	Longitudinal	-	Healthy ageing
Hogan et al. (1999)	1,799	-	85+	-	Canada	-	Longitudinal	Community dwelling and institutionalised	Health and ageing
Holahan et al. (2001)	399	79.63	75-84	M=194 F=205	USA	-	Longitudinal cohort	-	Successful ageing
Holahan and Velasquez (2011)	242	86.35(4.02)	75-95	M=114 F=128	USA	-	Longitudinal cohort	-	Successful later ageing
Ibrahim et al. (2010)	113	63	55+	M=58 F=55	USA	36% African America, 60% Caucasian, 2% Latino, 2% Other	Cross-sectional	Community dwelling	Successful ageing
Jorm et al. (1998)	1,045	-	70+	-	Australia	-	Cross-sectional	945 community dwelling, 100 residential care	Successful ageing
Lamb and Myers (1999)		-	60+	-	Indonesia, Sri Lanka & Thailand	-	Retrospective cohort	Community dwelling	Successful ageing
Lee et al. (2011)	312	74.51±6.29	-	M=157 F=155	Taiwan	-	Prospective cohort	-	Successful ageing
Leveille et al. (1999)	10,294	-	65+	-	USA	-	Prospective cohort	-	Successful ageing

Li et al. (2006)	1,640	72.67±5.71	65-99	M= 773 F=867	China	-	Cross-sectional	Community dwelling	Successful ageing
Liang et al. (2003)	2,200	-	60+	-	Japan	-	Longitudinal cohort	-	Successful ageing
Litwin (2005)	3,403	-	60+	-	Israel	60% Jewish-Israelis, 18% Arab-Israelis, 22% Russian Jews	Cross-sectional	Community dwelling	Successful ageing
McLaughlin et al. (2010)	9,236	-	65+	M=3815 F=5421	USA	87.4% White, 8% Black, 4.6% Hispanic	Longitudinal cohort	-	Successful ageing
Montross et al. (2006)	205	80.4±7.5	60-99	M=40%, F=60%	USA	96% White	Cross-sectional	Community dwelling	Successful ageing
Negash et al. (2011)	560	79.7±6.5	65+	M=192 F=368	USA	-	Retrospective cohort	Community dwelling	Successful ageing
Newman et al. (2003)	2,932	M=72.3±5.2 F=71.6±5.1	65+	M=1131 F=1801	USA	13% Black	Longitudinal cohort study	Community dwelling	Successful ageing
O'Rourke (2000)	143	79.7±6.69	65+	M=65 F=78	Canada	-	Longitudinal cohort	Community dwelling	Successful ageing
Parslow et al. (2011)	2,286	71.1±6.7	61-85	M=1127 F=1159	Australia	70.2% Australian	Cross-sectional	Community dwelling	Successful ageing
Palmore (1969)	268	-	60-94	-	USA	-	Longitudinal	Community dwelling	Longevity
Palmore (1979)	155	-	60-74	M=72 F=83	USA	65% White 35% Black	Longitudinal cohort	Community dwelling	Successful ageing

Pruchno et al. (2010)	5,688	60.7±7.1	50-70	M=2067 F=3621	USA	83.8% white 11.8% African American	Cross-sectional	Community dwelling	Successful ageing
Reed et al. (1998)	6,505	-	70-85	M=6505	Japan		Longitudinal cohort study	-	Healthy ageing
Robare et al. (2011)	389	73.9±5.4	-	M=158 F=231	USA	94.9% White 5.1% Black	Community based randomised trial	Community dwelling	Healthy ageing
Roos and Havens (1991)	2,943	-	65-84	M=1429 F=1514	Canada	-	Longitudinal cohort	Community dwelling	Successful ageing
Schonfield (1973)	100	72.36±6.07	65+	M=0 F=100	Canada	-	Cross-sectional	Community dwelling	Successful ageing
Simons et al. (2000)	2,805	65.7	60+	M=1235 F=1570	Australia	-	Longitudinal	Community dwelling	Healthy ageing
Strawbridge et al. (1996)	356	71.9	65+	M=147 F=209	USA	12% Black 88% White	Longitudinal	Community dwelling and nursing home residents`	Successful ageing
Strawbridge et al. (2002)	867	75	65-99	M=383 F=484	USA	5.5% African American, 4.2% Hispanic, 1.4% Native American	Longitudinal	Community dwelling	Successful ageing
Swindell et al. (2010)	4,097	-	65-69	M=0 F=4097	USA	100% Caucasian	Prospective cohort	Community dwelling	Healthy ageing

Tyas et al. (2007)	636	83	75-102	M=0 F=636	USA	-	Longitudinal	Members of School Sisters of Notre Dame (Roman Catholic Nuns)	Healthy ageing
Uotinen et al. (2003)	426	-	65-84	M=162 38% F=264 62%	Finland	-	Longitudinal	Community dwelling	Successful ageing
Vaillant and Vaillant (1990)	173	63±1	-	M=173 F=0	USA	100% white	Longitudinal	Harvard university students	Successful ageing
Vaillant and Mukamal (2001)	569	-	65-80	M=569 F=0	USA	-	Longitudinal	Community dwelling	Successful ageing
von Faber et al. (2001)	599	85	85	M=202 F=397	Netherlands	-	Longitudinal	Community dwelling & institutionalised	Successful aging
Wahlund et al. (1996)	24	79	75-85	M=8 F=16	Sweden	-	Clinical study	-	Successful ageing
Wiest et al. (2011)	3,124	58.9±12	40-85	M=53% F=47%	Germany	-	Cross-sectional	Community dwelling	Wellbeing
Young (2009)	2,616	-	65-85	M=91 F=2525	USA	-	Two longitudinal cohorts and one cross-sectional	Community dwelling	Successful ageing

Appendix C. Data extracted during the review

Elements	Paper	Measurement Type/Operationalisations
Abstract Reasoning	Andrews 2002	Wechsler Adult Intelligence Scale similarity items
	Castro-Lionard 2011	Wechsler Adult Intelligence Scale Total score
Accomplishment	Cha 2011	Yoon instrument
Acting Out	Vaillant 2001	DSM-IV Defensive Functioning Scale
Activity	Achour 2011	Population Physical Activity Questionnaire
	Baltes 1997	YI Instrument
	Garfein 1995	Frequency of activity
	Grundy 1999	Limited Never/rarely/often/sometimes/regularly
	Holahan 2001	Amount of time spent in recreation
	Jorm 1998	Did you engage in active sport/gardening/housework/physical exercise yes/no
	Lee 2011	Frequency
	Leveille 1999	Low, moderate, active, missing SR
	Li 2006	Frequency
	Litwin 2005	Frequency and diversity of physical activity score
	Palmore 1969	Total activity
	Reed 1998	Physical activity index
	Robare 2011	2.5hrs physical activity per week
	Schonfield 1973	Active hours per day/hours awake
	Uotinen 2003	Mean level of physical activity
Adaptability	Montross 2006	Connor-Davidson Resilience Scale
Affective Disorder	Garfein 1995	Centre for Epidiomiologic Studies Depression Scale
	Ibrahim 2010	Positive And Negative Symptom Scale
	Strawbridge 2002	Bradburn scale
Age	Hogan 1999	Years
	Jorm 1998	Years
	Li 2006	Years
	Montross 2006	Years
	O'Rourke 2000	Years
	Palmore 1979	Years
	Simons 2000	Years
	Strawbridge 1996	Years
	Swindell 2010	Years
Aggression	Schonfield 1973	Buss-Durkee Inventory
Agreeableness	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
Albumin	Costa 2000	Total
Alcohol use	Dupre 2008	Current/past/never
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Ford 200	Yes/No
	Guralnik 1989	Drinks/month 0/1-60/>60
	Holahan 2001	5 point scale from never drink to alcohol is a serious problem
	Ibrahim 2010	CAGE For Alcoholism
	Leveille 1999	None in past year/none in past month/<1 ounce per day,>ounce per day
	Li 2006	Up to moderate intake
	Reed 1998	ml ethanol/day
	Simons 2000	Self-report

	Strawbridge 1996	120-900 ml/month vs never vs greater amounts
	Vaillant 2001	DSM-III criteria for alcohol abuse
Altruism	Vaillant 2001	DSM-IV Defensive Functioning Scale
Alzheimer's Disease	Berkman 1993	Geometric figure copying
Anticipation	Vaillant 2001	DSM-IV Defensive Functioning Scale
Anxiety	Castro-Lionard 2011	Self-report Goldberg Anxiety scale: 0-9
	Driscoll 2008	Hamilton Rating Scale for Anxiety
	Dupre 2008	Self-report Yes or No
	Holahan 2001	Self-report 9 point scale from very tense, worried, anxious to very relaxed calm
Arm circumference	Costa 2000	Total
Arthritis	Strawbridge 2002	Presence or absence
Asthma	Strawbridge 2002	Presence or absence
Attention	Andrews 2002	Mini Mental State Exam
	Dupre 2008	Mini Mental State Exam
Attitude	Lamb 1999	Revised Philadelphia Geriatric Centre Moral scale
	Strawbridge 2002	Life Orientation Test
Awareness of time and place	Andrews 2002	Mini Mental State Exam no impairment
	Cernin 2011	Mini Mental State Exam 24+
	Christensen 2009	Mini Mental State Exam total score
	Dupre 2008	Mini Mental State Exam less than 24 = disabled
	Li 2006	Chinese equivalent Mini Mental State Exam
	Newman 2003	Mini Mental State Exam 80th percentile
Backward Digit Recall	Christensen 2009	Total score
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
Balance	Baltes 1997	Number of steps to turn 360° without falling
	Fernandez-Ballesteros 2011	Self-report
Basic Motor Skills	Andrews 2002	Mini Mental State Exam no impairment
	Cernin 2011	Mini Mental State Exam 24+
	Christensen 2009	Mini Mental State Exam total score
	Dupre 2008	Mini Mental State Exam less than 24 = disabled
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Li 2006	Chinese equivalent Mini Mental State Exam
	Newman 2003	Mini Mental State Exam 80th percentile
Bathe and Dress	Britton 2008	Short Form 36 Health Survey top tertile
	Driscoll 2008	Short Form 36 Health Survey score
	Li 2006	Chinese equivalent ADL score
Bathing	Achour 2011	ADL score
	Andrews 2002	ADL no impairment
	Dupre 2008	Max 1 ADL problem
	Grundy 1999	ADL score
	Ibrahim 2010	ADL score
	Lamb 1999	No ADL impairment
	Li 2006	Chinese equivalent ADL

	McLaughlin 2010	No ADL difficulty
	Newman 2003	No ADL difficulty
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Being able to make choices	Grundy 1999	Yes/No
Bend and Kneel	Britton 2008	Short Form 36 Health Survey top tertile
	Driscoll 2008	Short Form 36 Health Survey score
	Li 2006	Chinese equivalent ADL
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Blood Pressure	Andrews 2002	Seated BP
	Costa 2000	Total
	Fernandez-Ballesteros 2011	Total
	Reed 1998	Mean of 3 measurements
	Robare 2011	Systolic BP <140mmHg
	Swindell 2010	Standing BP
Body Mass Index	Fernandez-Ballesteros 2011	Number
	Leveille 1999	<21, 21-27, >27
	Reed 1998	Calculated based on retrospectively self-reported weight at age 25
	Simons 2000	Number
	Vaillant 2001	>28, <28.01->21.99, <22 overweight/underweight/optimal weight
Bone Mineral Density	Robare 2011	Receiving bone mineral density screening yes or no
Caffeine	Swindell 2010	Self-report
Calcium	Costa 2000	Total
Cancer	McLaughlin 2010	Presence or absence
	Newman 2003	Presence or absence
	Reed 1998	Presence or absence
	Robare 2011	Screening: mammogram, prostate or colonoscopy
	Roos 1991	Diagnosis of cancers other than skin cancer
	Strawbridge 2002	Presence or absence
Cardiovascular Disease	Newman 2003	Internal carotid thickness mm
	Palmore 1969	Presence or absence
	Reed 1998	Presence or absence
Cerebral Vascular Disease	Dupre 2008	Presence or absence
Chair Stand	Albert 1995	5 per 20 second
	Andrews 2002	5 per 20 seconds
	Cernin 2011	5 per 20 seconds
	Robare 2011	Short Physical Performance Battery
Change in Memory	Castro-Lionard 2011	Self-report visual analogue scale: 0-10
Chest Pain	Pruchno 2012	Self-rated
Childhood Socio-Economic Status	Dupre 2008	5 point scale
Chronic Conditions	Garfein 1995	Self-report during past 12 months
	Guralnik 1989	Self-report past 12 months
	Leveille 1999	Self-report

	Strawbridge 1996	Absence or presence during past 12 months of diabetes, arthritis, cancer, stroke, asthma and COPD
Chronic Obstructive Pulmonary Disease	Newman 2003	Presence or absence
	Reed 1998	Presence or absence
Circadian functioning	Driscoll 2008	Composite scale of morningness
Climb One Flight of Stairs	Britton 2008	Short Form 36 Health Survey top tertile
	Driscoll 2008	Short Form 36 Health Survey score
	Ford 2000	Medical Outcomes Study Short Form Health Survey
	Li 2006	Chinese equivalent ADL
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
	Strawbridge 2002	No difficulty
Climb Several Flights of Stairs	Britton 2008	Short Form 36 Health Survey top tertile
	Driscoll 2008	Short Form 36 Health Survey score
	Ford 2000	Medical Outcomes Study Short Form Health Survey
	Li 2006	Chinese equivalent ADL
Climb Stairs Without Difficulty	Britton 2008	Short Form 36 Health Survey top tertile
	Driscoll 2008	Short Form 36 Health Survey score
	Ford 2000	Medical Outcomes Study Short Form Health Survey
	Li 2006	Chinese equivalent ADL
Clinician Rated Disability	Ford 2000	Chronic illnesses
	Palmore 1979	Physician diagnosis
Cognitive Function	Albert 1995	≥6 of 9 correct mental status scale
	Almeida 2006	Mini Mental State Exam
	Andrews 2002	Mini Mental State Exam
	Avlund 1999	Digit span
		Digit symbol
		Word Fluency
		Visual Reproduction
		Raven's Progressive Matrices
	Britton 2008	Alice Heim 4I test
	Cernin 2011	24+ Mini Mental State Exam
		10+ animal naming task
	Christensen 2009	Mini Mental State Exam
	Fernandez-Ballesteros 2011	Digit symbol
		Digit backward
		Mini Mental State Exam
		Verbal learning AVLT
	Hogan 1999	Modified Mini Mental State Exam
	Jorm 1998	Mini Mental State Exam 23/24
	Garfein 1995	Lorge-Thorndike scale
		Short Portable Mental Status Questionnaire
	Gow 2007	Moray House Test
	McLaughlin 2010	Telephone interview
	Reed 1998	Cognitive abilities survey instrument
	Simons 2000	Questionnaire
	Swindell 2010	Short mini mental status exam
	Tyas 2007	Mini Mental State Exam
	Uotinen 2003	Self-report satisfaction with cognitive function
	Von Faber 2001	Mini Mental State Exam

	Wahlund 1996	Full Scale Intelligence Quotient
Cognitive Impairment	Ford 2000	Pfeiffer 10 item scale
	Garfein 1995	Short Portable Mental Status Questionnaire scale
	Liang 2003	Pfeiffer Short Portable Mental Status Questionnaire
Cognitive Plasticity	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
Communication	Cernin 2011	Max 1 IADL difficulty
	McLaughlin 2010	Max 1 IADL difficulty
Concentration	Castro-Lionard 2011	Self-report MacNair scale: out of 104
Conceptualisation	Albert 1995	Wechsler Adult Intelligence Scale Revised
Concerns over formal services	Ford 2000	Pfeiffer 10 item scale
Confidantes	Ibrahim 2010	3 or more
Conscientiousness	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
Contentedness	Palmore 1979	Yes/No
Contribution	Andrews 2002	Adelaide Activities Profile
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
Cooking	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Coping Strategies	Driscoll 2008	Cope instrument
	Holahan 2001	Coping Response Inventory
	Ibrahim 2010	Cognitive coping scale
Coronary Heart Disease	Britton 2008	GP report
	Reed 1998	Presence or absence
	Simons 2000	Family history of CHD, MI or chest pain
C-Reactive Protein	Newman 2003	Quintiles mg/L
Creatinine	Costa 2000	Total
Cynicism	Strawbridge 2002	Bradburn scale
Delayed Recall	Albert 1995	≥3 of 6 correct delayed recall story
		Boston Naming Task
	Christensen 2009	Score out of 12
	Tyas 2007	Rosen scale
Demi span	Costa 2000	Total
Denial	Vaillant 2001	Defensive Functioning Scale DSM-IV
Depression	Achour 2011	Geriatric Depression Scale
	Almeida 2006	Geriatric Depression Scale 15
	Andrews 2002	Centre For Epidiomiologic Studies Depression Scale
	Avlund 1999	Centre For Epidiomiologic Studies Depression Scale
	Cernin 2011	Geriatric Depression Scale 15
	De Moraes 2002	Geriatric Depression Scale 15
	Driscoll 2008	Hamilton rating scale
	Ford 2000	Centre For Epidemiologic Studies Depression Scale
	Garfein 1995	Centre For Epidemiologic Studies Depression Scale
	Ibrahim 2010	Centre For Epidemiologic Studies Depression Scale
	Lee 2011	Questionnaire
	McLaughlin 2010	Less than 4 Centre for epidemiologic studies of depression scale
	Robare 2011	Centre for Epidiomiologic Studies Depression Scale score <16
	Schonfield 1973	Costello & Comrey Scale
	Simons 2000	Centre for Epidemiological Studies Depression Scale

	Strawbridge 1996	Self-report never or sometimes vs often
	Strawbridge 2002	DSM-IV
	Uotinen 2003	No depressed mood
	Vaillant 2001	Yes/no based on clinician interview
	Von Faber 2001	Geriatric Depression Scale
Diabetes	McLaughlin 2010	Presence or absence
	Newman 2003	None/impaired fasting glucose/new onset diabetes/known diabetes
	Reed 2008	Presence or absence
Disability	Jorm 1998	Needing assistance with any ADL
	Li 2006	Physical disabilities questionnaire
	Montross 2006	Medical Outcomes Survey Short Form 36
	Simons 2000	ADLs
	Vaillant 2001	Physician rated & age of onset
Dissociation	Vaillant 2001	DSM-IV Defensive Functioning Scale
Dressing	Achour 2011	Not specified
	Andrews 2002	ADL no impairment
	Dupre 2008	Max 1 ADL problem
	Grundy 1999	No/slight/moderate/severe difficulty
	Ibrahim 2010	ADL score
	Lamb 1999	No ADL impairment
	Li 2006	Chinese equivalent ADL
	McLaughlin 2010	No ADL difficulty
	Newman 2003	No ADL difficulty
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
	Tyas 2007	ADL score
Driving	Andrews 2002	Yes/no
Dynamic Balance	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
Eating	Achour 2011	Not specified
	Andrews 2002	ADL no impairment
	Cernin 2011	Seniors in the Community Risk Evaluation for Eating and Nutrition questionnaire
	Costa 2000	Bambui Health and Ageing Study Baseline Survey
	Dupre 2008	Max 1 ADL problem
	Guralnik 1989	Breakfast regularly/sometimes/rarely
		Snacking never/rarely/sometimes/always
	Lamb 1999	No ADL impairment
	Li 2006	Breakfast, eating between meals
	McLaughlin 2010	No ADL difficulty
	Newman 2003	No ADL difficulty
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
	Reed 1998	Japanese foods vs Western foods
	Tyas 2007	ADL score
ECG	Costa 2000	Total
	Newman 2003	Major ECG abnormality
Economic Independence	Dupre 2008	Yes/No
Education	Cernin 2011	Wide range achievement test 3

	Dupre 2008	Yes/No
	Hogan 1999	Years of formal education
	Jorm 1998	Years of education
	Li 2006	Educational level
		Years of education
	Liang 2003	Number of years of schooling
	Litwin 2005	5 point scale based on years of schooling
	Montross 2006	Years of education & degrees completed
	O'Rourke 2000	Years of formal education
	Palmore 1969	Not specified
	Palmore 1979	Coded from 0 (no formal education) to 10 (PhD or other doctoral degrees)
	Reed 1998	School level completed
	Simons 2000	Questionnaire
	Strawbridge 1996	12 years or more vs less
	Uotinen 2003	High versus low status
	Vaillant 2001	Years of education
Emotional Balance	Liang 2003	Self-report 4 point scale (1=never, 4=very often) for 'do you feel cared for' and 'do you feel listened to'.
	Wiest 2011	Positive and Negative Affect Schedule
Emotional Security	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Palmore 1979	Cavan Adjustment Rating
Emphysema	Strawbridge 2002	Presence or absence
Employment	Fernandez-Ballesteros 2011	Self-report
	Garfein 2005	Paid vs unpaid, plus 30 hrs/week
	Holahan 2001	Percent of time spent in paid work
	Liang 2003	Self-report employment status
	Litwin 2005	Self-report employment status
	McLaughlin 2010	Paid work at present, voluntary work in previous year or grandchildren care in past year, minimum 100 hrs in past two years
Endurance	Fernandez-Ballesteros 2011	Self-report
Energy	Holahan 2011	Self-report 5 point scale
	Strawbridge 2002	Much more energy than others/a little more/a little less/a lot less
Episodic Memory	Castro-Lionard 2011	Freed and Queued Selective Reminding
	Driscoll 2008	Logical Memory Tests
Ethnicity	Strawbridge 1996	White/Black
Executive Function	Cernin 2011	Trail making test
	Negash 2011	Neuropsychology Screening Battery
Exercise	Andrews 2002	None, moderate, vigorous
	Cernin 2011	Regular engagement yes/no
	Fernandez-Ballesteros 2011	Health Interview Survey
	Lee 2011	Frequency of engagement
	Newman 2003	Kcal quintiles
	Strawbridge 1996	Walks for exercise
	Vaillant 2001	Burn more than 500kcals/week yes or no

Extraversion	Baltes 1997	Extraversion subscale of NEO Personality questionnaire
	Fernandez-Ballesteros 2011	NEO Personality Inventory
	Garfein 1995	Questionnaire
Family relationships	Litwin 2005	Number of children in geographic proximity
	Vaillant 2001	Warmth of family environment
Fatalism	Garfein 1995	Self-report 4 point scale
Fatigue	Christensen 2009	4 point scale
Feeling blue/sad	Driscoll 2008	Short Form 36 Health Survey total score
Filial Obligations Expectations	Ford 2000	Questionnaire
Financial Satisfaction	Palmore 1979	Self-report
	Schonfield 1973	10 point scale
	Uotinen 2003	Self-report satisfies versus not satisfied
Financial Security	Day 1993	Self-report
	Ibrahim 2010	Financial strain scale
	Lamb 1999	Self-report ability to manage money
Forced Expiratory Volume	Britton 2008	Top tertile
Forward Digit Recall	Christensen 2009	Total score
Friendship	Montross 2006	Number of close friendships
Functional Ability	Avlund 1999	Dependent or not dependent on help
		Physical Activities of Daily Living Help Scale
	Garfein 1995	Functional limitations score
		Physical activity score 1 to 10
	Liang 2003	ADL score
		IADL score
	Litwin 2005	ADL difficulties
	Montross 2006	Medical Outcomes Survey Short Form 36 scale
	Swindell 2010	ADLs
	Tyas 2007	Self-rated excellent/very good/good/fair/poor
Gait Speed	Britton 2008	Top tertile
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Robare 2011	m/s
	Swindell 2010	Not specified
Gender	Hogan 1999	Male or female
	Jorm 1998	Male or female
	Li 2006	Male or female
	Montross 2006	Male or female
	O'Rourke 2000	Male or female
	Palmore 1979	Male or female
	Simons 2000	Male or female
	Strawbridge 1996	Male or female
	Uotinen 2003	Male or female
General Health	Andrews 2002	5 point scale
	Driscoll 2008	Short Form 36 Health Survey
	Fernandez-Ballesteros 2011	Health Interview Survey
	Garfein 1995	Number of problems in past year
	Grundy 1999	General health questionnaire
	Gow 2007	Mini Mental State Exam
	Lamb 1999	Self-report Yes/No to chronic conditions or falls in past year

	Lee 2011	In past two weeks, 4 point scale and injuries
	Palmore 1969	Rating
	Vaillant 1990	Physician rating
	Vaillant 2001	Physician rating
Glucose	Costa 2000	Total
	Reed 1998	Serum glucose 1 hour after 50g glucose road
	Robare 2011	Blood glucose <110 mg/dL
Goals	Baltes 1997	Self-report goal strength
	Christensen 2009	Highest of 3 dynamometer readings
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Holahan 2001	Self-report goals
		Comparison to friends 9 point scale from much less to much more
Grip strength	Christensen 2009	Dynamometer
	Reed 1998	Dynamometer
Grooming	Andrews 2002	ADL no impairment
	Dupre 2008	Max 1 ADL problem
	Grundy 1999	ADL score
	Ibrahim 2010	ADL score
	Lamb 1999	No ADL impairment
	Li 2006	Chinese equivalent ADL
	McLaughlin 2010	No ADL difficulty
	Newman 2003	No ADL difficulty
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Haematocrit	Costa 2000	Total
Haemoglobin	Costa 2000	Total
Handle Small Objects	Strawbridge 1996	Writing or handling small objects: Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Happy	Driscoll 2008	Short Form 36 Health Survey total score
	Holahan 2001	Self-report not too happy, pretty happy, very happy
	Palmore 1979	Social worker rating from 0 (unhappy/discontented/worried/fearful/frustrated) to 9 (very happy/exultant/great contentment)
	Schonfield 1973	10 point scale
	Strawbridge 2002	Very happy/pretty happy/not too happy
Health Service Use	Garfein 1995	no of doctor & mental health visits and no nights in hospital
	Ibrahim 2010	Frequency
	O'Rourke 2000	Number of nights in hospital in past 12 months
	Roos 1991	Days spent in hospital; days spent in nursing home; physician visits; surgeries.
	Young 2009	No. of hospital admissions
Hearing	Baltes 1997	Auditory acuity, pure tone audiometer
	Garfein 1995	Self-report very well/quite well/somewhat well/not too well/not at all well
	Strawbridge 1996	Self-report excellent/good vs fair/poor or unable to hear at all
Heart Attack	Dupre 2008	Yes/No
Heart Disease	McLaughlin 2010	Yes/No

	Strawbridge 2002	Presence or absence
Height	Costa 2000	Total
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Swindell 2010	Total
High Density Lipoprotein-Cholesterol	Costa 2000	Total
Hip Circumference	Costa 2000	Total
Home Care	Fernandez-Ballesteros 2011	Receiving care
	Holahan 2001	Personal care or assistance 9 point scale from little of no help to considerable help
		Satisfaction with quality and availability of care
Home Environment	Grundy 1999	Like area yes/no
		Home warm enough never/rarely/unable to afford adequate heating/usually/always
		Security, scared to open door yes/no
	Li 2006	Self-report, 5 point scale
	Schonfield 1973	Satisfaction on a 10 point scale
Hopelessness	De Moraes 2002	Beck Hopelessness Scale
Household Composition	Avlund 1999	Live alone or with others
	Day 1933	Relatives in household
	Gow 2007	Number of people who share the home
	Lamb 1999	1 generation vs next
Household Size	Dupre 2008	Number of individuals within household
	Liang 2003	Number of individuals within household
	O'Rourke 2000	Number of individuals within household
Housework	Andrews 2002	Adelaide activities profile
	Cernin 2011	1 IADL difficulty
	Garfein 1995	No difficulty
	McLaughlin 2010	Max 1 IADL difficulty
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Humour	Vaillant 2001	DSM-IV Defensive Functioning Scale
Hypochondriasis	Vaillant 2001	DSM-IV Defensive Functioning Scale
Hypotension	Dupre 2008	Presence or absence
Income	Day 1993	Self-report
	Guralnik 1989	Very adequate/adequate/marginal/inadequate
	Li 2006	Self-report 5 point scale
	Liang 2003	Self-report
	Litwin 2005	9 point scale
	Montross 2006	Annual income
	Strawbridge 1996	Family income quintiles
Illnesses	Avlund 1999	Physician Diagnosis
	Cernin 2011	Charlson comorbidity index
	Christensen 2009	Score out of 12
	Driscoll 2008	Cumulative Illness Rating Scale-Geriatric
	Fernandez-Ballesteros 2011	Number diagnosed by physician
	Gundy 1999	Number of problems from checklist of 10 common complaints
	Hogan 1999	Self-report

	Holahan 2001	Total number and level of stress caused
	Ibrahim 2010	Multilevel assessment inventory
		Physical Self-Maintenance Sale
	Liang 2003	Number of serious conditions (diabetes/heart disease/hypertension/stroke)
		Number of chronic conditions
	Litwin 2005	Number of illnesses
	Montross 2006	Self-report cancer/diabetes/high blood pressure/cataracts/heart attack/heart disease/stroke/osteoporosis/Parkinson's disease/respiratory disease
	O'Rourke 2000	Number of problems
	Pruchno 2010	Number of chronic age-related conditions
	Roos 1991	Number of physician diagnoses
	Reed 1998	Medical records and examination
	Simons 2000	Hospital admission reason
	Uotinen 2003	Self-report
Immediate Recall	Christensen 2009	Mini Mental State Exam
Immunisation	Robare 2011	Influenza or pneumonia
Independence	Ford 2000	No help with any personal or instrumental ADL
	Grundy 1999	Selection from 7 facial expressions
	Hogan 1999	Needing no help with ADLs or IADLs
	Montross 2006	Living independently
	Roos 1991	Not dependent for any ADLs
Indoor mobility	Andrews 2002	ADL no impairment
	Dupre 2008	Max 1 ADL problem
	Grundy 1999	ADL score
	Ibrahim 2010	ADL score
	Lamb 1999	No ADL impairment
	Li 2006	Chinese equivalent ADL
	McLaughlin 2010	No ADL difficulty
	Newman 2003	No ADL difficulty
Inductive Reasoning	Britton 2008	Alice Heim Top tertile
Intelligence	Jorm 1998	National Adult Reading Test IQ estimate
	Palmore 1969	Wechsler Adult Intelligence Scale performance, verbal and full
	Palmore 1979	Wechsler Adult Intelligence Scale verbal and performance
Introversion	Schonfield 1973	Maudsley Personality Inventory
Job Satisfaction	Palmore 1969	Burgess Scale
	Palmore 1979	Chicago Inventory of Activities and Attitudes
Job Success	Palmore 1969	Burgess Scale
Judgement	Cha 2011	Yoon instrument
Language use and comprehension	Albert 1995	18 items Boston Naming Test
	Andrews 2002	Mini Mental State Exam no impairment
	Cernin 2011	Mini Mental State Exam 24+
	Christensen 2009	Mini Mental State Exam total score
	Costa 2000	Mini Mental State Exam total score
	Dupre 2008	Mini Mental State Exam less than 24 = disabled
	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Li 2006	Chinese equivalent Mini Mental State Exam
	Negash 2011	Neuropsychology Screening Battery
	Newman 2003	Mini Mental State Exam 80th percentile

Learning	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
Leisure	Achour 2011	Not specified
	Fernandez-Ballesteros 2011	Time out of the year
	Holahan 2001	Percent time in sedentary recreation
	Li 2006	Recreational outings, hobbies, other amusements, reading
	Litwin 2005	Frequency of leisure activities
	Palmore 1979	Self-report hobbies, plans excursion done alone
	Tyas 2007	Reading and using telephone
	Uotinen 2003	Hobbies self-report
Life Satisfaction	Avlund 1999	Very satisfies/mostly satisfied/dissatisfied
	Costa 2000	Self-report Satisfied/Indifferent/Unsatisfied
	Fernandez-Ballesteros 2011	Self-report
	Garfein 1995	5 point scale completely/very/somewhat/not very/not at all
	Gow 2007	Satisfaction with life scale
	Grundy 1999	Neurgarten over 14
	Holahan 2001	Self-report 9 point scale from completely dissatisfied to completely satisfied
	Holahan 2011	Self-report 9 point scale from completely dissatisfied to completely satisfied
	Li 2006	Life Satisfaction Index A
	Litwin 2005	Self-report 4 point scale
	Montross 2006	Medical Outcomes Survey Short Form 36 Emotional health/well-being subscale
	Parslow 2011	Delighted-Terrible scale (delighted/pleased/mostly satisfied/mixed/mostly dissatisfied/unhappy/terrible)
	Pruchno 2010	Self-rated 10 point scale
	Roos 1991	Excellent/good/fair/bad
	Strawbridge 2002	Strongly agree/moderately agree/disagree
	Uotinen 2003	Self-report
	Vaillant 1990	Observer rated
	Vaillant 2001	Self-rated
	Wiest 2011	Satisfaction with Life Scale
Lift a 10lb Weight	Andrews 2002	Able to/not able to
	Strawbridge 1996	No more than a little difficulty
Lift and Carry Groceries	Britton 2008	Short Form 36 Health Survey top tertile
	Driscoll 2008	Short Form 36 Health Survey score
	Ford 2000	Number
	Li 2006	Chinese equivalent ADL
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Light Housework	Andrews 2002	No difficulty
	Ibrahim 2010	IADL score
	Strawbridge 1996	Self-rated ability
List Generating Fluency	Negash 2011	Boston Naming Task
Locus of Control	Vaillant 2001	Not specified
Lonely	Avlund 1999	Very seldom/seldom/often/always
	Dupre 2008	Yes/No
	Gow 2007	Yes/no and 5 point scale
	Grundy 1999	Never/rarely/sometimes/most of the time/often

	McLaughlin 2010	Max 1 IADL difficulty
	Uotinen 2003	Lonely/not lonely
	Von Faber 2001	De Jong-Gierveld & Kamphuis questionnaire
Long Distance Walking	Li 2006	Chinese equivalent ADL
Long Term Memory	Castro-Lionard 2001	Visual Analogue Scale
Longevity	Hogan 1999	Living at age 85
	Palmore 1979	Survival to 75
	Roos 1991	Alive at follow up
	Vaillant 2001	Ancestral longevity
Looking on the bright side	Dupre 2008	Yes/No
Low Density Lipoprotein Cholesterol	Costa 2000	Total
	Robare 2011	<100 mg/dL
Lower Body Strength	Newman 2003	Isokinetic dynamometer
		Isometric dynamometer
Lung Disease	McLaughlin 2010	Yes/No
Magnesium	Costa 2000	Total
Managing Money	Cernin 2011	1 IADL difficulty
	Ibrahim 2010	ADL score
	McLaughlin 2010	Max 1 IADL difficulty
	Tyas 2007	ADL score
Manual Dexterity	Fernandez-Ballesteros 2011	Tapping test
Marital Status	Dupre 2008	Married yes/no
	Guralnik 1989	Married/not married
	Jorm 1998	Married vs other
	Liang 2003	Married yes/no
	Litwin 2005	Not specified
	McLaughlin 2010	Married yes/no
	Montross 2006	Current marital status
	O'Rourke 2000	Not specified
	Palmore 1979	Not specified
	Strawbridge 1996	Married vs other
	Vaillant 2001	Stable marriage until age 50
Medication	Britton 2008	Self-report medication use
	Driscoll 2008	Inventory of all medication
	Fernandez-Ballesteros 2011	Total number of medications taken per day
	Swindell 2010	Inventory
	Tyas 2007	IADL score
Memory	Achour 2011	Not specified
	Albert 1995	Delayed Recognition Span Test
	Ibrahim 2010	Dementia Rating Scale
	Negash 2011	Neuropsychology Screening Battery
	Wahlund 1996	Wechsler Memory Scale
Mental Health	Litwin 2005	Number of visits to mental health clinic in past 6 months
	Montross 2006	Medical Outcomes Survey Short Form 36 Scale
	Parslow 2011	Self-rated (excellent/very good/good/fair/poor)

		Mini Mental State Exam
	Strawbridge 2002	Self-report excellent/good/fair/poor
	Vaillant 1990	Psychological Adjustment Scale
	Vaillant 2001	Independent rating
Mental Status	Andrews 2002	Short Portable Mental Status Questionnaire
	Berkman 1993	Short Portable Mental Status Questionnaire
	Fernandez-Ballesteros 2011	Backward digit span
		Digit symbol
	Holahan 2001	Changes in mental wellbeing
Mobility	Andrews 2002	Nagi items
Moderate Activity	Britton 2008	Short Form 36 Health Survey top tertile
	Driscoll 2008	Short Form 36 Health Survey score
	Ford 2000	Number
Mood	Garfein 1995	Centre for Epidiomiologic Studies Depression Scale
	Holahan 2001	Self-report 9 point scale from very depressed, gloomy to very cheerful elated
	Ibrahim 2010	Positive and negative symptom scale
	Li 2006	Self-report excellent/good/fair
Morale	Andrews 2002	Philadelphia Geriatric Centre Morale Scale
Motor Speed	Fernandez-Ballesteros 2011	Tapping test
	Wahlund 1996	Finger tapping
Movement	Ibrahim 2010	Abnormal involuntary movement scale
Nervous	Driscoll 2008	Short Form 36 Health Survey total score
Neuroticism	Fernandez-Ballesteros 2011	NEO Personality Inventory
	Garfein 1995	Self-report 5 point scale
	Schonfield 1973	Maudsley Personality Inventory
No Regrets	Young 2009	Self-rating
Number of Stressful Life Events	Driscoll 2008	Life Experience Survey
	Garfein 1995	Number in past 3 years and past lifetime
	Ibrahim 2010	Lifetime Trauma and Victimisation Scale
	Li 2006	Checklist
Obesity	Strawbridge 2002	Yes/No
Occupation	Dupre 2008	Professional versus agricultural
	Jorm 1998	White collar/proprietor/managerial/professional/unskilled/semi-skilled/skilled
	O'Rourke 2000	Professional/managerial/trade/not employed/service/unskilled (Wilson-Barona scale)
	Reed 1998	Unskilled to professional
Openness	Fernandez-Ballesteros 2011	NEO Personality Inventory
Osteoporosis	Strawbridge 2002	Yes/No
Pain	Pruchno 2010	4 point Likert scale response from 0 (low) to 3 (high in response to: how often are you troubled with pain, how bad is the pain most of the time and how often does the pain make it difficult for you to do usual activities, chores or work
Parental Survival	Dupre 2008	Mother survived to 80+ yes/no, father survived to 80+ yes/no
	Palmore 1969	Mother's and father's age at death
Parkinson's Disease	Reed 1998	Yes/No
Passive Aggression	Vaillant 2001	DSM-IV Defensive Functioning Scale

Peaceful	Driscoll 2008	Short Form 36 Health Survey total score
Perceived Control	Andrews 2002	Self-report
	Grundy 1999	Self-report
	Strawbridge 2002	Perceived control scale
Perceived Social Support	Baltes 1997	Number of different instances of social support received during the past 3 months
	Cernin 2011	Interpersonal support evaluation list
	Driscoll 2008	Interpersonal Support Evaluation List
	Gow 2007	Significant Others Scale
	Li 2006	Unskilled vs skilled
	Liang 2003	How often help provided when needed, 4 point scale (1=never, 4=very often)
	Roos 1991	Predeceased by spouse yes or no
	Simons 2000	Centre for Epidemiologic Depression Scale
	Vaillant 2001	Independent rater
Personal Growth	Montross 2006	Connor-Davidson Resilience Scale
Personality	Fernandez-Ballesteros 2011	European Survey on Ageing Protocol
	Jorm 1998	Eysenck Personality Questionnaire - Revised
Phosphorous	Costa 2000	Total
Physical Health	Albert 1995	0 (no disability) on ADL scale ≤1 to 8 mobility and physical performance scale
	Andrews 2002	Rosow & Breslau Scale
	Cernin	Max 1 IADL disability
	Fernandez-Ballesteros 2011	De Bruin Health Interview Survey
	Guralnik 1989	Self-report
	Holahan 2001	Changes in function
	Montross 2006	Medical Outcomes Survey Short Form 36 Scale
	O'Rourke 2000	ADLS and IADLS
	Palmore 1979	Physician rating from 0 (total disability) to 5 (no pathology)
	Pruchno 2010	5 point scale from 1 (cannot do it at all) to 5 (not at all difficult) response to: walking for a quarter mile, walking up 10 steps, standing for 2 hrs and stooping
	Swindell 2010	Seconds to complete 5 stands
	Uotinen 2003	Self-report compared to peers
	Von Faber 2001	Groningen Activity Restriction Scale
	Young 2009	ADLs and IADLs
Platelet Count	Costa 2000	Total
Positivity	Vaillant 2001	DSM-IV Defensive Functioning Scale
Productivity	Fernandez-Ballesteros 2011	Time out of the year
	Garfein 1995	Total hours
Projection	Vaillant 2001	DSM-IV Defensive Functioning Scale
Proximity to Offspring	Dupre 2008	Same house/village/not
Psychological Distress	Garfein 1995	Scales of Affective Status Probe
Pulmonary Disorder	Dupre 2008	Yes/No
	Britton 2008	Forced Expiratory Volume
	Fernandez-Ballesteros 2011	Peak flow
	Simons 2000	Peak expiratory flow
Pulse	Swindell 2010	Lying down
Purpose	Palmore 1979	Chicago inventory of Activities and Attitudes

	Schonfield 1973	10 point scale
Push and Pull Heavy Objects	Andrews 2002	No more than a little difficulty
Quality of Life	Driscoll 2008	Short Form 36 Health Survey for HR QoL
	Ibrahim 2010	Quality of Life Index
	Von Faber 2001	Cantril Ladder
Reach Above Shoulder Level	Reed 1998	Able or not
Reaction Time	Wahlund 1996	Seconds
Reasoning	Baltes 1997	Figural analogies
		Letter series
		Practical problems
	Driscoll 2008	Test of nonverbal intelligence 3
		Folstein Mini-Mental Status Exam
Red Blood Cells	Costa 2000	Total
Reminders	Garfein 1995	Frequency of reminders for sleep, exercise or taking medication self-report often/sometimes/rarely/never
Religious Values	Ford 2000	Questionnaire
Religiously Active	Andrews 2002	Importance
	Dupre 2008	Yes/No
	Garfein 1995	Frequency
Resilience	Montross 2006	Connor-Davidson Resilience Scale (CD-RISC)
Retirement Age	Castro-Lionard 2000	Age at retirement
Risk Perception	Von Faber 2001	Self-report
Satisfaction with Free Time	Costa 2000	Self-report Satisfied/Indifferent/Unsatisfied
	Litwin 2005	Self-report 4 point scale
	Schonfield 1973	10 point scale
	Strawbridge 2002	Enjoy free time a lot/some/not very much
Satisfaction with Own Health	Costa 2000	Satisfied/Indifferent/Unsatisfied
	Garfein 1995	Completely/very/somewhat/not very/not at all
	Liang 2003	5 point scale
	Palmore 1969	6 point scale
	Schonfield 1973	10 point scale
Satisfaction with Social Network	Costa 2000	Self-report Satisfied/Indifferent/Unsatisfied
	Fernandez-Ballesteros 2011	Social Network Scale
	Holahan 2001	Self-report would like much more/fully satisfied/would like much more
	Schonfield 1973	10 point scale
	Strawbridge 2002	Very/somewhat/ not at all
Self Confidence	Andrews 2002	Self-report
Self Efficacy	Garfein 1995	Self-report 4 point scale
Self Esteem	Driscoll 2008	Interpersonal support evaluation list
Self-Maintenance	Ibrahim 2010	Physical self-maintenance scale
Self-Rated Function	Uotinen 2003	5 point scale
Self-Rated Health	Achour 2011	Self-rated
	Avlund 1999	Unusually well, well vs fair, poor
	Fernandez-Ballesteros 2011	Health Interview Survey
	Garfein 1995	5 point scale
	Grundy 1999	General Health Questionnaire 0-5
	Hogan 1999	Very good/pretty good/not too good/poor/very poor

	Holahan 2001	Self-report 5 point scale
	Holahan 2011	Self-report 5 point scale
	Jorm 1998	Excellent/good/fair/poor
	Liang 2003	Self-report 5 point scale
		Comparison with peers better/same/worse
	O'Rourke 2000	Very good/pretty good/not too good/poor/very poor
	Parslow 2011	Excellent/very good/good/fair/poor
	Roos 1991	Excellent to fair
	Schonfield 1973	10 point scale
	Simons 2000	Best/good/poor
	Swindell 2010	Questionnaire
	Uotinen 2003	Very good, good, less than good
	Vaillant 2001	SF-36
	Young 2009	Excellent/very good/good/fair/poor
Self-Rated Successful Ageing	Cernin 2011	Poor, fair, good, very good, excellent
	Holahan 2011	How has ageing compared with expectations better, worse, same
	Ibrahim 2010	Self-rating 6 point scale
	Montross 2006	Self-rated on 10 point scale
	Pruchno 2010	10 point scale
	Tyas 2007	Excellent/very good/good/other
Self Worth	Driscoll 2008	Not specified
Semantic Memory	Cernin 2011	Score of 10+ on animal naming task
Semi-tandem Balance	Albert 1995	10 second hold
	Andrews 2002	10 second hold
Sense of Peace	Baltes 1997	Not specified
Sensory Restrictions	Fernandez-Ballesteros 2011	Health Interview Survey
Severity of Stressful Life Events	Driscoll 2008	Life Experience Survey
	Garfein 1995	Number in past 3 years and past lifetime
	Li 2006	Checklist
Shopping for groceries or clothing	Cernin 2011	1 IADL difficulty
	Ibrahim 2010	IADL score
	McLaughlin 2010	Max 1 IADL difficulty
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Short Term Memory	Castro-Lionard 2011	Benton retention test
Short-term Visual Memory	Castro-Lionard 2011	Benton retention test: Total score
Sleep	Cernin 2011	Pittsburgh sleep quality index
	Driscoll 2008	Epworth Sleepiness scale
		Multiple Sleep Latency Test
		Pittsburgh Sleep Diary and Quality Index
		Hours per day
	Garfein 1995	Number of hours
	Guralnik 1989	Hours/night <7/7-8/>8
Smoking Status	Andrews 2002	Packs per year
	Dupre 2008	Yes/No
	Fernandez-Ballesteros 2011	5 point scale
	Ford 2000	Current/past/never
	Guralnik 1989	Never/past/current
	Holahan 2001	Current smoker
	Jorm 1998	Have you ever smoked tobacco regularly/do you smoke now

	Leveille 1999	Yes/No
	Li 2006	Smoking habits
	Newman 2003	Pack years
	Reed 1998	Pack years
	Robare 2011	Current smoking behaviour
	Simons 2000	Current/past/never
	Strawbridge 1996	Does not currently smoke
	Vaillant 2001	Pack years from age 15
Social Activity	Achour 2011	Not specified
	Andrews 2002	Attendance, communication with communication with friends, visiting family members
	Avlund 1999	Low or high amount
	Baltes 1997	Availability of relationship roles
	Li 2006	Adelaide activities profile
	Litwin 2005	Frequency
	Montross 2006	Hours per week
	Palmore 1969	Burgess scale
	Palmore 1979	Self-report
	Von Faber 2001	Time Spending Pattern Questionnaire
Social Contact	Achour 2011	Not specified
	Avlund 1999	Frequency of contacts
	Garfein 1995	Frequency of phone calls frequency of visits frequency of attending meetings
	Ibrahim 2010	Number of interactions with neighbours, friends and family in past year
	Lee 2011	Friends in neighbourhood, see neighbours in past week
	Litwin 2005	Frequency
	Robare 2011	Once per week
	Strawbridge 1996	5+ close contacts vs fewer
	Uotinen 2003	Number of friends 0/1-5/6-10
Static Balance	Fernandez-Ballesteros 2011	Number
Steps to turn 360°	Baltes 1997	Number of steps to turn 360° without falling
Stooping/Kneeling	Andrews 2002	No difficulty
Strength	Fernandez-Ballesteros 2011	1-5 Nagi strength scale
	Lamb 1999	Perceived stress scale
Stress	Driscoll 2008	COPE instrument
	Holahan 2001	Non-health hassles score
	Lee 2011	Yes/No
Stroke	McLaughlin 2010	Clinician diagnosis
	Reed 1998	Yes or no
	Simons 2000	Previous stroke
	Strawbridge 2002	Yes or no
Social Network Quality	Fernandez-Ballesteros 2011	Social Network Scale
	Ibrahim 2010	Network Analysis Profile
Socioeconomic Status	Baltes 1997	Occupational status or that of spouse
	Lamb 1999	Self-report
	Liang 2003	Home ownership, education and income
	Simons 2000	Home ownership
	Uotinen 2003	Very good, good, less than good

Speed	Fernandez-Ballesteros 2011	Tapping test
Sublimation	Vaillant 2001	DSM-IV Defensive Functioning Scale
Suppression	Vaillant 2001	DSM-IV Defensive Functioning Scale
Taking Medications as prescribed	Cernin 2011	no help with 7 IADL
	Ibrahim 2010	Max 1 IADL difficulty
	McLaughlin 2010	IADL score
	Simons 2000	Blood pressure medication
Tandem Balance	Andrews 2002	10 second hold
	Cernin 2011	1 IADL difficulty
Technology Use	Cernin 2011	No help with 7 IADL
	Ibrahim 2010	Max 1 IADL difficulty
Telomere Length	McLaughlin 2010	Mean length terminal restriction fragments
Toileting	Andrews 2002	Max 1 ADL problem
	Dupre 2008	No help with 7
	Grundy 1999	ADL score
	Ibrahim 2010	No ADL impairment
	Lamb 1999	Chinese equivalent ADL
	Li 2006	No ADL difficulty
	McLaughlin 2010	No ADL difficulty
	Newman 2003	Mg/dl
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
	Tyas 2007	Nurse report or self-report
Total Cholesterol	Costa 2000	Total
	Reed 1998	Total serum cholesterol
Total Protein	Costa 2000	Total
Transportation within the community	Cernin 2011	1 IADL difficulty
	Ibrahim 2010	IADL score
	Schonfield 1973	Satisfaction, 10 point scale
Transfer in and out of bed	Andrews 2002	ADL no impairment
	Avlund 1999	No difficulty
	Berkman 1993	No difficulty
	Dupre 2008	Max 1 ADL problem
	Ford 2000	No difficulty
	Grundy 1999	ADL score
	Ibrahim 2010	ADL score
	Jorm 1998	No difficulty
	Lamb 1999	No ADL impairment
	Li 2006	Chinese equivalent ADL
	McLaughlin 2010	No ADL difficulty
	Newman 2003	No ADL difficulty
	Roos 1991	No diffiulty
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
Triceps Skinfold	Costa 2000	Total
Triglycerides	Costa 2000	Total
	Reed 1998	Total serum triglycerides
Unworried	Palmore 1979	Yes/No
Urea	Costa 2000	Total
Uric Acid	Costa 2000	Yes/No
	Reed 1998	Total serum uric acid

Usefulness	Palmore 1969	Not specified
Verbal Fluency	Cernin 2011	Total score
	Christensen 2009	Total
	Dupre 2008	Score of 10+ on animal naming task
Very Low Density Lipoprotein Cholesterol	Costa 2000	Short Form 36 Health Survey top tertile
Vigorous Activity	Britton 2008	Short Form 36 Health Survey score
	Driscoll 2008	Max 1
	Ford 2000	Medical Outcomes Study Short Form Health Survey
	Li 2006	Self-report 5 point scale
Vision	Baltes 1997	Distance and close acuity
	Garfein 1995	Self-report very well/quite well/somewhat well/not too well/not at all well
	Swindell 2010	Contrast sensitivity Pelli-Robson letter charts
Visual Construction	Albert 1995	Delayed recognition span test
	Negash 2011	Neuropsychology Screening Battery
Voluntary Work	Holahan 2001	Percent time in unpaid or volunteer work
	Litwin 2005	Yes/no and frequency of engagement
Vulnerability	Garfein 1995	Self-report 4 point
Walk Half a Mile	Andrews 2002	No difficulty
	Li 2006	Chinese equivalent ADLs
	Young 2009	Do you have any difficulty walking half a mile yes/no
Walk One Block	Britton 2008	Short Form 36 Health Survey score
	Driscoll 2008	Max 1 ADL difficulty
	Li 2006	Short Form 36 Health Survey top tertile
Walk One Mile	Britton 2008	Short Form 36 Health Survey score
	Driscoll 2008	Max 1 ADL difficulty
	Li 2006	Short Form 36 Health Survey top tertile
Walk Several Blocks	Britton 2008	Short Form 36 Health Survey score
	Driscoll 2008	Max 1 ADL difficulty
	Garfein 1995	No difficulty
	Li 2006	Walking speed over 8ft course
Walking Ability	Britton 2008	Total
	Strawbridge 1996	Not able to do/have a lot of difficulty/have some difficulty/have a little difficulty/have no difficulty
	Tyas 2007	ADL score
Waist Circumference	Costa 2000	Centimetres
Weight	Costa 2000	Maintaining normal weight
	Fernandez-Ballesteros 2011	Body weight in kg
	Guralnik 1989	Moderate weight/other
	Li 2006	Body weight in kg
	Palmore 1969	Obesity and emaciation
Wheelchair Use	Roos 1991	Not needing a wheelchair
White Blood Cell Count	Costa 2000	WBC count
Widowhood	Baltes 1997	Not specified
Wisdom	Baltes 1997	Not specified
Word List Recall	Andrews 2002	Mini Mental State Exam 24+
	Cernin 2011	Mini Mental State Exam total score
	Christensen 2009	Mini Mental State Exam total score
	Costa 2000	Mini Mental State Exam less than 24 = disabled

	Dupre 2008	Mini Mental State Exam
	Fernandez-Ballesteros 2011	Wechsler Adult Intelligence Scale Revised
	Li 2006	Mini Mental State Exam 80th percentile
	Newman 2003	Letter-Numbering sequencing
Working Memory	Driscoll 2008	Total
	Fernandez-Ballesteros 2011	Wechsler Adult Intelligence Scale Revised
Wrist Circumference	Costa 2000	Centimetres

Appendix D. Standardised instructions

Standardised instructions for open sorts

Your task is to sort the cards on the table into categories and then give each category a name. There is no right or wrong way to create the categories. You can create as many or as few categories as you want, but each card can only be placed in one category. If you are not sure about what a word or phrase on a card means please ask.

Instructions for the closed sort

Your task is to sort the cards on the table into categories which have been written on envelopes at the head of the table. There is no right or wrong way to sort the cards into the categories, but each card can only be placed in one category. If you are not sure about what a word or phrase on a card means please ask.

Appendix E. Cards removed from the sort by Group 1 which were not included for subsequent sorts, arranged alphabetically.

Acting Out	Community Dwelling	Genes	Mental status	Sleep
Activity	Drinking	Height	Moderate activity	Smoking
Adherence to medication	Eat vegetables	Household composition	Mother lived past 80	Spirituality
ADLs eating	Education	Household Size	Occupations	Substance abuse
Age	Employment	Immunisation	Orientation	Taking medication as prescribed
Age at retirement	Ethnicity	Income	Passive aggression	Weight
Amount of Holidays	Exercise	Leisure	Personality	Widowhood
Anticipation	Father lived past 80	Longevity	Religious Values	Vigorous activity
Caffeine use	Food	Married	Religiously active	Using technology
Childhood Socioeconomic status	Gender	Medications	SES	

Cards removed for being either a) vague, b) not directly relevant, c) mechanisms to improve health rather than health itself, or d) mediating factors

Appendix F. Clarification of terms

Term	Meaning
Abstract reasoning	The ability to solve abstract problems and recognise patterns and relationships
Accomplishments	Accomplishing, completing or achieving something
Adaptability	Being able to adapt or change to suit the circumstances
Affective disorder	Mood disorders such as bipolar disorder or anxiety disorder
Agreeableness	A personality trait characterised by generosity, warmth and kindness
Albumin	A protein found in the blood that helps to carry other molecules
Altruism	Selfless concern or selfless actions which benefit others
Alzheimer's disease	A common form of dementia involving degenerative memory loss
Anxiety	A feeling of uneasiness or apprehension
Arithmetic	Mathematical skills
Arm circumference	A measurement around the upper arm
Arthritis	A condition involving pain or inflammation in the joints
Asthma	A disease characterised by difficulty breathing
Attention	Sustained concentration on a specific thought or activity
Attitude	A way of thinking or feeling about something
Awareness of time and place	Knowing when and where you are
Backward digit recall	Being able to recite a string of numbers in reverse order
Balance	Being able to stand upright without falling over
Basic motor skills	Being able to perform basic movements
Bathe and dress	Being able to wash and clothe yourself
Bathing	Being able to wash yourself
Being able to make choices	Being able to make choices for yourself

Bend and kneel	Being able to bend or kneel
Blood pressure	The pressure that the circulation of blood exerts of blood vessel walls
Bone mineral density	The density of minerals, e.g. calcium, in the bones. It can be used to predict the risk of fractures or diagnose osteoporosis
Calcium	An important component of bones and teeth
Cancer	A common condition which involves cells start to reproduce uncontrollably, damaging nearby healthy tissue
Cardiovascular disease	Conditions that affect the heart and blood vessels
Cerebrovascular disease	Disease that affects the blood vessels in the brain and the membranes which cover it
Chair stand	Being able to stand up from a seated position in a chair
Change in memory	Changes in the ability to store and recall information and experiences
Chest pain	Discomfort and soreness of the chest
Chronic conditions	Conditions which develop and progress over time
Chronic obstructive pulmonary disease (COPD)	A disease of the airways which causes difficulty in breathing
Circadian functioning	A biological process which occurs in 24 cycles such as the sleep/wake cycle
Climb one flight of stairs	The ability to climb up one flight of stair
Climb several flights of stairs	The ability to climb several flight of stairs
Climb stairs without difficulty	The ability to climb stairs without any difficulty
Clinician rated disability	The level of disability as rated by a clinician such as a doctor
Cognitive function	The mental process which lead to the acquisition of knowledge including memory, attention, language and reasoning
Cognitive impairment	An impairment in the quality or strength of cognitive functions
Cognitive plasticity	The ability of the brain to adapt by developing new neural connections

Concentration	Focusing all of your attention on one particular thing
Concerns over formal services	Concerns with formal services, provided by paid staff, such as health care
Confidantes	A close friend or associate who can be trusted with secrets of private information
Conscientiousness	Wanting to something or perform a duty to the best of your ability
Contented	Feelings of happiness and satisfaction
Coping strategies	Specific actions taken to reduce the impact of a stressful event or situation
Coronary heart disease	A build up of fatty plaque inside the coronary arteries which supply the heart with oxygenated blood
Creatinine	A by-product of muscle metabolism
Delayed recall	The ability to memorise information and then recall it after a delay
Demi span	The distance from the middle of the chest to the tip of the middle finger of an arm outstretched to the side
Denial	A psychological process in which a person refuses to accept reality
Depression	Persistent low mood accompanied by lack of interest in activities that would normally be enjoyable
Diabetes	A disease in which wither the pancreas does not produce enough insulin or insulin produced by the pancreas is not used by the body properly leading to problems with blood sugar levels
Disability	A reduction in a persons capacity to function and carry out usual activities
Dissociation	A feeling of being disconnected from experiences
Do light housework	The ability to perform light household tasks
Dressing	The ability to dress yourself
Driving	The ability to drive

Dynamic balance	Being able to maintain balance while changing positions
Economically independent	Having enough money to maintain yourself
Electrocardiogram (ECG)	A recording of the electrical activity of the heart
Emotional balance	Being able to regulate strong emotions and keep perspective
Emotional security	Being able to remain emotionally stable under during times of pressure or stress
Emphysema	Damage to the air sacs in the lungs leading to shortness of breath
Endurance	Being able to maintain and continue performance or functioning under difficult or stressful conditions
Energy	Having enough strength and vitality to complete usual physical or mental activities
Episodic memory	Memory for specific personal events or experiences
Family relationships	The relationships between family members
Fatalism	The idea that the things which happen to us are predetermined and cannot be changes, only accepted
Fatigue	Exhaustion associated with strenuous or demanding physical or mental work
Feeling blue/sad	Having low mood
Filial obligations expectation	The expectation of receiving care from adult children
Financial satisfaction	Being happy or satisfied with your financial situation
Financial security	Having the financial resources to support your standard of living
Forced expiratory volume	How much air someone can breathe out during a forced breath
Forward digit recall	Recalling number in the sae order in which they were presented
Friendship	A relationship between friends
Function	A natural activity or purpose of a person

Functional ability	The ability to perform basic activities of daily life without assistance
Gait speed	Walking speed
General health	A state of physical, mental and social wellbeing , not just absence of illness or disease
Glucose	A simple sugar which is an important energy source and helps form many carbohydrates
Goals	An aim or desired result
Grip strength	The strength of your grip
Grooming	Behaviours relating to the care of the body and maintaining appearance
Haematocrit	The volume of red blood cells as a percentage of total blood volume
Haemoglobin	A molecule in red blood cells which carriers oxygen
Handle small objects	The ability to touch, grasp or manipulate small objects
Happy	Feeling or showing pleasure contentment or satisfaction
Health service use	Use of health services such as hospitals and GPs
Hearing	Being able to perceive sounds
Heart attack	A sudden blockage of blood flow to the heart resulting in the death or damage of part of the heart muscle
Heart disease	A range of diseases which affect the heart such as congenital defect, problems with the rhythm of the heart of disease of the coronary arteries
High density lipoprotein cholesterol (HDL-C)	Helps to remove harmful cholesterol from the body, lowering risk of heart disease
Hip circumference	Measurement of the distance around the hips
Home care	Care provided to an individual within their own home, usually involving personal care such as bathing or dressing
Home environment	How safe, comfortable and enjoyable the environment fo the home is
Hopelessness	A feeling or despair or lack of hope

Housework	Regular tasks carried out around the home including cleaning and tidying
Humour	Being able to appreciate and express humour
Hypertension	High blood pressure
Hypochondriasis	A high level of anxiety about your own health including interpreting normal feelings or sensations within the body as illness
Illnesses	A period of sickness caused by disease, stress, accident or injury
Immediate recall	The ability to memorise information and then recall it immediately afterwards
Independence	Being independent, not being reliant or controlled by another
Indoor mobility	Being able to move around easily indoors
Inductive reasoning	Inferring general principles from specific examples. For example, you see a white swan and from that infer that all swans are white
Job satisfaction	The degree of contentment with a job
Job success	Achieving desired aims or goals relating to your job
Judgement	A considered opinion, decision or conclusion
Language use and comprehension	Being able to understand and use language
Learning	Acquiring knowledge or skills through experience or study
Life satisfaction	A subjective reflection of a person's overall satisfaction with their own life
Lift and carry groceries	Being able to life and carry groceries
Lifting 10lb weight	Being able to lift a 10lb weight
List generating fluency	Being able to generate as many words as possible in a set length of time
Locus of control	Style of thinking whereby people believe that things happen to them because of their own effort or behaviour, or they believe things happen to them because of chance or fate
Lonely	A feeling of being isolated from others which can lead to sadness, depression and anxiety
Long distance walking	B3eing able to walk long distances

Long term memory	A memory containing information which is stored for long periods of time
Looks on bright side	Being able to consider the positive aspects of situations or experiences which could also be perceived negatively
Low density lipoprotein cholesterol (LDL-C)	A type of cholesterol which can collect on the walls of arteries leading to a greater risk of heart attack
Lower body strength	The strength of the lower body, such as the legs
Lung disease	Any disease of the lungs which prevents their proper functioning
Magnesium	A chemical element which is necessary for the nervous system and muscles to function properly
Making a contribution	Helping to achieve a result or cause something to happen
Managing money	Being able to look after your own spending, saving or investing
Manual dexterity	Being able to manipulate objects using the hands
Memory	Being able to preserve, store and recall information
Mobility	Being able to move around easily
Mood	A temporary but sustained emotional state
Motor speed	The speed at which someone is able to move
Movement	Being able to move the body
Nervous	Apprehension, agitation or anxiety
Neuroticism	A personality trait characterised by anxiety, envy, and frustration
No regrets	Not feeling sad, repentant or disappointed over something you have done or failed to do
Number of stressful life events	The number of times you have a stressful significant life event such as death or divorce
Obesity	Being excessively fat or overweight
Openness	Willingness to accept new ideas, situations, or change

Osteoporosis	Reduced bone mineral density resulting in fragile or brittle bones
Pain	A strongly unpleasant physical and emotional sensational arising from illness or injury etc.
Parkinson's disease	A progressive neurological disorder characterised by tremors and difficulty moving
Peaceful	The feeling of being untroubled, calm, or tranquil
Perceived control	A person's belief that they control their own behaviour and the environment around them to achieve the desired outcomes
Perceived social support	The degree to which someone believes they have support available to them from their social network
Personal growth	Development as an individual
Phosphorus	A chemical element with many uses in the body
Physical health	The health of the body
Platelet count	The number of platelets in a certain volume of blood
Positivity	The quality or character trait of being positive or optimistic
Productivity	Being productive, producing something through effort or work
Projection	A defence mechanism in which unpleasant thoughts or feelings are attributed to someone else
Proximity to offspring	Physical distance or closeness to your children
Psychological distress	Distressing thoughts or feeling which affect behaviour and functioning
Pulmonary disorder	Impaired lung function
Pulse	The rate of the heartbeat
Purpose	Aims or goals which motivate behaviour
Pushing or pulling heavy objects	Being able to push or pull heavy objects
Quality of life	The amount of physical and mental wellbeing and happiness experienced by someone
Quality of social network	Quality of friendships and other social connections

Reaching above shoulder level	Being able to reach above the level of your shoulders
Reasoning	A cognitive process used to find solutions to problems via logical and rational thinking
Red blood cells	The blood cells which carry oxygen around the body
Risk perception	How a person perceives the risks carried by a particular activity or environment
Satisfaction with free time arrangements	How satisfied someone is with what they do in their free time
Satisfaction with own health	How satisfied someone is with what their health
Satisfaction with social network	How satisfied someone is with their network of social relationships
Self confidence	The extent to which someone has confidence in their own abilities, decisions and judgement
Self-efficacy	A person's belief in their own ability to achieve a specific goal or result
Self esteem	A person's attitude towards or evaluation of themselves
Self-maintenance	The ability to function or survive without help
Self-rated health	How a person rated their own health
Self-rated successful ageing	How a person rates whether they have achieved successful ageing or not
Self-worth	Similar to self esteem; a person's sense of their own value or worth
Semantic memory	A type of long term memory for factual information
Semi tandem balance	Being able to balance with one foot partially in front of and slightly parallel to the other 
Sense of peace	A person's sense of peace with themselves or their surroundings, often considered to be the opposite of stress or anxiety

Sensory restrictions	The loss or impairment of one or more senses, e.g. vision, hearing, touch, taste and smell
Severity of stressful life events	The degree of the impact of stressful significant life events such as death or divorce
Shopping for groceries or clothing	Being able to shop for your own food and clothing
Short term memory	A memory system that can hold a limited amount of information for a short period of time, for example remembering the start of a sentence until you have heard the end of it
Short term visual memory	Short terms memory for objects of scenes we have just viewed
Social activity	Taking part in activities with other people
Social contact	Interactions with other people
Speed	The speed of physical activity
Static balance	Being able to maintain balance while still
Steps to turn 360	The number of steps required to turn in a full circle
Stooping/kneeling	The ability to stoop over or kneel down
Strength	Being physically strong
Stress	Physical or mental strain or tension created by experiences which are difficult to endure
Stroke	An interruption in blood supply to the brain leading to oxygen deprivation in the part of the brain affected
Sublimation	A defence mechanism in which socially unacceptable desires are subconsciously transferred onto social acceptable behaviours, for example channelling aggression into playing or watching violent sports
Suppression	The act of suppressing a painful memory so that is no longer available to the conscious mind
Tandem balance	Being able to balance with one foot directly in front of the other

	
Telomere length	The length of the end of the chromosome involves in DNA replication which shorten every time a cell divides
Toileting	The ability to use the toilet unaided
Total cholesterol	The level of all of the different types of cholesterol in the blood
Total protein	The total amount of protein in the blood
Transfer in and out of bed	The ability to get yourself in and out of bed
Transportation within the community	Access to transport to move around within the community
Triceps skin fold	The width of a fold of skin taken over the triceps muscle on the upper arm
Triglycerides	The main form of fat in the body
Unworried	Not worried or anxious
Urea	The main product of protein metabolism
Uric acid	A substance created when the body breaks down purines which are found in some types of food and drink
Use of telephone or other form of communication	Being able to use the telephone or another means to communicate with others
Verbal fluency	The ability to say as many words from a given category, e.g. animals or fruits, in a set amount of time.
Very low density lipoprotein cholesterol (VLDL-C)	A type of cholesterol which can collect on the walls of arteries leading to a greater risk of heart attack
Vision	Being able to perceive objects in the environment via the eyes
Visuospatial ability	The cognitive ability to see an object or scene as a set of parts then construct
Vulnerability	The ability to visually perceive objects and the spatial relationship between objects

Waist circumference	Measurement of the distance around the waist
Walk a mile	The ability to walk for one mile or 1609 meters
Walk half a mile	The ability to walk for half a mile or 805 meters
Walk one block	The ability to walk for one block
Walk several blocks	The ability to walk for several blocks
Walking ability	The ability to walk
Wheelchair use	Whether or not a person requires the use of a wheelchair
White blood cell count	A measure of the number of white blood cells in the blood
Wisdom	Being wise, having experience and good judgement
Word list recall	The number of words from a list a person can recall
Working memory	A cognitive system which allows the holding and temporary storage of information which is in use, such as keeping track of what we are doing
Wrist circumference	Measurement of the distance around the wrist

Definitions of terms were amalgamations of definition found in the Oxford English Dictionary (www.oed.com) and Oxford Reference (www.oxfordreference.com), both published by Oxford University Press and the World Health Organisation website (www.who.int).

Appendix G. Categories and the cards they contain created by Group 1 and arranged alphabetically

Brain function	Fulfilling potential	Health Problems	Independence	Measuring Ageing	Mood	Personality	Physical Function	Social Support	Wellbeing
Abstract reasoning	Accomplishments	Affective disorder	Bathe and dress	Albumin	Agreeableness	Adaptability	Balance	Confidantes	Energy
Arithmetic	Altruism	Alzheimer's disease	Bathing	Arm circumference	Conscientiousness	Attitude	Basic motor skills	Emotional security	Job satisfaction
Attention	Filial obligations expectation	Arthritis	Concerns over formal services	Blood pressure	Contented	Being able to make choices	Bend and kneel	Family relationships	Job success
Awareness of time and place	Goals	Asthma	Do light housework	Bone mineral density	Denial	Coping strategies	Chair stand	Friendship	Life satisfaction
Backward digit recall	Learning	Cancer	Dressing	Calcium	Dissociation	Fatalism	Circadian functioning	Home care	No regrets
Cognitive function	Making a contribution	Cardiovascular disease	Driving	Creatinine	Emotional balance	Humour	Climb one flight of stairs	Home environment	Quality of life
Cognitive impairment	Personal growth	Cerebrovascular disease	Economically independent	Demi span	Feeling blue/sad	Judgement	Climb several flights of stairs	Perceived social support	Satisfaction with own health
Cognitive plasticity	Productivity	Chest pain	Financial satisfaction	ECG	Happy	Locus of control	Climb stairs without difficulty	Proximity to offspring	Self-rated general health
Delayed recall	Purpose	Chronic conditions	Financial security	Glucose	Hopelessness	Perceived control	Clinician rated disability	Quality of social network	Self-rated health
Episodic memory		COPD	Grooming	Haematocrit	Lonely	Projection	Disability	Satisfaction with free time arrangements	Self-rated successful ageing

Forward digit recall		Coronary heart disease	Housework	Haemoglobin	Looks on bright side	Risk perception	Dynamic balance	Satisfaction with social network	Sense of peace
Immediate recall		Depression	Independence	HDL-C	Mood	Self confidence	Endurance	Social activity	Wisdom
Inductive reasoning		Diabetes	Managing money	Hip circumference	Nervous	Self-efficacy	Forced expiratory volume	Social contact	
Language use and comprehension		Emphysema	Self-maintenance	LDL-C	Neuroticism	Sublimation	Functional ability	Use of telephone or other form of communication	
List generating fluency		Fatigue	Shopping for groceries or clothing	Magnesium	Number of stressful life events		Gait speed		
Long term memory		Health service use	Toileting	Phosphorus	Openness		Grip strength		
Memory		Heart attack	Transportation within the community	Platelet count	Peaceful		Handle small objects		
Reasoning		Heart disease		Pulse	Positivity		Hearing		
Self-rated change in memory		Hypertension		Red blood cells	Psychological distress		Indoor mobility		
Self-rated concentration		Hypochondriasis		Telomere length	Self esteem		Lift and carry groceries		
Semantic memory		Illnesses		Total cholesterol	Self-rated anxiety		Lifting 10lb weight		

Short term memory		Lung disease		Total protein	Self-worth		Long distance walking		
Short term visual memory		Obesity		Triceps skin fold	Severity of stressful life events		Lower body strength		
Verbal fluency		Osteoporosis		Triglycerides	Stress		Manual dexterity		
Visual construction		Pain		Urea	Suppression		Mobility		
Word list recall		Parkinson's disease		Uric acid	Unworried		Motor speed		
Working memory		Pulmonary disorder		VLDL-C	Vulnerability		Movement		
		Stroke		Waist circumference			Physical health		
				White blood cell count			Pushing or pulling heavy objects		
				Wrist circumference			Reaching above shoulder level		
							Self-rated function		
							Semi tandem balance		
							Sensory restrictions		
							Speed		

							Static balance		
							Steps to turn 360		
							Stooping/kneeling		
							Strength		
							Tandem balance		
							Transfer in and out of bed		
							Vision		
							Walk a mile		
							Walk half a mile		
							Walk one block		
							Walk several blocks		
							Walking ability		
							Wheelchair use		

Table showing category names and which cards were included in each category by Group 1 (Academics with an interest in ageing)

Appendix H. Categories and the cards the contain created by Group 2 organised alphabetically

Assessment	Brain	Health Problems	Independence	Physical function	Personality	Social	Wellbeing
Albumin	Abstract reasoning	Affective disorder	Accomplishments	Balance	Adaptability	Confidantes	Economically independent
Arm circumference	Arithmetic	Alzheimer's disease	Bathe and dress	Basic motor skills	Agreeableness	Family relationships	Financial satisfaction
Blood pressure	Attention	Arthritis	Bathing	Bend and kneel	Altruism	Filial obligations expectation	Financial security
Calcium	Awareness of time and place	Asthma	Concerns over formal services	Chair stand	Attitude	Friendship	Job satisfaction
Circadian functioning	Backward digit recall	Bone mineral density	Do light housework	Climb one flight of stairs	Being able to make choices	Proximity to offspring	Job success
Creatinine	Cognitive function	Cancer	Dressing	Climb several flights of stairs	Conscientiousness	Quality of social network	Life satisfaction
ECG	Cognitive impairment	Cardiovascular disease	Driving	Climb stairs without difficulty	Contented	Satisfaction with free time arrangements	Managing money
Fatigue	Cognitive plasticity	Cerebrovascular disease	Goals	Demi span	Coping strategies	Satisfaction with social network	No regrets
Forced expiratory volume	Coping strategies	Chest pain	Grooming	Dynamic balance	Denial	Social activity	Satisfaction with own health
Glucose	Delayed recall	Chronic conditions	Health service use	Endurance	Dissociation	Social contact	Self-efficacy
Haematocrit	Episodic memory	Clinician rated disability	Home care	Energy	Emotional balance		Self-rated anxiety
Haemoglobin	Immediate recall	COPD	Home environment	Functional ability	Emotional security		Self-rated change in memory

HDL-C	Inductive reasoning	Coronary heart disease	Housework	Gait speed	Fatalism		Self-rated function
Hearing	Language use and comprehension	Depression	Independence	Grip strength	Feeling blue/sad		Self-rated general health
Hip circumference	Learning	Diabetes	Perceived social support	Handle small objects	Happy		Self-rated health
LDL-C	List generating fluency	Disability	Productivity	Indoor mobility	Hopelessness		Self-rated successful ageing
Magnesium	Long term memory	Emphysema	Purpose	Lift and carry groceries	Humour		
Obesity	Memory	Heart attack	Quality of life	Lifting 10lb weight	Judgement		
Phosphorus	Reasoning	Heart disease	Self-maintenance	Long distance walking	Locus of control		
Platelet count	Risk perception	Hypertension	Shopping for groceries or clothing	Lower body strength	Lonely		
Pulse	Self-rated concentration	Hypochondriasis	Toileting	Manual dexterity	Looks on bright side		
Red blood cells	Semantic memory	Illnesses	Transportation within the community	Mood	Making a contribution		
Sensory restrictions	Short term memory	Lung disease	Use of telephone or other form of communication	Motor speed	Nervous		
Telomere length	Short term visual memory	Mood		Movement	Number of stressful life events		
Total cholesterol	Verbal fluency	Neuroticism		Pushing or pulling heavy objects	Openness		

Total protein	Visual construction	Osteoporosis		Reaching above shoulder level	Peaceful		
Triceps skin fold	Word list recall	Pain		Semi tandem balance	Perceived control		
Triglycerides	Working memory	Parkinson's disease		Speed	Personal growth		
Urea		Physical health		Static balance	Positivity		
Uric acid		Psychological distress		Steps to turn 360	Projection		
Vision		Pulmonary disorder		Stooping/kneeling	Self confidence		
VLDL-C		Stroke		Strength	Self esteem		
Waist circumference				Tandem balance	Self-worth		
White blood cell count				Transfer in and out of bed	Sense of peace		
Wrist circumference				Walk a mile	Severity of stressful life events		
				Walk half a mile	Stress		
				Walk one block	Sublimation		
				Walk several blocks	Suppression		
				Walking ability	Unworried		
				Wheelchair use	Vulnerability		
					Wisdom		

Table showing category names and which cards were included in each category by Group 2 (Older people)

Appendix I. Categories and the cards they contain created by Group 3 organised alphabetically

Brain Function	Disease	Impairments	Independence	Measurement	Mood	Personality	Physical	Self-perception	Social
Abstract reasoning	Affective disorder	Chest pain	Bathe and dress	Albumin	Contented	Agreeableness	Balance	Accomplishments	Adaptability
Arithmetic	Alzheimer's disease	Chronic conditions	Bathing	Arm circumference	Denial	Conscientiousness	Basic motor skills	Attitude	Altruism
Attention	Arthritis	Clinician rated disability	Chair stand	Blood pressure	Emotional balance	Neuroticism	Bend and kneel	Emotional security	Concerns over formal services
Awareness of time and place	Asthma	Cognitive impairment	Climb one flight of stairs	Bone mineral density	Fatalism	Openness	Do light housework	Financial satisfaction	Confidantes
Backward digit recall	Cancer	Disability	Climb several flights of stairs	Calcium	Feeling blue/sad		Endurance	Goals	Family relationships
Being able to make choices	Cardiovascular disease	Illnesses	Climb stairs without difficulty	Circadian functioning	Happy		Energy	Job satisfaction	Filial obligations expectation
Cognitive function	Cerebrovascular disease	Pain	Dressing	Creatinine	Hopelessness		Fatigue	Life satisfaction	Friendship
Cognitive plasticity	COPD	Sensory restrictions	Driving	Demi span	Humour		Functional ability	Perceived control	Health service use
Coping strategies	Coronary heart disease		Economically independent	Dynamic balance	Looks on bright side		Grip strength	Personal growth	Home care

Delayed recall	Depression		Financial security	ECG	Mood		Handle small objects	Physical health	Home environment
Dissociation	Diabetes		Grooming	Forced expiratory volume	Nervous		Hearing	Quality of life	Independence
Episodic memory	Emphysema		Job success	Gait speed	No regrets		Housework	Risk perception	Lonely
Forward digit recall	Heart attack		Lift and carry groceries	Glucose	Peaceful		Indoor mobility	Satisfaction with free time arrangements	Making a contribution
Immediate recall	Heart disease		Lifting 10lb weight	Haematocrit	Positivity		Lower body strength	Satisfaction with own health	Number of stressful life events
Inductive reasoning	Hypertension		Long distance walking	Haemoglobin	Sense of peace		Manual dexterity	Satisfaction with social network	Perceived social support
Judgement	Hypochondriasis		Managing money	HDL-C	Stress		Mobility	Self confidence	Proximity to offspring
Language use and comprehension	Lung disease		Productivity	Hip circumference	Unworried		Motor speed	Self-efficacy	Quality of social network
Learning	Obesity		Pushing or pulling heavy objects	LDL-C			Movement	Self esteem	Severity of stressful life events
List generating fluency	Osteoporosis		Shopping for groceries or clothing	Magnesium			Reaching above shoulder level	Self-maintenance	Social activity
Locus of control	Parkinson's disease		Stooping/kneeling	Phosphorus			Self-rated function	Self-rated general health	Social contact

Long term memory	Psychological distress		Toileting	Platelet count			Semi tandem balance	Self-rated health	Transportation within the community
Memory	Pulmonary disorder		Transfer in and out of bed	Pulse			Speed	Self-rated successful ageing	
Projection	Self-rated anxiety		Use of telephone or other form of communication	Red blood cells			Static balance	Self-worth	
Purpose	Stroke		Walk a mile	Telomere length			Steps to turn 360	Vulnerability	
Reasoning			Walk half a mile	Total cholesterol			Strength	Wisdom	
Self-rated change in memory			Walk one block	Total protein			Tandem balance		
Self-rated concentration			Walk several blocks	Triceps skin fold			Vision		
Semantic memory			Wheelchair use	Triglycerides			Walking ability		
Short term memory				Urea					
Short term visual memory				Uric acid					
Sublimation				VLDL-C					
Suppression				Waist circumference					
Verbal fluency				White blood cell count					

Visual construction				Wrist circumference					
Word list recall									
Working memory									

Table showing category names and which cards were included in each category by Group 3 (Academics without an interest in ageing)

Appendix J. Categories and the cards they contain created by Participant 1, organised alphabetically.

Blood	Finances	Health Problems	Independence	Memory	Mental Health	Movement	Services	Traits
Albumin	Altruism	Arm circumference	Bathe and dress	Arithmetic	Affective disorder	Balance	Abstract reasoning	Accomplishments
Blood pressure	Economically independent	Arthritis	Bathing	Awareness of time and place	Alzheimer's disease	Basic motor skills	Cognitive function	Adaptability
Calcium	Financial satisfaction	Asthma	Dressing	Backward digit recall	Cognitive impairment	Bend and kneel	Cognitive plasticity	Agreeableness
Cardiovascular disease	Financial security	Bone mineral density	Family relationships	Forward digit recall	Delayed recall	Chair stand	Concerns over formal services	Attention
Circadian functioning	Managing money	Cancer	Grooming	Immediate recall	Denial	Climb one flight of stairs	Dissociation	Attitude
Creatinine		Cerebrovascular disease	Hearing	List generating fluency	Depression	Climb several flights of stairs	Driving	Being able to make choices
Haematocrit		Chest pain	Home care	Long term memory	Episodic memory	Climb stairs without difficulty	Energy	Confidantes
Haemoglobin		Chronic conditions	Home environment	Memory	Fatalism	Demi span	Health service use	Conscientiousness
HDL-C		Clinician rated disability	Hypochondriasis	Risk perception	Feeling blue/sad	Do light housework	Mood	Contented
Hypertension		COPD	Proximity to offspring	Self rated concentration	Hopelessness	Dynamic balance	Perceived social support	Coping strategies
LDL-C		Coronary heart disease	Quality of social network	Semantic memory	Lonely	Functional ability	Productivity	Emotional balance
Magnesium		Diabetes		Short term memory	Nervous	Gait speed	Reasoning	Emotional security
Phosphorus		Disability	Satisfaction with social network	Short term visual memory	Neuroticism	Grip strength	Self rated general health	Endurance

Platelet count		ECG	Sensory restrictions	Word list recall	Number of stressful life events	Handle small objects	Self rated health	Filial obligations expectation
Pulse		Emphysema	Social activity	Working memory	Psychological distress	Housework	Sublimation	Friendship
Red blood cells		Fatigue	Social contact		Self rated anxiety	Indoor mobility	Toileting	Goals
Total cholesterol		Forced expiratory volume	Vision		Self rated change in memory	Lift and carry groceries	Transportation within the community	Happy
Triglycerides		Glucose			Severity of stressful life events	Lifting 10lb weight		Humour
Urea		Heart attack			Stress	Locus of control		Independence
Uric acid		Heart disease			Suppression	Long distance walking		Inductive reasoning
VLDL-C		Hip circumference			Vulnerability	Lower body strength		Job satisfaction
White blood cell count		Illnesses				Manual dexterity		Job success
		Lung disease				Mobility		Judgement
		Obesity						
		Osteoporosis				Motor speed		Language use and comprehension
		Pain				Movement		Learning
		Parkinson’s disease				Pushing or pulling heavy objects		Life satisfaction
		Physical health				Reaching above shoulder level		Looks on bright side

		Pulmonary disorder				Self rated function		Making a contribution
		Stroke				Semi-tandem balance		No regrets
		Telomere length				Shopping for groceries or clothing		Openness
		Total protein				Speed (fitness)		Peaceful
		Triceps skin fold				Static balance		Perceived control
		Visual construction				Steps to turn 360		Personal growth
		Waist circumference				Stooping/knee ling		Positivity
		Wrist circumference				Strength		Projection
						Tandem balance		Purpose
						Transfer in and out of bed		Quality of life
						Walk a mile		Satisfaction with free time arrangements
						Walk half a mile		Satisfaction with own health
						Walk one block		Self confidence
						Walk several blocks		Self efficacy
						Walking ability		Self esteem
								Self maintenance

								Self rated successful ageing
								Self worth
								Sense of peace
								Unworried
								Use of telephone or other form of communicatio n
								Verbal fluency
								Wheelchair use
								Wisdom

Table showing category names and which cards were included in each category by Participant 1

Appendix K. Categories and the cards they contain created by Participant 2, organised alphabetically

Blood	Health Problems	Memory	Movement	Quality of Life	Services	Stress
Albumin	Arthritis	Abstract reasoning	Arm circumference	Accomplishments	Concerns over formal services	Circadian functioning
Calcium	Asthma	Affective disorder	Balance	Adaptability	Coping strategies	Denial
Creatinine	Blood pressure	Alzheimer's disease	Basic motor skills	Agreeableness	Family relationships	Depression
Glucose	Bone mineral density	Attention	Bathe and dress	Altruism	Filial obligations expectation	Dissociation
Haematocrit	Cancer	Awareness of time and place	Bathing	Arithmetic	Financial satisfaction	Fatalism
Haemoglobin	Cardiovascular disease	Backward digit recall	Bend and kneel	Attitude	Health service use	Fatigue
HDL-C	Cerebrovascular disease	Cognitive function	Chair stand	Being able to make choices	Home care	Feeling blue/sad
Phosphorus	Chest pain	Cognitive impairment	Climb one flight of stairs	Confidantes	Home environment	Hopelessness
Platelet count	Chronic conditions	Cognitive plasticity	Climb several flights of stairs	Conscientiousness	Job satisfaction	Illnesses
Red blood cells	COPD	Delayed recall	Climb stairs without difficulty	Contented	Judgement	Lonely
Telomere length	Coronary heart disease	Episodic memory	Clinician rated disability	Economically independent	Life satisfaction	Mood
Total cholesterol	Diabetes	Forward digit recall	Demi span	Emotional balance	Perceived social support	Nervous
Total protein	ECG	Immediate recall	Disability	Emotional security	Proximity to offspring	Neuroticism
Triglycerides	Emphysema	Inductive reasoning	Do light housework	Endurance	Quality of social network	Number of stressful life events
Urea	Forced expiratory volume	Language use and comprehension	Dressing	Energy	Satisfaction with free time arrangements	Pain

Uric acid	Heart attack	Learning	Driving	Financial security	Satisfaction with own health	Psychological distress
VLDL-C	Heart disease	List generating fluency	Dynamic balance	Friendship	Satisfaction with social network	Self rated anxiety
White blood cell count	Hypertension	Locus of control	Gait speed	Functional ability	Social contact	Self rated general health
	Hypochondriasis	Long term memory	Grip strength	Goals	Transportation within the community	Self rated health
	LDL-C	Memory	Handle small objects	Grooming		Sensory restrictions
	Lung disease	Self rated change in memory	Hearing	Happy		Severity of stressful life events
	Obesity	Self rated concentration	Hip circumference	Humour		Stress
	Osteoporosis	Self rated function	Housework	Independence		Sublimation
	Parkinson's disease	Semantic memory	Indoor mobility	Job success		Suppression
	Pulmonary disorder	Short term memory	Inductive reasoning	Looks on bright side		Vulnerability
	Pulse	Short term visual memory	Lift and carry groceries	Making a contribution		
	Stroke	Verbal fluency	Lifting 10lb weight	Managing money		
	Triceps skin fold	Word list recall	Long distance walking	No regrets		
		Working memory	Lower body strength	Openness		
			Manual dexterity	Peaceful		
			Mobility	Personal growth		
			Motor speed	Physical health		
			Movement	Positivity		
			Perceived control	Productivity		
			Projection	Purpose		

			Pushing or pulling heavy objects	Quality of life		
			Reaching above shoulder level	Reasoning		
			Risk perception	Self confidence		
			Semi tandem balance	Self efficacy		
			Shopping for groceries or clothing	Self esteem		
			Static balance	Self maintenance		
			Steps to turn 360	Self rated successful ageing		
			Stooping/kneeling	Self worth		
			Strength	Sense of peace		
			Tandem balance	Social activity		
			Toileting	Speed (fitness)		
			Transfer in and out of bed	Unworried		
			Use of telephone or other form of communication	Wisdom		
			Vision			
			Visual construction			
			Waist circumference			
			Walk a mile			
			Walk half a mile			
			Walk one block			
			Walk several blocks			
			Walking ability			
			Wheelchair use			
			Wrist circumference			

Appendix L. Categories and the cards they contain created by Participant 3, organised alphabetically

Accomplishments	Health Problems	Memory	Mood	Movement	Quality of Life	Tests	Traits
Accomplishments	Affective disorder	Alzheimer's disease	Cognitive impairment	Basic motor skills	Arithmetic	Albumin	Abstract reasoning
Adaptability	Arthritis	Awareness of time and place	Confidantes	Climb one flight of stairs	Bathe and dress	Arm circumference	Agreeableness
Attention	Asthma	Backward digit recall	Coping strategies	Climb several flights of stairs	Bathing	Calcium	Altruism
Goals	Blood pressure	Cognitive plasticity	Denial	Climb stairs without difficulty	Being able to make choices	Creatinine	Attitude
Independence	Bone mineral density	Delayed recall	Depression	Disability	Circadian functioning	Demi span	Balance
Inductive reasoning	Cancer	Forward digit recall	Dissociation	Handle small objects	Concerns over formal services	Glucose	Bend and kneel
Language use and comprehension	Cardiovascular disease	Immediate recall	Emotional balance	Long distance walking	Do light housework	Haematocrit	Chair stand
List generating fluency	Cerebrovascular disease	Long term memory	Emotional security	Mobility	Dressing	Haemoglobin	Cognitive function
Personal growth	Chest pain	Memory	Episodic memory	Motor speed	Driving	Hip circumference	Conscientiousness
Productivity	Chronic conditions	Self rated change in memory	Feeling blue/sad	Movement	Economically independent	Magnesium	Contented
Projection	Clinician rated disability	Short term memory	Hopelessness	Steps to turn 360	Energy	Obesity	Dynamic balance
Self rated concentration	COPD	Short term visual memory	Lonely	Stooping/kneeling	Family relationships	Phosphorus	Endurance
Self rated function	Coronary heart disease	Visual construction	Neuroticism	Transfer in and out of bed	Filial obligations expectation	Platelet count	Fatalism
Use of telephone or other form of communication	Diabetes	Wisdom	Number of stressful life events	Walk a mile	Financial satisfaction	Pulse	Gait speed

Verbal fluency	ECG	Word list recall	Psychological distress	Walk half a mile	Financial security	Red blood cells	Grip strength
	Emphysema	Working memory	Self rated anxiety	Walk one block	Friendship	Semantic memory	Happy
	Fatigue		Severity of stressful life events	Walk several blocks	Functional ability	Telomere length	Humour
	Forced expiratory volume		Stress	Walking ability	Grooming	Total cholesterol	Job satisfaction
	HDL-C		Sublimation	Wheelchair use	Health service use	Total protein	Job success
	Heart attack		Suppression		Hearing	Triceps skin fold	Judgement
	Heart disease		Vulnerability		Home care	Triglycerides	Learning
	Hypertension				Home environment	Urea	Life satisfaction
	Hypochondriasis				Housework	Uric acid	Locus of control
	Illnesses				Indoor mobility	Waist circumference	Looks on bright side
	LDL-C				Lift a 10lb weight	White blood cell count	Lower body strength
	Lung disease				Lift and carry groceries	Wrist circumference	Manual dexterity
	Osteoporosis				Making a contribution		Mood
	Pain				Managing money		Nervous
	Parkinson's disease				Perceived social support		No regrets
	Pulmonary disorder				Physical health		Openness
	Stroke				Proximity to offspring		Peaceful
	VLDL-C				Quality of life		Perceived control

					Quality of social network		Positivity
					Satisfaction with free time arrangements		Purpose
					Satisfaction with own health		Pushing or pulling heavy objects
					Satisfaction with social network		Reaching above shoulder level
					Self maintenance		Reasoning
					Self rated general health		Risk perception
					Self rated health		Self confidence
					Self rated successful ageing		Self efficacy
					Shopping for groceries or clothing		Self esteem
					Social activity		Self worth
					Social contact		Semi tandem balance
					Social contact		Sense of peace
					Speed (fitness)		Static balance
					Toileting		Strength
					Transportation within the community		Tandem balance
					Vision		Unworried

Table showing category names and which cards were included in each category by Participant 3

Appendix M. Categories and the cards they contain created by Participant 4, organised alphabetically.

Blood	Brain Function	Cardiovascular	Health Problems	Mental Health	Movement	Outside Influences	Social Interaction	Tests	Traits
Albumin	Abstract reasoning	Blood pressure	Affective disorder	Coping strategies	Balance	Concerns over formal services	Confidantes	Arm circumference	Accomplishments
Calcium	Arithmetic	Chest pain	Alzheimer's disease	Denial	Basic motor skills	Economically independent	Family relationships	Bone mineral density	Adaptability
Creatinine	Attention	ECG	Arthritis	Emotional balance	Bathe and dress	Financial satisfaction	Filial obligations expectation	Demi span	Agreeableness
Glucose	Awareness of time and place	Forced expiratory volume	Asthma	Emotional security	Bathing	Financial security	Friendship	Hip circumference	Altruism
Haemoglobin	Backward digit recall	Haematocrit	Cancer	Hypochondriasis	Bend and kneel	Health service use	Lonely	Phosphorus	Attitude
HDL-C	Being able to make choices	Heart attack	Cardiovascular disease	Locus of control	Chair stand	Home care	Making a contribution	Telomere length	Conscientiousness
LDL-C	Circadian functioning	Hypertension	Cerebrovascular disease	Nervous	Climb one flight of stairs	Home environment	Perceived social support	Triceps skin fold	Contented
Magnesium	Cognitive function	Pulmonary disorder	Chronic conditions	Neuroticism	Climb several flights of stairs	Physical health	Proximity to offspring	Waist circumference	Fatalism
Platelet count	Cognitive impairment	Pulse	Clinician rated disability	Number of stressful life events	Climb stairs without difficulty	Quality of life	Quality of social network	Wrist circumference	Feeling blue/sad

Red blood cells	Cognitive plasticity	Stress	COPD	Psychological distress	Do light housework	Satisfaction with own health	Satisfaction with free time arrangements		Goals
Total cholesterol	Delayed recall	Blood pressure	Coronary heart disease	Self rated anxiety	Dressing	Self rated general health	Satisfaction with social network		Happy
Total protein	Dissociation	Chest pain	Depression	Severity of stressful life events	Driving	Self rated health	Self esteem		Hopelessness
Triglycerides	Episodic memory	ECG	Diabetes	Sublimation	Dynamic balance		Social activity		Humour
Urea	Forward digit recall	Forced expiratory volume	Disability	Suppression	Endurance		Social contact		Job satisfaction
Uric acid	Hearing	Haematocrit	Emphysema	Vulnerability	Energy				Job success
VLDL-C	Immediate recall	Heart attack	Heart disease	Coping strategies	Fatigue				Life satisfaction
White blood cell count	Inductive reasoning	Hypertension	Illnesses	Denial	Functional ability				Looks on bright side
	Judgement	Pulmonary disorder	Lung disease	Emotional balance	Gait speed				Mood
	Language use and comprehension	Pulse	Obesity	Emotional security	Grip strength				No regrets
	Learning	Stress	Osteoporosis	Hypochondriasis	Grooming				Openness

	List generating fluency		Parkinson's disease	Locus of control	Handle small objects				Peaceful
	Long term memory		Sensory restrictions	Nervous	Housework				Personal growth
	Managing money		Stroke	Neuroticism	Independence				Positivity
	Memory			Number of stressful life events	Indoor mobility				Productivity
	Perceived control			Psychological distress	Lift and carry groceries				Purpose
	Projection			Self rated anxiety	Lifting 10lb weight				Self confidence
	Reasoning			Severity of stressful life events	Long distance walking				Self efficacy
	Risk perception			Sublimation	Lower body strength				Self rated function
	Self rated change in memory			Suppression	Manual dexterity				Self rated successful ageing
	Self rated concentration			Vulnerability	Mobility				Self worth
	Semantic memory				Motor speed				Sense of peace
	Short term memory				Movement				Unworried
	Short term visual memory				Pain				Wisdom

	Use of telephone or other form of communication				Pushing or pulling heavy objects				
	Verbal fluency				Reaching above shoulder level				
	Visual construction				Self maintenance				
	Word list recall				Semi tandem balance				
	Working memory				Shopping for groceries or clothing				
					Speed (fitness)				
					Static balance				
					Steps to turn 360				
					Stooping/kneeling				
					Strength				
					Tandem balance				
					Toileting				
					Transfer in and out of bed				
					Transportation within the community				
					Vision				
					Walk a mile				

					Walk half a mile				
					Walk one block				
					Walk several blocks				
					Walking ability				
					Wheelchair use				

Table showing category names and which cards were included in each category by Participant 4

Appendix N. Placement of cards in predetermined categories by Group 2 in the closed sort, organised alphabetically.

Brain function	Fulfilling potential	Health Problems	Independence	Measuring Ageing	Mood	Personality	Physical Function	Social Support	Wellbeing
Abstract reasoning	Accomplishments	Alzheimer's disease	Bathe and dress	Albumin	Affective disorder	Agreeableness	Basic motor skills	Confidantes	Emotional security
Adaptability	Goals	Arthritis	Bathing	VLDL-C	Anxiety	Altruism	Bend and kneel	Home care	Family relationships
Arithmetic	Job success	Asthma	Chair stand	Arm circumference	Contented	Attitude	Clinician rated disability	Number of stressful life events	Filial obligations expectations
Attention	Making a contribution	Cancer	Climb one flight of stairs	Waist circumference	Denial	Conscientiousness	Disability	Perceived social support	Financial satisfaction
Awareness of time and place	Personal growth	Cardiovascular disease	Climb several flights of stairs	Balance	Depression	Friendship	Endurance	Severity of stressful life events	General health
Backward digit recall	Productivity	Cerebrovascular disease	Climb stairs without difficulty	White blood cell count	Dissociation	Judgement	Energy	Social contact	Home environment
Being able to make choices	Purpose	Chest pain	Concerns over formal services	Blood pressure	Emotional balance	Nervous	Fatigue		Job satisfaction
Change in memory		Chronic conditions	Do light housework	Bone mineral density	Fatalism	Neuroticism	Fitness		Life satisfaction
Cognitive function		COPD	Does not use wheelchair	Calcium	Feeling blue/sad	Openness	Function		Physical health
Cognitive impairment		Coronary heart disease	Dressing	Circadian functioning	Happy	Perceived control	Functional ability		Proximity to offspring

Cognitive plasticity		Diabetes	Driving	Creatinine	Hopelessness	Projection	Gait speed		Quality of social network
Concentration		Emphysema	Economically independent	Demi-span	Humour	Self confidence	Handle small objective		Quality of life
Coping strategies		Health service use	Financial security	Dynamic balance	Lonely	Self esteem	Hearing		Rating of health
Delayed recall		Heart attack	Grooming	ECG	Looks on the bright side	Self worth	Indoor mobility		Satisfaction with free time arrangements
Episodic memory		Heart disease	Housework	Forced expiratory volume	Mood	Sublimation	Lower body strength		Satisfaction with own health
Forward digit recall		Hypertension	Independence	Glucose	No regrets		Manual dexterity		Satisfaction with social network
Immediate recall		Hypochondriasis	Lift and carry groceries	Grip strength	Peaceful		Mobility		Successful ageing
Inductive reasoning		Illness	Lifting a 10lb weight	Haematocrit	Positivity		Motor speed		
Language use and comprehension		Lung disease	Long distance walking	Haemoglobin	Psychological distress		Movement		
Learning		Obesity	Managing money	HDL-C	Sense of peace		Pain		
List generating fluency		Osteoporosis	Pushing or pulling heavy objects	Hip circumference	Stress		Reaching above shoulder level		

Locus of control		Parkinson's disease	Self efficacy	LDL-C	Unworried		Sensory restrictions		
Long term memory		Pulmonary disorder	Self maintenance	Uric acid			Social activity		
Memory		Stroke	Shopping for groceries or clothing	Magnesium			Strength		
Reasoning			Stooping/kneeling	Phosphorus			Steps to turn 360		
Risk perception			Toileting	Platelet count			Vision		
Semantic memory			Transfer in and out of bed	Pulse			Walking ability		
Short term memory			Transportation within the community	Red blood cell count					
Short term visual memory			Use of telephone of other form of communication	Semi-tandem balance					
Suppression			Vulnerability	Static balance					
Verbal fluency			Walk 1/2 mile	Tandem balance					
Visual construction			Walk a mile	Telomere length					
Wisdom			Walk one block	Total cholesterol					

Word list recall			Walk several blocks	Total protein					
Working memory				Triceps skin fold					
				Triglycerides					
				Urea					
				Wrist circumference					

Table showing card placed in predetermined categories by Group 2 during the closed sort.

Appendix O. Card content and card numbers of each card found in each cluster on the heat map showing the co-occurrence of cards in the open group sorts.

Cluster	Card content	Card number
1	Hearing	95
	Vision	212
2	Dynamic balance	64
	Gait speed	83
3	Walk several blocks	219
	Walk a mile	216
	Walk half a mile	217
	Walk one block	218
	Transfer in and out of bed	202
	Stooping/kneeling	190
	Pushing or pulling heavy objects	161
	Long distance walking	123
	Lift and carry groceries	118
	Lifting 10lb weight	119
	Wheelchair use	61
	Climb several flights of stairs	38
	Climb stairs without difficulty	39
	Climb one flight of stairs	37
	Chair stand	31
4	Walking ability	220
	Tandem balance	197
	Strength	191
	Speed (fitness)	187
	Static balance	188
	Steps to turn 360	189
	Semi tandem balance	178
	Reaching above shoulder level	164
	Motor speed	135
	Movement	136
	Mobility	133
	Manual dexterity	131
	Lower body strength	127
	Indoor mobility	110
	Handle small objects	91
	Grip strength	87
	Functional ability	82
	Endurance	70
	Bend and kneel	23
	Balance	18
	Basic motor skills	19
5	Circadian functioning	36
	Forced expiratory volume	79
6	Wrist circumference	225

	White blood cell count	221
	Waist circumference	215
	VLDL-C	211
	Urea	207
	Uric acid	208
	Triceps skin fold	204
	Triglycerides	205
	Total cholesterol	200
	Total protein	201
	Telomere length	198
	Red blood cells	166
	Pulse	159
	Platelet count	152
	Phosphorus	150
	Magnesium	129
	LDL-C	126
	HDL-C	98
	Hip circumference	99
	Haematocrit	89
	Haemoglobin	90
	Glucose	85
	ECG	66
	Creatinine	52
	Calcium	27
	Blood pressure	24
	Arm circumference	11
	Albumin	6
7	Working memory	224
	Word list recall	223
	Visual construction	213
	Verbal fluency	210
	Short term memory	183
	Short term visual memory	184
	Self efficacy	172
	Reasoning	165
	Memory	132
	Long term memory	124
	List generating fluency	120
	Language use and comprehension	115
	Inductive reasoning	111
	Immediate recall	108
	Forward digit recall	80
	Episodic memory	72
	Delayed recall	53
	Cognitive plasticity	43
	Self rated concentration	44
	Cognitive function	41

	Awareness of time and place	16
	Backward digit recall	17
	Attention	14
	Abstract reasoning	1
	Arithmetic	10
8	Pain	144
	Illnesses	107
	Chest pain	33
	Chronic conditions	34
9	Stroke	193
	Pulmonary disorder	158
	Parkinson's disease	145
	Osteoporosis	143
	Lung disease	128
	Hypertension	105
	Hypochondriasis	106
	Heart attack	96
	Heart disease	97
	Emphysema	69
	Depression	56
	Diabetes	57
	Coronary heart disease	51
	COPD	35
	Cerebrovascular disease	30
	Cancer	28
	Cardiovascular disease	29
	Arthritis	12
	Asthma	13
	Affective disorder	4
	Alzheimer's disease	8
10	Disability	58
	Making a contribution	49
11	Severity of stressful life events	181
	Personal growth	149
12	Vulnerability	214
	Self esteem	175
	Self worth	176
13	Suppression	196
	Dissociation	59
14	Sublimation	194
	Projection	155
	Locus of control	121
	Being able to make choices	22
	Coping strategies	50
15	Openness	142
	Agreeableness	5
	Conscientiousness	47
16	Unworried	206

	Peaceful	146
	Looks on bright side	125
	Happy	92
	Contented	48
17	Stress	192
	Positivity	153
	Nervous	137
	Hopelessness	102
	Emotional balance	67
	Feeling blue/sad	25
	Denial	55
18	Satisfaction with free time arrangements	168
	Satisfaction with social network	170
19	Social activity	185
	Social contact	186
	Quality of social network	163
	Proximity to offspring	156
	Friendship	81
	Confidantes	46
	Family relationships	73
20	Self confidence	171
	Attitude	15
	Self efficacy	172
21	Self rated successful ageing	195
	Satisfaction with own health	169
	Life satisfaction	117
	Job satisfaction	112
	Self rated health	93
	Self rated general health	84
22	Goals	86
	Accomplishments	2
23	Managing money	130
	Economically independent	65
	Financial security	78
24	Perceived social support	148
	Home environment	100
	Home care	101
25	Transportation within the community	203
	Independence	109
	Concerns over formal services	45
26	Housework	103
	Do light housework	60
27	Toileting	199
	Shopping for groceries or clothing	182

	Grooming	88
	Dressing	62
	Driving	63
	Bathe and dress	20
	Bathing	21

Appendix P. Card content and card numbers of each card found in each cluster the heat map showing the co-occurrence of cards in the individual open sorts.

Cluster	Card content	Card number
1	Shopping for groceries or clothing	182
	Lift and carry groceries	118
	Indoor mobility	110
	Do light housework	60
	Do light housework	103
2	Driving	63
	Toileting	199
3	Dressing	62
	Bathe and dress	20
	Bathing	21
4	Tandem balance	197
	Strength	191
	Static balance	188
	Reaching above shoulder level	164

	Pushing or pulling heavy objects	161
	Manual dexterity	131
	Lower body strength	127
	Grip strength	87
	Gait speed	83
	Dynamic balance	64
	Chair stand	31
	Balance	18
	Bend and kneel	23
5	Walking ability	220
	Walk several blocks	219
	Walk one block	218
	Walk half a mile	217
	Walk a mile	216
	Transfer in and out of bed	202
	Stooping/kneeling	190
	Steps to turn 360	189

	Movement	136
	Motor speed	135
	Mobility	133
	Long distance walking	123
	Lifting 10lb weight	119
	Handle small objects	91
	Climb stairs without difficulty	39
	Climb several flights of stairs	38
	Basic motor skills	19
	Climb one flight of stairs	37
6	Fatigue	75
	Pain	144
7	Blood pressure	24
	Hypertension	105
8	Pulmonary disorder	158
	Heart attack	96
	Forced expiratory volume	79

	Chest pain	33
	ECG	66
9	Stroke	193
	Parkinson's disease	145
	Osteoporosis	143
	Lung disease	128
	Heart disease	97
	Emphysema	69
	Diabetes	57
	Coronary heart disease	51
	COPD	35
	Chronic conditions	34
	Cerebrovascular disease	30
	Cancer	28
	Arthritis	12
	Asthma	13
10	Feeling blue/sad	25

	Hopelessness	102
11	Vulnerability	214
	Suppression	196
	Severity of stressful life events	181
	Psychological distress	157
	Number of stressful life events	140
	Neuroticism	138
	Self-rated anxiety	9
	Denial	55
12	Wrist circumference	225
	Waist circumference	215
	Arm circumference	11
	Hip circumference	99
13	HDL-C	98
	VLDL-C	211
14	Glucose	85
	Total protein	201

15	White blood cell count	221
	Uric acid	208
	Urea	207
	Triglycerides	205
	Total cholesterol	200
	Red blood cells	166
	Platelet count	152
	Magnesium	129
	Haemoglobin	90
	Creatinine	52
	Albumin	6
	Calcium	27
16	Emotional balance	67
	Emotional security	68
17	Making a contribution	49
	Friendship	81
18	Personal growth	149

	Grooming	88
	Accomplishments	2
	Adaptability	3
19	Life satisfaction	117
	Job satisfaction	112
20	Unworried	206
	Sense of peace	179
	Self-worth	176
	Self-efficacy	172
	Self confidence	171
	Purpose	160
	Positivity	153
	Peaceful	146
	Openness	142
	No regrets	139
	Looks on bright side	125
	Job success	113

	Humour	104
	Happy	92
	Conscientiousness	47
	Contented	48
	Agreeableness	5
	Attitude	15
21	Concerns over formal services	45
	Health service use	94
22	Satisfaction with own health	169
	Home care	101
	Self-rated health	93
	Home environment	100
23	Social contact	186
	Satisfaction with social network	170
	Quality of social network	163
	Family relationships	73
	Proximity to offspring	156

24	Functional ability	82
	Speed (fitness)	187
25	Filial obligations expectation	76
	Satisfaction with free time arrangements	168
26	Economically independent	65
	Financial security	78
27	Self-rated change in memory	32
	Delayed recall	53
28	Cognitive impairment	42
	Episodic memory	72
29	Self-rated concentration	44
	List generating fluency	120
30	Working memory	224
	Word list recall	223
	Short term visual memory	184
	Short term memory	183
	Long term memory	124

	Immediate recall	108
	Forward digit recall	80
	Awareness of time and place	16
	Backward digit recall	17
	Self-rated function	174
31	Language use and comprehension	115
	Attention	14
	Inductive reasoning	111
	Verbal fluency	210
32	Cognitive function	41
	Abstract reasoning	1
33	Projection	155
	Use of telephone or other form of communication	209

Appendix Q. Card content and card numbers of each card found in each cluster the heat map showing the co-occurrence of cards in the closed group sort.

Cluster	Card content	Card number
1	Wrist circumference	225
	White blood cell count	221
	Waist circumference	215
	VLDL-C	211
	Urea	207
	Uric acid	208
	Triceps skin fold	204
	Triglycerides	205
	Total protein	201
	Telomere length	198
	Red blood cells	166
	Pulse	159
	Platelet count	152
	Phosphorus	150
	Magnesium	129
	LDL-C	126
	HDL-C	98
	Hip circumference	99
	Haematocrit	89
	Haemoglobin	90
	Glucose	85
	ECG	66
	Demi span	54
	Creatinine	52
	Bone mineral density	26
	Calcium	27
	Blood pressure	24
	Arm circumference	11
	Albumin	6
2	Tandem balance	197
	Static balance	188
	Semi tandem balance	178
	Grip strength	87
	Forced expiratory volume	79
	Dynamic balance	64
	Circadian functioning	36
	Balance	18
3	Walk a mile	216
	Walk half a mile	217
	Walk one block	218
	Walk several blocks	219
	Transfer in and out of bed	202
	Stooping/kneeling	190

	Pushing or pulling heavy objects	161
	Long distance walking	123
	Lift and carry groceries	118
	Lifting 10lb weight	119
	Wheelchair use	61
	Climb several flights of stairs	38
	Climb stairs without difficulty	39
	Climb one flight of stairs	37
	Chair stand	31
4	Walking ability	220
	Vision	212
	Strength	191
	Steps to turn 360	189
	Speed (fitness)	187
	Sensory restrictions	180
	Self rated function	174
	Reaching above shoulder level	164
	Motor speed	135
	Movement	136
	Manual dexterity	131
	Lower body strength	127
	Indoor mobility	110
	Hearing	95
	Handle small objects	91
	Functional ability	82
	Gait speed	83
	Endurance	70
	Disability	58
	Clinician rated disability	40
	Bend and kneel	23
	Basic motor skills	19
5	Risk perception	167
	Locus of control	121
	Coping strategies	50
	Being able to make choices	22
	Adaptability	3
6	Word list recall	223
	Working memory	224
	Visual construction	213
	Verbal fluency	210
	Short term memory	183
	Short term visual memory	184
	Semantic memory	177
	Reasoning	165
	Memory	132
	Long term memory	124

	List generating fluency	120
	Language use and comprehension	115
	Inductive reasoning	111
	Independence	109
	Forward digit recall	80
	Episodic memory	72
	Delayed recall	53
	Cognitive function	41
	Cognitive impairment	42
	Cognitive plasticity	43
	Self rated concentration	44
	Self rated change in memory	32
	Awareness of time and place	16
	Backward digit recall	17
	Attention	14
	Abstract reasoning	1
	Arithmetic	10
7	Fatigue	75
	Pain	144
8	Stroke	193
	Pulmonary disorder	158
	Parkinson's disease	145
	Osteoporosis	143
	Obesity	141
	Lung disease	128
	Hypertension	105
	Hypochondriasis	106
	Illnesses	107
	Heart attack	96
	Heart disease	97
	Health service use	94
	Emphysema	69
	Diabetes	57
	Coronary heart disease	51
	Chronic conditions	34
	COPD	35
	Chest pain	33
	Cancer	28
	Cardiovascular disease	29
	Cerebrovascular disease	30
	Asthma	13
	Arthritis	12
	Alzheimer's disease	8
9	Depression	56
	Affective disorder	4
10	No regrets	139
	Sense of peace	179

11	Fatalism	74
	Humour	104
12	Number of stressful life events	140
	Severity of stressful life events	181
13	Self worth	176
	Self esteem	175
	Openness	142
	Nervous	137
	Neuroticism	138
	Conscientiousness	47
	Agreeableness	5
14	Unworried	206
	Stress	192
	Psychological distress	157
	Positivity	153
	Peaceful	146
	Mood	134
	Looks on bright side	125
	Lonely	122
	Hopelessness	102
	Happy	92
	Emotional balance	67
	Dissociation	59
	Denial	55
	Contented	48
	Self rated anxiety	9
15	Transportation within the community	203
	Toileting	199
	Shopping for groceries or clothing	182
	Self maintenance	173
	Managing money	130
	Independence	109
	Housework	103
	Grooming	88
	Financial security	78
	Economically independent	65
	Driving	63
	Dressing	62
	Do light housework	60
	Concerns over formal services	45
	Bathe and dress	20
	Bathing	21
16	Sublimation	194
	Self confidence	171

	Projection	155
	Perceived control	147
	Judgement	114
	Attitude	15
17	Social contact	186
	Perceived social support	148
	Home care	101
	Confidantes	46
18	Purpose	160
	Productivity	154
	Personal growth	149
	Goals	86
	Making a contribution	49
	Accomplishments	2
19	Self rated successful ageing	195
	Satisfaction with own health	169
	Quality of life	162
	Life satisfaction	117
	Job satisfaction	112
	Self rated health	93
	Self rated general health	84
20	Satisfaction with social network	170
	Satisfaction with free time arrangements	168
	Quality of social network	163
	Proximity to offspring	156
	Home environment	100
	Family relationships	73
	Emotional security	68

Appendix R. Creation of subgroupings for each category

Component	Subgroup	Outcome from literature review
Measuring Ageing	Bone Health	Bone Mineral Density
		Calcium
		Phosphorous
	Kidney Function	Urea
		Creatinine
	Influence of Genes	Telomere Length
	General Health	Uric Acid
		Albumin
		Total Protein
	Blood Composition	Platelet Count
		Haemoglobin
		White Blood Cell Count
		Red Blood Cell Count
		Haematocrit
	Heart Function	ECG
		Blood Pressure
		Pulse
		Magnesium
	Blood Glucose	Glucose
	Blood Lipids	LDL-C
		HDL-C
		Total Cholesterol
		VLDL-C
		Triglycerides
	Adiposity	Hip Circumference
		Arm Circumference
		Triceps Skin Fold
		Wrist Circumference
		Waist Circumference
		Demi span
Health Problems	Diabetes	Diabetes
	Dementia	Alzheimer's
	Bone Disease	Osteoporosis
		Arthritis
	Pain	Pain
	Fatigue	Fatigue
	Cancer	Cancer
	Obesity	Obesity
	Degenerative Brain Disease	Parkinson's
	Mood Disorders	Depression
		Affective Disorder
	Lung Problems	Pulmonary Disorder
		COPD
		Asthma
		Emphysema
		Lung Disease
	Cardiovascular Problems	Chest Pain
		Hypertension

		Heart Attack
		Heart Disease
		Cardiovascular Disease
		Coronary Heart Disease
		Stroke
		Cerebrovascular Disease
	Health Service Use	Chronic Conditions
		Health Service Use
		Illnesses
		Hypochondriasis
Independence	Finances	Financial Security
		Financial Satisfaction
		Economically Independent
		Managing Money
	Self-maintenance	Self-maintenance
		Dressing
		Grooming
		Toileting
		Bathing
		Bathe and dress
	Daily Activities	Housework
		Do light housework
		Shopping for groceries or clothing
	Transport	Transportation within the community
		Driving
	Formal services	Concerns over formal services
Mood	General Mood	Contented
		Happy
		Blue/sad
		Mood
		Nervous
		Peaceful
		Looks on Bright Side
		Unworried
		Emotional Balance
		Emotional Security
		Sense of Peace
	Coping Ability	Dissociation
		Denial
		Suppression
		Neuroticism
		Positivity
		Hopelessness
		Sublimation
	Life Events	Number of stressful life event
		Severity of stressful life events
	Stress	Stress
		Psychological Distress
	Anxiety	Anxiety
	Self-esteem	Self-esteem

		Self-worth
	Loneliness	Lonely
	Personality Traits	Openness
		Conscientiousness
		Agreeableness
		Vulnerability
Personality	Confidence	Self Confidence
	Self-efficacy	Self-efficacy
		Being able to make choices
	Sense of humour	Humour
	Outlook	Attitude
		Fatalism
		Judgement
		Altruism
	Control	Locus of Control
		Perceived Control
	Coping	Coping Strategies
		Adaptability
		Projection
	Risk assessment	Risk assessment
Brain Function	Memory	Working Memory
		Episodic Memory
		Semantic Memory
		Delayed Recall
		Change in Memory
		Word List Recall
		Short Term Visual Memory
		Backward Digit Recall
		Long Term Memory
		Short term Memory
		Immediate Recall
		Memory
	Attention	Attention
		Concentration
	Reasoning	Abstract Reasoning
		Reasoning
		Inductive Reasoning
	Cognitive Plasticity	Cognitive Plasticity
		Cognitive Impairment
		Cognitive Function
		Awareness of Time and Place
	Cognitive Skills	List Generating Fluency
		Language Use and Comprehension
		Verbal fluency
		Arithmetic
		Visual construction
Fulfilling Potential	Purpose	Purpose
	Accomplishment	Accomplishment

	Contribution	Contribution
		Productivity
	Personal growth	Goals
		Personal Growth
		Learning
		Wisdom
	Family Support	Filial Obligation Expectations
Wellbeing	Life Satisfaction	Life Satisfaction
		No Regrets
	Quality of Life	Quality of Life
	How well someone feels that they are ageing	Successful Ageing
	Energy	Energy
	Job Satisfaction	Job Success
		Job Satisfaction
	Satisfaction with Health	General Health
		Satisfaction with Own Health
		Health
Social Support	Social Activity	Quality of Social Network
		Satisfaction with Free Time Arrangements
		Satisfaction with Social Network
		Perceived Social Support
		Social Contact
		Social Activity
	Friendships	Friendship
		Confidantes
	Social Relationships	Proximity to Offspring
		Family Relationships
	Home	Homecare
		Home Environment
	Communication	Use of telephone or other form of communication
Physical function	Disability	Clinician Rated Disability
		Disability
		Functional Ability
		Wheelchair Use
	Sensory Impairment	Hearing
		Sensory restrictions
		Vision
	Lung Function	Forced Expiratory Volume
	Balance	Tandem Balance
		Semi Tandem Balance
		Static Balance
		Dynamic Balance
		Balance
	Strength	Strength
		Grip Strength
		Lower Body Strength
	Endurance	Endurance
	Walking	Gait Speed

		Speed
		Long Distance Walking
		Walk Several Blocks
		Walk a Mile
		Walking Ability
		Walk 1/2 mile
		Walk One Block
	Movement	Movement
		Climb Several Flights of Stairs
		Climb One Flight of Stairs
		Bend and Kneel
		Reaching Above Shoulder Level
		Climb Stairs Without Difficulty
		Stooping and Kneeling
		Pushing and Pulling Heavy Objects
		Transfer In and Out of Bed
		Lifting a 10lb weight
		Chair Stand
		Indoor Mobility
		Basic Motor Skills
		Lift and Carry Groceries
		Steps to turn 360°
		Motor Speed
	Dexterity	Handle Small Objects
		Manual Dexterity
	Sleep	Circadian Functioning
	Self-rated health	Self-rated Function
		Physical Health

Appendix S. Ethics

Newcastle University

18 April 2013

Evelyn Barron
Institute for Ageing and Health
1.43 Biomedical Research Building
Campus for Ageing & Vitality

Faculty of Medical Sciences

Newcastle University
The Medical School
Framlington Place
Newcastle upon Tyne
NE2 4HH United Kingdom

Professor Michael Whitaker
FIBiol FMed Sci
Dean of Research & Innovation

FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE

Dear Evelyn

Title: What do we mean by healthy ageing?
Application No: 00638/2013
Start date to end date: 11 March 2013 to 11 July 2013

On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of your proposal have been considered and your study has been given ethical approval.

The approval is limited to this project: **00638/2013**. If you wish for a further approval to extend this project, please submit a re-application to the FMS Ethics Committee and this will be considered.

During the course of your research project you may find it necessary to revise your protocol. Substantial changes in methodology, or changes that impact on the interface between the researcher and the participants must be considered by the FMS Ethics Committee, prior to implementation.*

At the close of your research project, please report any adverse events that have occurred and the actions that were taken to the FMS Ethics Committee.*

Best wishes,

Yours sincerely

M. Holbrough

Marjorie Holbrough
On behalf of Faculty Ethics Committee

cc.
Professor Michael Whitaker, Dean of Research & Innovation
Ms Lois Neal, Assistant Registrar (Research Strategy)

*Please refer to the latest guidance available on the internal Newcastle Biomedicine web-site.

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THE QUEEN'S ANNIVERSARY PRIZES
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2009

Newcastle University

18 April 2013

Evelyn Barron
Institute for Ageing and Health
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Faculty of Medical Sciences

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Framlington Place
Newcastle upon Tyne
NE2 4HH United Kingdom

Professor Michael Whitaker
FIBiol FMed Sci
Dean of Research & Innovation

FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE

Dear Evelyn

Title: What do we mean by healthy ageing?
Application No: 00638/2013
Start date to end date: 11 March 2013 to 11 July 2013

On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of your proposal have been considered and your study has been given ethical approval.

The approval is limited to this project: **00638/2013**. If you wish for a further approval to extend this project, please submit a re-application to the FMS Ethics Committee and this will be considered.

During the course of your research project you may find it necessary to revise your protocol. Substantial changes in methodology, or changes that impact on the interface between the researcher and the participants must be considered by the FMS Ethics Committee, prior to implementation.*

At the close of your research project, please report any adverse events that have occurred and the actions that were taken to the FMS Ethics Committee.*

Best wishes,

Yours sincerely

M. Holbrough

Marjorie Holbrough
On behalf of Faculty Ethics Committee

cc.
Professor Michael Whitaker, Dean of Research & Innovation
Ms Lois Neal, Assistant Registrar (Research Strategy)

*Please refer to the latest guidance available on the internal Newcastle Biomedicine web-site.

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THE QUEEN'S ANNIVERSARY PRIZES
FOR HIGHER AND FURTHER EDUCATION

11 April 2014

Evelyn Barron
Institute for Ageing and Health

Faculty of Medical Sciences
Newcastle University
The Medical School
Framlington Place
Newcastle upon Tyne
NE2 4HH United Kingdom

FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE

Dear Evelyn

Title: Opinions on healthy ageing
Application No: 00752/2014
Start date to end date: 21 March 2014 to 30 August 2014

On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of your proposal have been considered and your study has been given ethical approval.

The approval is limited to this project: **00752/2014**. If you wish for a further approval to extend this project, please submit a re-application to the FMS Ethics Committee and this will be considered.

During the course of your research project you may find it necessary to revise your protocol. Substantial changes in methodology, or changes that impact on the interface between the researcher and the participants must be considered by the FMS Ethics Committee, prior to implementation.*

At the close of your research project, please report any adverse events that have occurred and the actions that were taken to the FMS Ethics Committee.*

Best wishes,

Yours sincerely

M. Holbrough

Marjorie Holbrough
On behalf of Faculty Ethics Committee

cc.
Professor Andy Hall, Chair of FMS Ethics Committee
Ms Lois Neal, Assistant Registrar (Research Strategy)

*Please refer to the latest guidance available on the internal Newcastle web-site.

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THE QUEEN'S ANNIVERSARY PRIZES

Appendix T. Survey 1

What do we mean by healthy ageing?

What do we mean by healthy ageing?

Many of us have a good idea what we mean by "healthy ageing" but there is no overall agreement about the definition. In this Delphi Survey we are asking for your opinion on what healthy ageing means. A Delphi Survey is a series of questionnaires that allow us to reach a group consensus on a particular topic. The opinions given in this round of the survey will determine which questions are included in the second round. All the answers that you give are anonymous and your completed survey will remain confidential.

Thank you for agreeing to participate in this survey.

If you have any questions, or no longer wish to take part in the survey, then please contact:

Evelyn Barron

evelyn.barron@ncl.ac.uk

0191 248 1141

About you

1. Are you male ☐ or female ☐ ? (please tick)
2. What is your age? _____
3. What is the first part of your postcode? (e.g. NE12) _____

Instructions

Throughout the rest of the survey you will be asked to say how important some statements are in respect of healthy ageing. You will be asked to use the following rating scale to answer the questions…..

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

……and then write a number in the box next to each statement. For example, if you want to answer 'extremely important' write 5 in the box.

Measuring Ageing

Some people think that maintaining good body functions is important in healthy ageing. In this section please rate how important you feel the following things are when thinking about how well someone is ageing. Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

4. Measuring bone health e.g. how strong bones are	
5. Measuring kidney function	
6. Looking at how genes can influence health	
7. Using general measures of health	
8. Measuring the amount of red and white blood cells and platelets in blood	
9. Measuring heart function e.g. blood pressure and pulse	
10. Measuring blood glucose i.e. the amount of sugar in the blood	
11. Measuring blood lipids e.g. the amount and type of cholesterol	
12. Measuring adiposity i.e. where fat is stored in the body and how much	

Please use this space to comment on any of the items above, to list any items which should be removed or add extra items you think should be included.

Health Problems

Some people think that the remaining free of disease is important in healthy ageing. In this section please rate how important you feel the following health problems are when thinking about healthy ageing. For example, some people may have one or more of the health problems listed but may not feel that these health problems affect how well they are ageing. Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

13. Diabetes	
14. Dementia e.g. Alzheimer's disease	
15. Bone or joint disease e.g. arthritis or osteoporosis	
16. Chronic Pain	
17. Fatigue	
18. Cancer	
19. Obesity	
20. Degenerative brain diseases e.g. Parkinson's disease	
21. Mood disorders e.g. depression	
22. Lung problems e.g. asthma or emphysema	
23. Cardiovascular problems e.g. hypertension, heart attacksor stroke	
24. Health service use e.g. number of visits to GP or hospital	

Please use this space to comment on any of the items above, or to list any items which should be removed or add extra items you think should be included.

Independence

Some people think that the ability to remain independent is important in healthy ageing. In this section please rate how important you feel the following things are when thinking about independence and ageing

Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

25. Finances e.g. being able to manage money yourself, being satisfied with finances, being financially independent	
26. Self maintenance e.g. being able to dress and bathe one's self	
27. Ability to undertake day to day activities e.g. housework and grocery shopping	
28. Access to suitable transport e.g. being able to get around within the community, being able to keep driving (if driving was a usual activity)	
29. Formal services such as home visits from a carer, having meals delivered	

Please use this space to comment on any of the items above, or to list any items which should be removed or add extra items you think should be included.

Mood

Some people think that mood is important in healthy ageing. In this section please rate how important you feel the following aspects of mood are when thinking about healthy ageing. Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

30. General mood e.g. happy, sad or worried	
31. Ability to cope with problems e.g. dealing with problems in a positive way or denying a problem exists	
32. Number and severity of life events, such as moving house, divorce, or death of a spouse	
33. Coping with or avoiding stress	
34. Coping with or avoiding anxiety	
35. Self-esteem and self worth	
36. Coping with or avoiding loneliness	
37. Personality traits e.g. conscientiousness, openness	

Please use this space to comment on any of the items above, or to list any items which should be removed or to add extra items you think should be included.

Personality

Some people think that aspects of personality are important in healthy ageing. In this section please rate how important you feel the following aspects of personality are when thinking about healthy ageing.

Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

38. Self confidence i.e. self-assuredness in one's personal judgement and abilities	
39. Self efficacy i.e. belief in one's ability to succeed in specific situations or judgments of personal capability	
40. A good sense of humour	
41. Attitude towards life e.g. have a positive or negative outlook on life	
42. A sense of being in control of things which happen either to, or around, one.	
43. Having good coping strategies e.g. being able to cope with changes or problems, being able to adapt to new situations	
44. Being able to assess risk	

Please use this space to comment on any of the items above, or to list any items which should be removed or to add extra items you think should be included.

Brain function

Some people think that maintaining good brain function is important in healthy ageing. In this section please rate how important you feel the following aspects of brain function are when thinking about ageing healthily.

Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

45. Memory	
46. Attention and concentration	
47. Reasoning e.g. problem solving, making generalisations	
48. Cognitive plasticity i.e. the ability to acquire or improve cognitive skills such as problem solving and recalling lists or events	
49. Cognitive skills such as ability to do arithmetic and ability to read, write and speak	

Please use this space to comment on any of the items above, or to list any items which should be removed or to add extra items you think should be included.

Fulfilling your potential

Some people think that fulfilling your potential is important in healthy ageing. This is known as self-actualisation and has also been described as 'becoming everything that you are capable of becoming'. In this section please rate how important you feel the following aspects of self-actualisation are in healthy ageing.

Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

50. Having a sense of purpose	
51. Having a sense of accomplishment	
52. Having a sense of having made a contribution – this might be a contribution to family life, a group, or society in general	
53. Personal growth e.g. learning, wisdom, achieving goals	
54. Support from family	

Please use this space to comment on any of the items above, or to list any items which should be removed or to add extra items you think should be included.

Wellbeing

Some people think that the way one feels about one's life is an important aspect of healthy ageing. Subjective wellbeing refers to how people think and feel about the quality of their lives.

Please put a number in each box from the scale below to rate how important you feel the following aspects of subjective wellbeing are in healthy ageing.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

55. Satisfaction with life	
56. Quality of life	
57. How well someone feels that they are ageing	
58. How much energy one has	
59. Job satisfaction, either in your current work (paid or voluntary) in your work before retirement, or any other type of work such as voluntary work	
60. General satisfaction with one's own health	

Please use this space to comment on any of the items above, or to list any items which should be removed or to add extra items you think should be included.

Social support

Some people think that having good social support is an important aspect of healthy ageing. This section will ask about how important different aspects of social support networks are in respect of healthy ageing. Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

61. Satisfaction with the quality and amount of social activities	
62. Satisfaction with the number and quality of friendships	
63. Satisfaction with family relationships	
64. Satisfaction with the home e.g. location, keeping warm	
65. Being able to communicate with family and friends e.g. by using the telephone or email	

Please use this space to comment on any of the items above, or to list any items which should be removed or to add extra items you think should be included.

Physical function

Some people think that good physical functioning is an important aspect of healthy ageing. This section will ask about the importance of different aspects of physical functioning for healthy ageing. Please put a number in each box from the scale below.

1	2	3	4	5
Not at all important	Not very important	Neither important nor unimportant	Important	Extremely important

66. Absence of disability	
67. Not having a sensory impairment e.g. problems with hearing or vision	
68. Good lung function	
69. Having good physical balance	
70. Being physically strong e.g. grip strength or upper body strength	
71. Having endurance – this is also sometimes referred to as stamina or staying power	
72. Good walking ability i.e. the speed and distance you are able to walk	
73. Movement e.g. being able to climb stairs, being able to get in and out of bed	
74. Good motor skills e.g. dexterity, being able to handle small objects	
75. Getting an adequate amount and quality of sleep	
76. Good self-rated physical health and functioning	

Please use this space to comment on any of the items above, or to list any items which should be removed or to add extra items you think should be included.

Thank you for completing the survey! Your answers will be very valuable.

Now please return the questionnaire as soon as possible by your chosen method (either by email or by using the pre-paid envelope included).

Appendix U. Survey 2

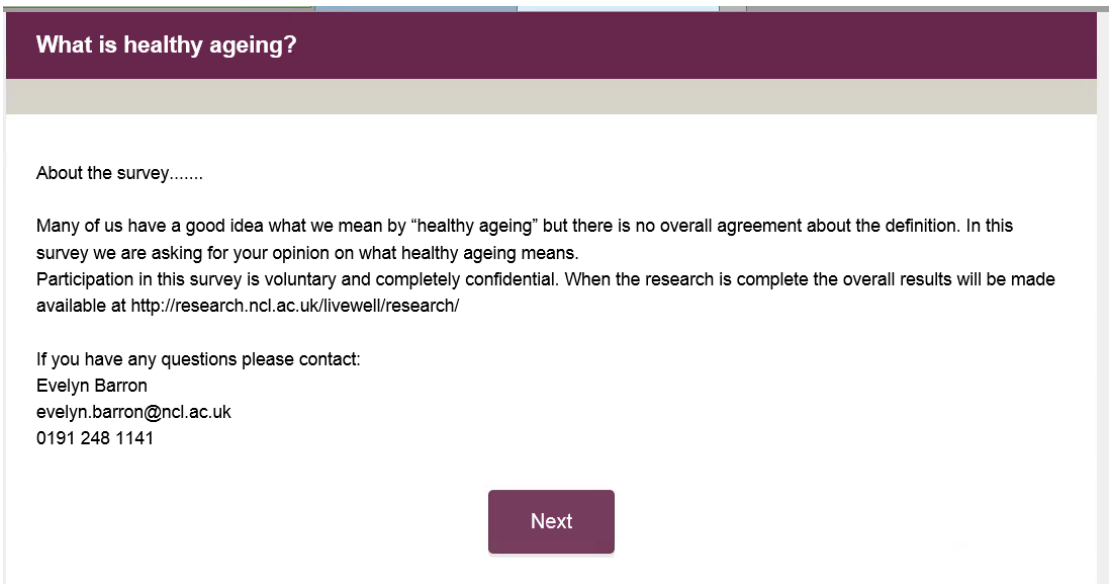
What do we mean by 'healthy ageing'?

About the survey
Many of us have a good idea what we mean by "healthy ageing" but there is no overall agreement about the definition. In this survey we are asking for your opinion on what healthy ageing means. Participation in this survey is voluntary and completely confidential. If you have any questions please contact: Evelyn Barron evelyn.barron@ncl.ac.uk 0191 248 1141

Instructions	
Please complete the following information: Age_____ Gender_____ The first part of your postcode (e.g. NE2)_____ Please rate how important you feel the following things are when thinking about 'healthy ageing'. Below are ten statements. Please rate them **in order of how important they are** for healthy ageing. **1 is the least important, 10 is the most important**. Please rate all of the statements and give each its own rating. Please do not try and rate two statements as equally important, and do not miss any out.	
Having ways to measure how 'healthily' someone is ageing, e.g. blood tests	
Mood	
Brain function	
Subjective wellbeing (or quality of life)	
The absence of health problems	
Physical capability	
Aspects of personality	
Fulfilling your full potential	
Social support	
Maintaining independence	

Thank you for completing the survey! Please return it to evelyn.barron@ncl.ac.uk

Appendix V. Survey 3 (for all non Target Audience participants)



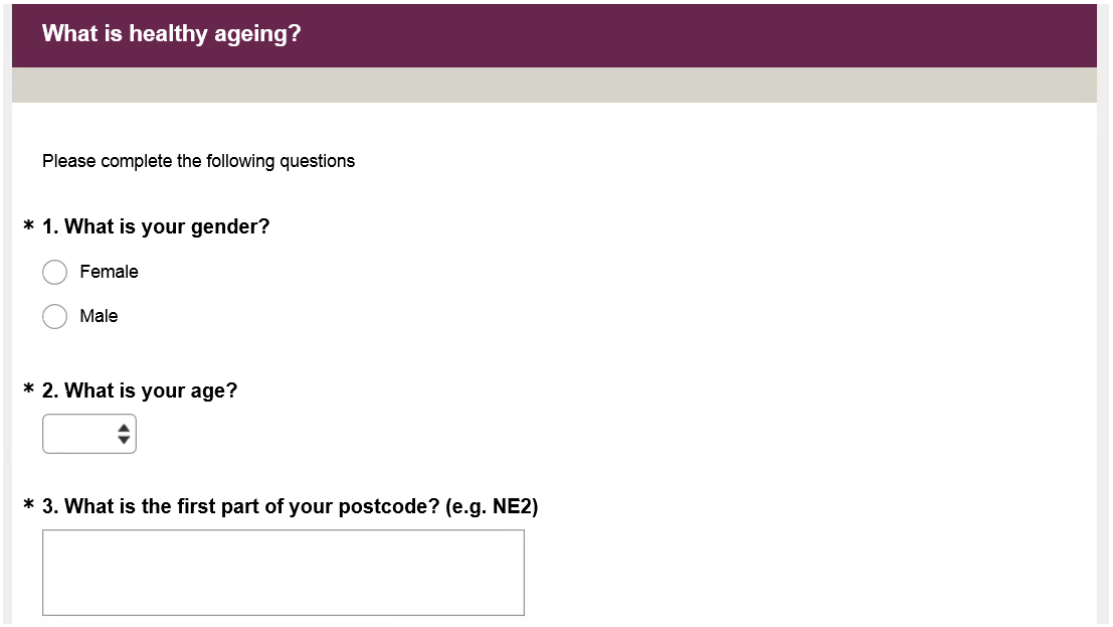
What is healthy ageing?

About the survey.....

Many of us have a good idea what we mean by "healthy ageing" but there is no overall agreement about the definition. In this survey we are asking for your opinion on what healthy ageing means.
Participation in this survey is voluntary and completely confidential. When the research is complete the overall results will be made available at http://research.ncl.ac.uk/livewell/research/

If you have any questions please contact:
Evelyn Barron
evelyn.barron@ncl.ac.uk
0191 248 1141

Next



What is healthy ageing?

Please complete the following questions

*** 1. What is your gender?**

- ◯ Female
- ◯ Male

*** 2. What is your age?**

*** 3. What is the first part of your postcode? (e.g. NE2)**

What is healthy ageing?

* 4. Please rate how important you feel the following things are when thinking about 'healthy ageing'.

Below are ten statements. Please rate them in order of how important they are for healthy ageing. 1 is the least important, 10 is the most important.

Please rate all of the statements and give each its own rating. Please do not try and rate two statements as equally important, and do not miss any out.

	1	2	3	4	5	6	7	8	9	10
Self-actualization (or fulfilling your full potential)	○	○	○	○	○	○	○	○	○	○
Physical capability	○	○	○	○	○	○	○	○	○	○
Subjective wellbeing (or quality of life)	○	○	○	○	○	○	○	○	○	○
Aspects of personality	○	○	○	○	○	○	○	○	○	○
Having ways to measure how 'healthily' someone is ageing, e.g. blood tests	○	○	○	○	○	○	○	○	○	○
Mood	○	○	○	○	○	○	○	○	○	○
Social support	○	○	○	○	○	○	○	○	○	○
The absence of health problems	○	○	○	○	○	○	○	○	○	○
Maintaining independence	○	○	○	○	○	○	○	○	○	○
Brain function	○	○	○	○	○	○	○	○	○	○

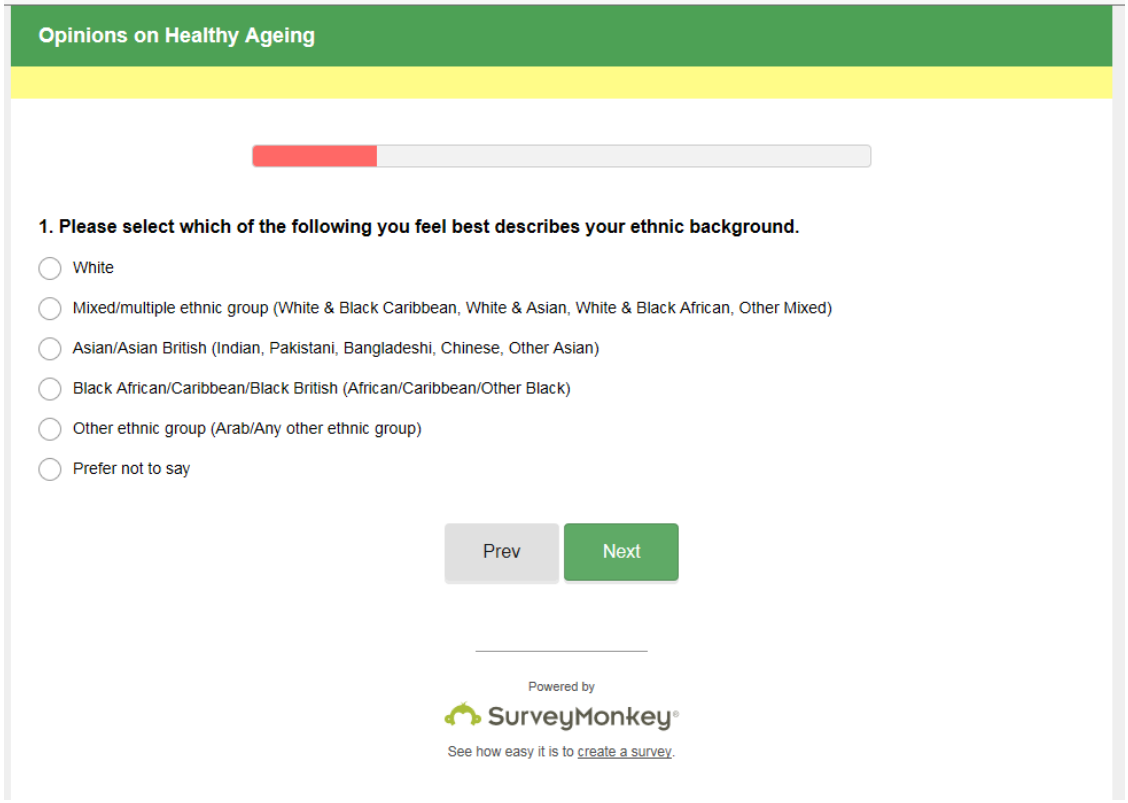
Prev Next

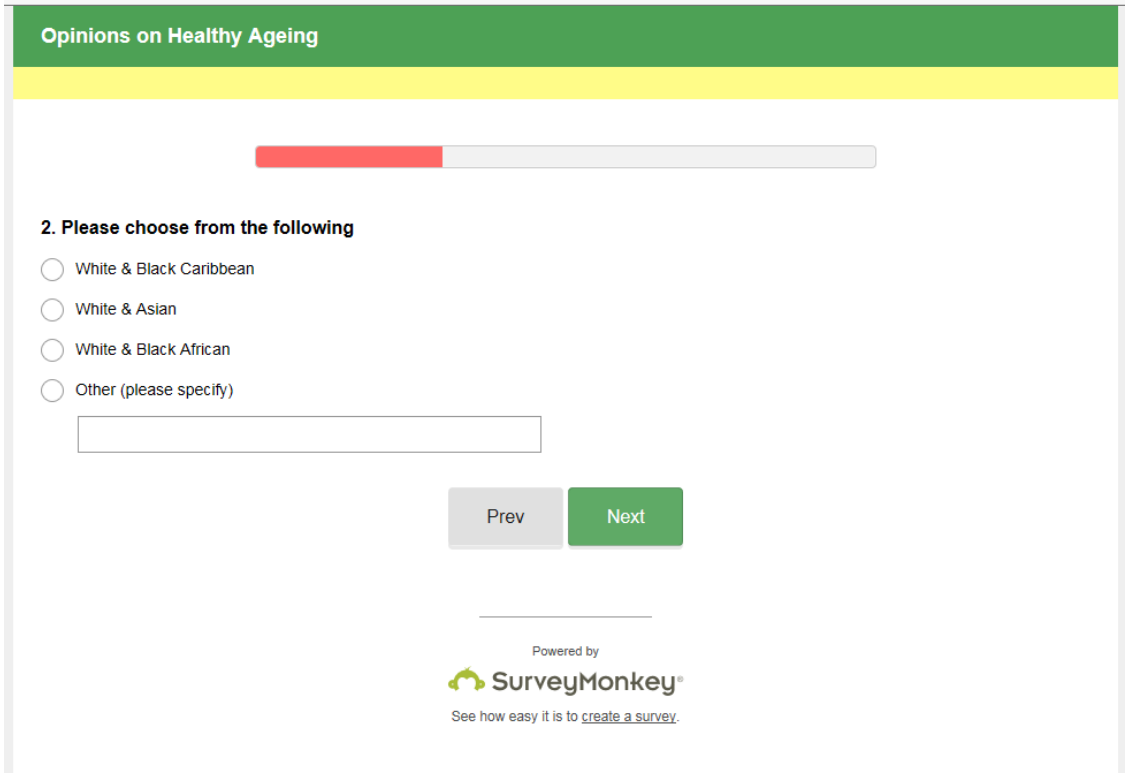
What is healthy ageing?

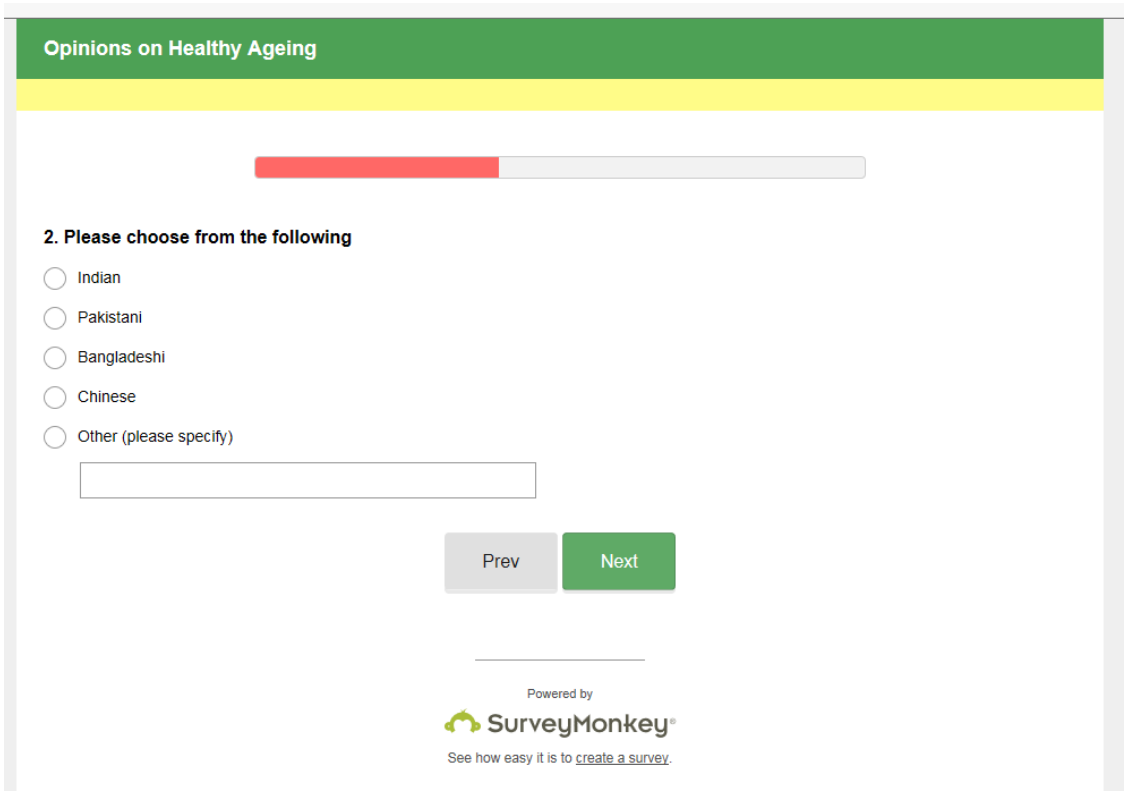
Thank you for taking part in this survey!

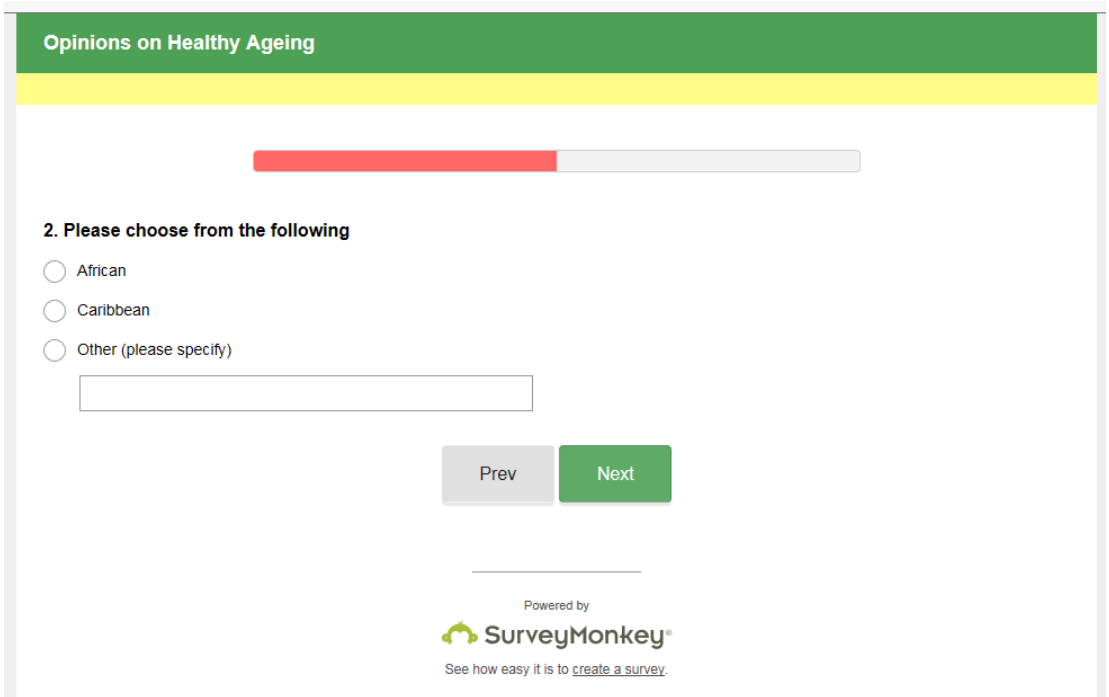
Prev Done

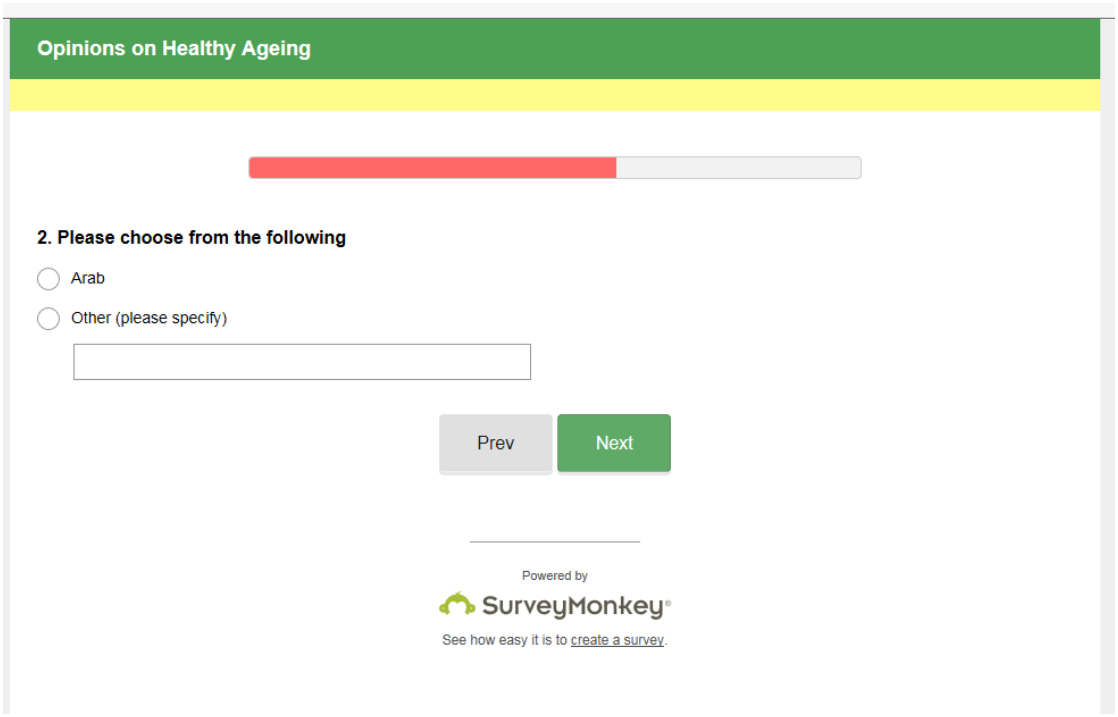
Appendix W. Survey 3 for Targeted Audience participants






Opinions on Healthy Ageing
2. Please choose from the following
Indian
Pakistani
Bangladeshi
Chinese
Other (please specify)
Prev
Next
Powered by
SurveyMonkey
See how easy it is to create a survey.


Opinions on Healthy Ageing
2. Please choose from the following
African
Caribbean
Other (please specify)
Prev
Next
Powered by
SurveyMonkey
See how easy it is to create a survey.


Opinions on Healthy Ageing
2. Please choose from the following
Arab
Other (please specify)
Prev
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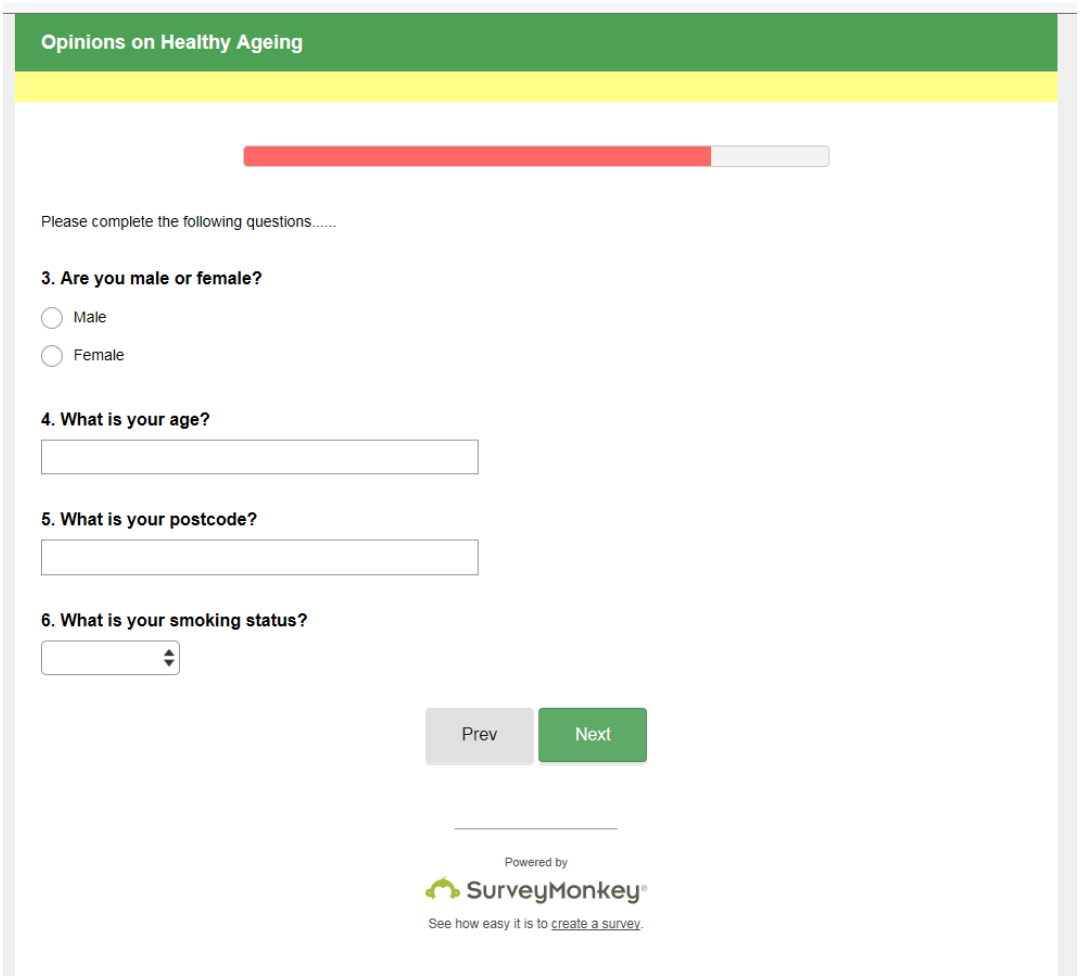
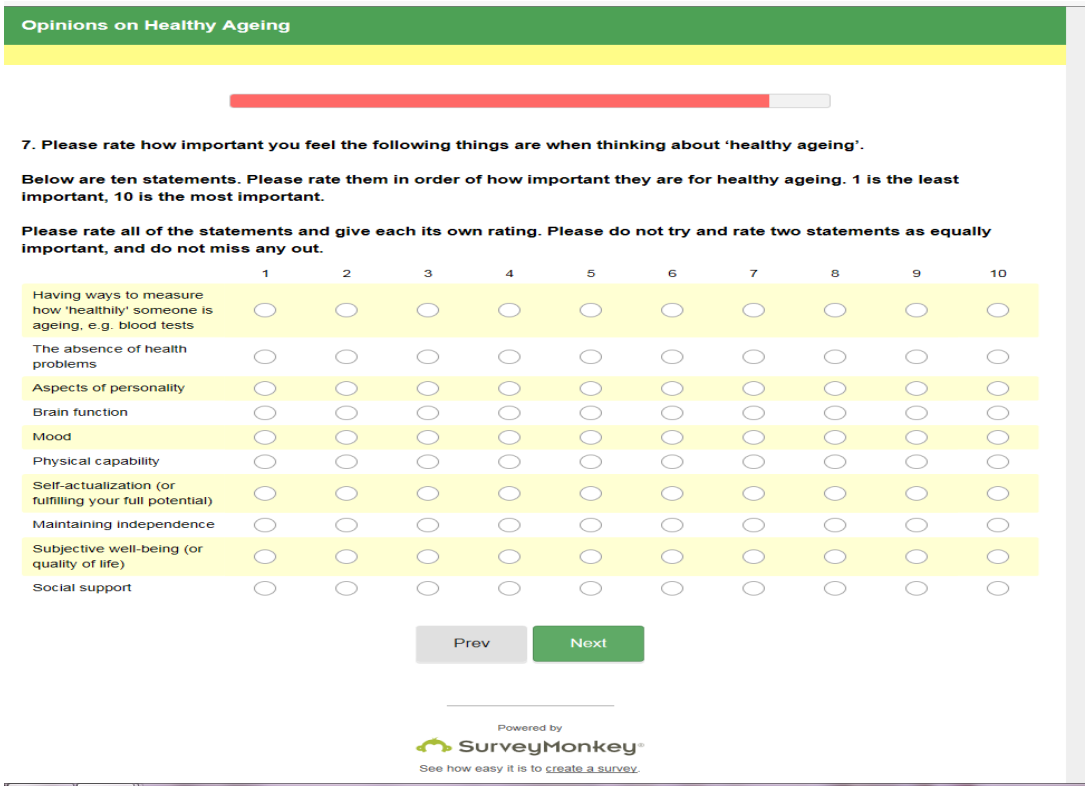
SurveyMonkey
See how easy it is to create a survey.


Opinions on Healthy Ageing
Please complete the following questions.....
3. Are you male or female?
Male
Female
4. What is your age?
5. What is your postcode?
6. What is your smoking status?
Prev
Next
Powered by
SurveyMonkey
See how easy it is to create a survey.



Opinions on Healthy Ageing

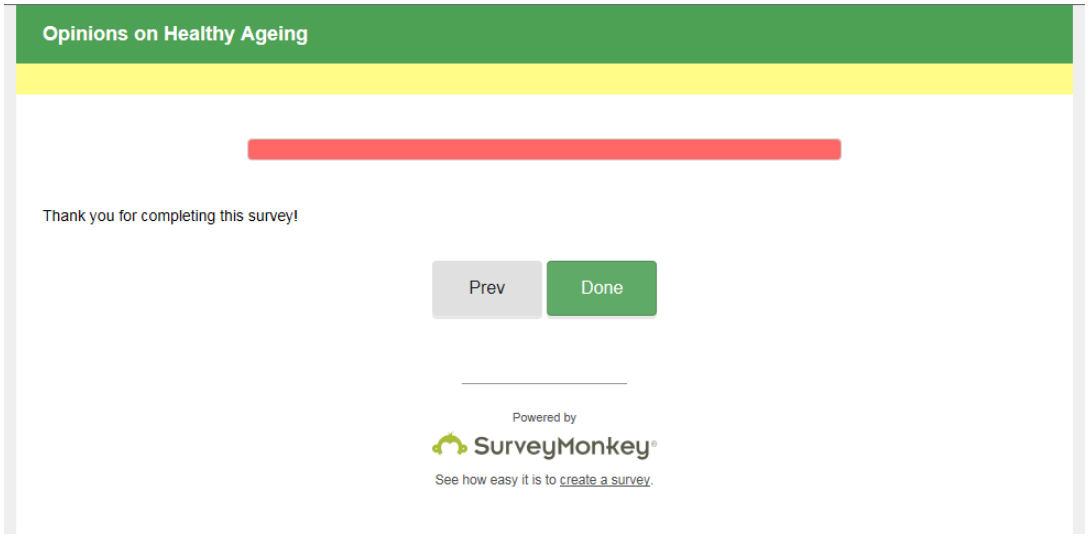
7. Please rate how important you feel the following things are when thinking about 'healthy ageing'.

Below are ten statements. Please rate them in order of how important they are for healthy ageing. 1 is the least important, 10 is the most important.

Please rate all of the statements and give each its own rating. Please do not try and rate two statements as equally important, and do not miss any out.

	1	2	3	4	5	6	7	8	9	10
Having ways to measure how 'healthily' someone is ageing, e.g. blood tests	○	○	○	○	○	○	○	○	○	○
The absence of health problems	○	○	○	○	○	○	○	○	○	○
Aspects of personality	○	○	○	○	○	○	○	○	○	○
Brain function	○	○	○	○	○	○	○	○	○	○
Mood	○	○	○	○	○	○	○	○	○	○
Physical capability	○	○	○	○	○	○	○	○	○	○
Self-actualization (or fulfilling your full potential)	○	○	○	○	○	○	○	○	○	○
Maintaining independence	○	○	○	○	○	○	○	○	○	○
Subjective well-being (or quality of life)	○	○	○	○	○	○	○	○	○	○
Social support	○	○	○	○	○	○	○	○	○	○

Prev Next

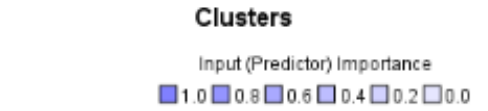


Opinions on Healthy Ageing

Thank you for completing this survey!

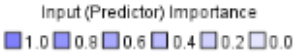
Prev Done

Appendix X. Two step cluster analysis for participants in Survey 3 who were not recruited via Targeted audience



Cluster	1	2
Label		
Description		
Size	86.9% (398)	13.1% (60)
Inputs	CatHealthProblems low importance (55.0%)	CatHealthProblems low importance (100.0%)
	CatSocialSupport low importance (57.0%)	CatSocialSupport low importance (100.0%)
	CatPersonality high importance (57.8%)	CatPersonality high importance (100.0%)
	CatPhysicalFunction high importance (58.8%)	CatPhysicalFunction high importance (100.0%)
	CatBrainFunction high importance (61.3%)	CatBrainFunction high importance (100.0%)
	CatSubjective Wellbeing low importance (60.1%)	CatSubjective Wellbeing low importance (100.0%)
	CatMood high importance (66.3%)	CatMood high importance (100.0%)
	CatFullPotential low importance (68.6%)	CatFullPotential low importance (100.0%)
	CatIndependence high importance (71.9%)	CatIndependence high importance (100.0%)
	CatMeasuringAgeing low importance (75.4%)	CatMeasuringAgeing low importance (100.0%)

Clusters



Cluster	2	1	3	4
Label				
Description				
Size	33.6% (154)	27.1% (124)	26.2% (120)	13.1% (60)
Inputs	CatFullPotential low importance (98.7%)	CatFullPotential high importance (99.2%)	CatFullPotential low importance (100.0%)	CatFullPotential low importance (100.0%)
	CatSubjective Wellbeing high importance (70.8%)	CatSubjective Wellbeing low importance (62.1%)	CatSubjective Wellbeing low importance (98.3%)	CatSubjective Wellbeing low importance (100.0%)
	CatBrainFunction high importance (60.4%)	CatBrainFunction low importance (59.7%)	CatBrainFunction high importance (84.2%)	CatBrainFunction high importance (100.0%)
	CatPersonality low importance (51.3%)	CatPersonality low importance (51.6%)	CatPersonality high importance (79.2%)	CatPersonality high importance (100.0%)
	CatMeasuringAgeing low importance (94.8%)	CatMeasuringAgeing low importance (66.9%)	CatMeasuringAgeing low importance (59.2%)	CatMeasuringAgeing low importance (100.0%)
	CatPhysicalFunction high importance (76.0%)	CatPhysicalFunction high importance (50.8%)	CatPhysicalFunction low importance (55.0%)	CatPhysicalFunction high importance (100.0%)
	CatMood high importance (81.2%)	CatMood high importance (52.4%)	CatMood high importance (61.7%)	CatMood high importance (100.0%)
	CatSocialSupport high importance (54.5%)	CatSocialSupport low importance (68.5%)	CatSocialSupport low importance (60.0%)	CatSocialSupport low importance (100.0%)
	CatHealthProblems low importance (63.0%)	CatHealthProblems low importance (57.3%)	CatHealthProblems high importance (57.5%)	CatHealthProblems low importance (100.0%)
	CatIndependence high importance (64.3%)	CatIndependence high importance (62.9%)	CatIndependence high importance (90.8%)	CatIndependence high importance (100.0%)

Appendix Y. Two step cluster analysis for all participants in Survey 3

Clusters

Input (Predictor) Importance

1.0 0.8 0.6 0.4 0.2 0.0

Cluster	2	1	3
Label			
Description			
Size	51.0% (294)	38.5% (222)	10.4% (60)
Inputs	CatMA low importance (66.3%)	CatMA low importance (78.4%)	CatMA low importance (100.0%)
	CatMood high importance (64.6%)	CatMood high importance (55.0%)	CatMood high importance (100.0%)
	CatSubjWellbeing low importance (95.9%)	CatSubjWellbeing high importance (96.4%)	CatSubjWellbeing low importance (100.0%)
	CatFullPot low importance (94.6%)	CatFullPot high importance (85.1%)	CatFullPot low importance (100.0%)
	CatPhysFunc high importance (57.5%)	CatPhysFunc high importance (64.0%)	CatPhysFunc high importance (100.0%)
	CatHealthProb high importance (54.4%)	CatHealthProb low importance (59.0%)	CatHealthProb low importance (100.0%)
	CatBrainFunction high importance (70.1%)	CatBrainFunction high importance (53.2%)	CatBrainFunction high importance (100.0%)
	CatSocSupport low importance (54.8%)	CatSocSupport low importance (64.4%)	CatSocSupport low importance (100.0%)
	CatPersonality high importance (65.3%)	CatPersonality low importance (60.8%)	CatPersonality high importance (100.0%)
	CatIndependence high importance (74.1%)	CatIndependence high importance (58.6%)	CatIndependence high importance (100.0%)

Clusters

Input (Predictor) Importance

1.0 0.8 0.6 0.4 0.2 0.0

Cluster	1	2	3	4
Label				
Description				
Size	38.2% (220)	35.2% (203)	16.1% (93)	10.4% (60)
Inputs	CatSubjWellbeing high importance (95.0%)	CatSubjWellbeing low importance (91.6%)	CatSubjWellbeing low importance (100.0%)	CatSubjWellbeing low importance (100.0%)
	CatFullPot high importance (87.3%)	CatFullPot low importance (95.6%)	CatFullPot low importance (95.7%)	CatFullPot low importance (100.0%)
	CatPersonality low importance (63.2%)	CatPersonality high importance (97.5%)	CatPersonality low importance (100.0%)	CatPersonality high importance (100.0%)
	CatMood high importance (55.0%)	CatMood high importance (54.2%)	CatMood high importance (87.1%)	CatMood high importance (100.0%)
	CatHealthProb low importance (58.6%)	CatHealthProb high importance (50.2%)	CatHealthProb high importance (62.4%)	CatHealthProb low importance (100.0%)
	CatBrainFunction high importance (52.7%)	CatBrainFunction high importance (67.0%)	CatBrainFunction high importance (77.4%)	CatBrainFunction high importance (100.0%)
	CatSocSupport low importance (63.2%)	CatSocSupport low importance (62.1%)	CatSocSupport high importance (58.1%)	CatSocSupport low importance (100.0%)
	CatIndependence high importance (59.1%)	CatIndependence high importance (67.5%)	CatIndependence high importance (87.1%)	CatIndependence high importance (100.0%)
	CatPhysFunc high importance (62.3%)	CatPhysFunc high importance (52.2%)	CatPhysFunc high importance (73.1%)	CatPhysFunc high importance (100.0%)
	CatMA low importance (75.9%)	CatMA low importance (63.1%)	CatMA low importance (79.6%)	CatMA low importance (100.0%)

Appendix Z. Variables and outcome data used in the analysis of the HAS and WII datasets

Whitehall

The following variables were available for analysis: Demographic data and information on health behaviour is available for each of the three phases. Data for 'mood' is available for all three phases, while data for 'wellbeing' and 'social support' are only available for Phase 1 and 2. 'Brain function' date is only available for Phase 3. The majority of the health problems data is available for all three phases while some is only available for Phase 3. Outcome data is available for participants in all phases.

	Phase 1 variables	Phase 2 variables	Phase 3 variables
Demographics			
Age at questionnaire completion	age_q	zage_q	xage_q
Sex	sex	sex	sex
ethnicity	ethnicity	ethnicity	ethnicity
Marital status	statusx	zstatusx	xstatusx
Age of father when he died	aodf	zaodf	xaodf
Age of mother when she died	aodm	zaodm	xaodm
Employment grade	grlump	zgrlump	xgrlump
Health Behaviour			
Frequency of vigorous exercise	vig	zvig	xvig
Currently smoke cigarettes	smoke	zsmoke	xsmoke
Mood			
GHQ score	ghq	zghq	xghq
Wellbeing			
Life event	eventall	zevental	-
Satisfaction with standard of living	stdliv	zstdliv	-
Satisfaction with leisure time	leisure	zleisure	-
Social support			
Network scale	netw	znetw	-
Satisfaction with personal relations	persrel	zpersrel	-
Brain Function			
AH4 total score	-	-	xah4
Mill hill score	-	-	xmh
Health Problems			

Angina pectoris	ang1	zang1	xang1
Diagnosis of heart trouble	htrdiag	zhtrdiag	xhtrdiag
Incident dementia	dmincum	zdmincum	xdmincum
Known dementia	dmkncum	zdmkncum	xdmkncum
Suffer from diabetes	diabetes	zdiabete	xdiabete
State of health in the last year	hlthyr	zhlthyr	xhlthyr
Drug class: anti-hypertensives	antihyp	zantihyp	xantihyp
Drug class: CNS medication	cnsdrg	zcnsdrg	xcnsdrg
Drug class: CVD medication	cvddrg	zcvddrg	xcvddrg
Drug class: diabetes medication	diabdrg	zdiabdrg	xdiabdrg
Outcomes			
Mortality status as of 31/08/2012	stat0812		
CHD mortality	ej12chd		
CVD mortality	ej12cvd		
Malignant neoplasms	ej12neo		
Non-CVD mortality	ej12ncvd		
Deaths (excl cvd,neo,resp)	ej12othd		
Respiratory mortality	ej12resp		
Stroke mortality	ej12strk		
Total mortality	ej12ac		

HAS

The following variables were available for analysis from the HAS cohort.

Demographics	
Date of birth	dob1y
Sex	sex
Marital status	marstat (married, single, divorced, widowed)
Own social class	socclass
Father's social class	soccfath
Age left school	schoolag
Health Behaviours	
Smoking status	Smokstat (never, ex, current)
Alcohol use	Unitsalc (number of units per week)

BMI	bmi
Health Problems	
Angina	angina
High blood pressure	highbp
Stroke	stroke
Emphysema	semph
Macular degeneration	armdall
Number of medications	drugno
Physical Function	
Walking problems	walkprob
Walking speed	walkspd
Ability to climb stairs	stairs
Able to carry loads	loads
Brain Function	
AH4 total score	numcorr
Mill Hill total score	numcorr9
Measuring Ageing	
Skin thickness	adjskin
Lens opacity	lorslens
Grip strength	bestgrip
Visual acuity score	rscore
Outcome Measures	
ICD 10 cause of death	icd10uc113012011
Date of death	datedth13012011
Mortality status	status13012011
Length of follow up time to mortality status	fuptime1994_5to13012011